Health Consultation

Samples Collected in 2004 for the Alaska Traditional Diet Project

CONTAMINANTS IN SUBSISTENCE FOODS
FROM THE WESTERN ALASKA COASTAL REGION

Prepared by the
Alaska Department of Health and Social Services

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

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

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

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Prepared By:

Alaska Department of Health and Social Services
Division of Public Health Service, Section of Epidemiology
Environmental Public Health Program
Agency for Toxic Substances and Disease Registry (ATSDR)

SUMMARY

INTRODUCTION	The mission of the Environmental Public Health Program (EPHP) is to ensure that residents of Alaska have the information they need about contaminants in the environment to safeguard their health. The Alaska Department of Health and Social Services (DHSS) evaluated contaminant levels in subsistence foods collected from the western Alaska coastal region because participating villages wanted to know whether these foods were safe to eat. EPHP used dietary survey and contaminant data collected in 2004 by ATSDR for the Alaska Traditional Diet Project. We also examined whether a historical mining site might be affecting contaminant levels in fish near Village A.
CONCLUSION	1. Metals (arsenic, cadmium, lead, and mercury) and persistent organic pollutants (pesticides and polychlorinated biphenyls) were present at different levels in sampled foods. 2. EPHP determined that generally, if the samples collected were representative of the area from which they were collected, eating subsistence foods with metals (arsenic, cadmium, lead, and mercury) and persistent organic pollutants (pesticides and polychlorinated biphenyls) from the Western Alaska Coastal Region is not expected to harm people's health. 3. EPHP also determined that eating fish with the contaminant levels found is not expected to harm the health of Village A residents. 4. EPHP could not determine whether differences in contaminant levels among fish samples collected from the three sampling locations near Village A were a result of the old mining site.
BASIS FOR DECISION	Metals (arsenic, cadmium, lead, and mercury) and persistent organic pollutants (POPs) (pesticides and polychlorinated biphenyls) present at different levels in sampled foods were below levels of health concern, so eating them does not pose a risk to human health. When the fact that most of the total arsenic in fish and marine mammals is in the much less toxic organic form was taken into consideration, levels of arsenic in all foods were well below the EPA fish consumption guidelines for unlimited consumption which are based on the toxic inorganic form of arsenic. Although cadmium levels in moose liver samples were above EPA health guidelines for unlimited consumption, cadmium in organ meats and other foods is not well-absorbed by the body, and this food is generally not eaten in large amounts. Although PCB levels in burbot liver were above EPA guidelines for unlimited consumption, dietary survey data suggest that most children and adults do not eat enough burbot liver to exceed the recommended exposure dose for PCBs. Levels of some POPs in marine mammal samples were above EPA health guidelines for unlimited consumption. However, they were not at levels of health concern, upon further evaluation, because the calculated doses for the median consumer were below EPA guidelines, based on consumption data from the dietary survey. Total mercury levels in three fish species (rainbow trout, whitefish, and grayling) were below the Alaska fish consumption guidelines for unlimited consumption

in all villages, including Village A. Two fish species (dolly varden and pike) had higher levels of mercury. However, eating dolly varden and pike from any village, including Village A is unlikely to harm health, as long as women of child-bearing age and young children follow the Alaska fish consumption guidance. It is important to understand a fish's (e.g. where they feed and travel) range when creating a sampling plan. Sampling locations should be far enough apart to ensure that distinct fish populations are sampled when searching for locational differences. Information was not available describing the distances between sampling locations near the old mining site by Village A, thus we could not determine if the sampling plan was adequate to detect differences in fish sampled upstream and downstream of the potentially contaminated site.

NEXT STEPS

People should continue to enjoy their subsistence foods, which provide many nutritional and health benefits. Alaska health officials also recommend that everyone eat at least two fish meals per week in order to maximize the health benefits associated with fish consumption. There are no suggested consumption limits for any species of Alaskan fish advised for adult men, teenage boys, and elder women. Women of child-bearing age and young children should follow the state's fish consumption guidelines for Alaska-caught fish, and limit their meals of pike to no more than 16 meals per month (if eaten fresh, see text) and those living in Village A, should also limit meals of dolly varden to 16 per month. All other groups, including teenage and adult males, and older women may eat pike in unlimited amounts. Women and young children limiting their consumption of pike and dolly varden are encouraged to substitute these fish with other species that have lower amounts of mercury, such as salmon. People who are concerned about cadmium exposure should not smoke cigarettes or use other tobacco products. EPHP will conduct the following outreach activities within three months of the release of this health consultation:

- Share this report with participating villages and stakeholders.
- Prepare and distribute a fact sheet that summarizes this report.
- Conduct an informal needs assessment with the communities to ensure that the results of the report have been disseminated appropriately, and to identify any potential health education needs or ongoing concerns.
- Conduct outreach and education activities as warranted by the needs assessment.

FOR MORE INFORMATION

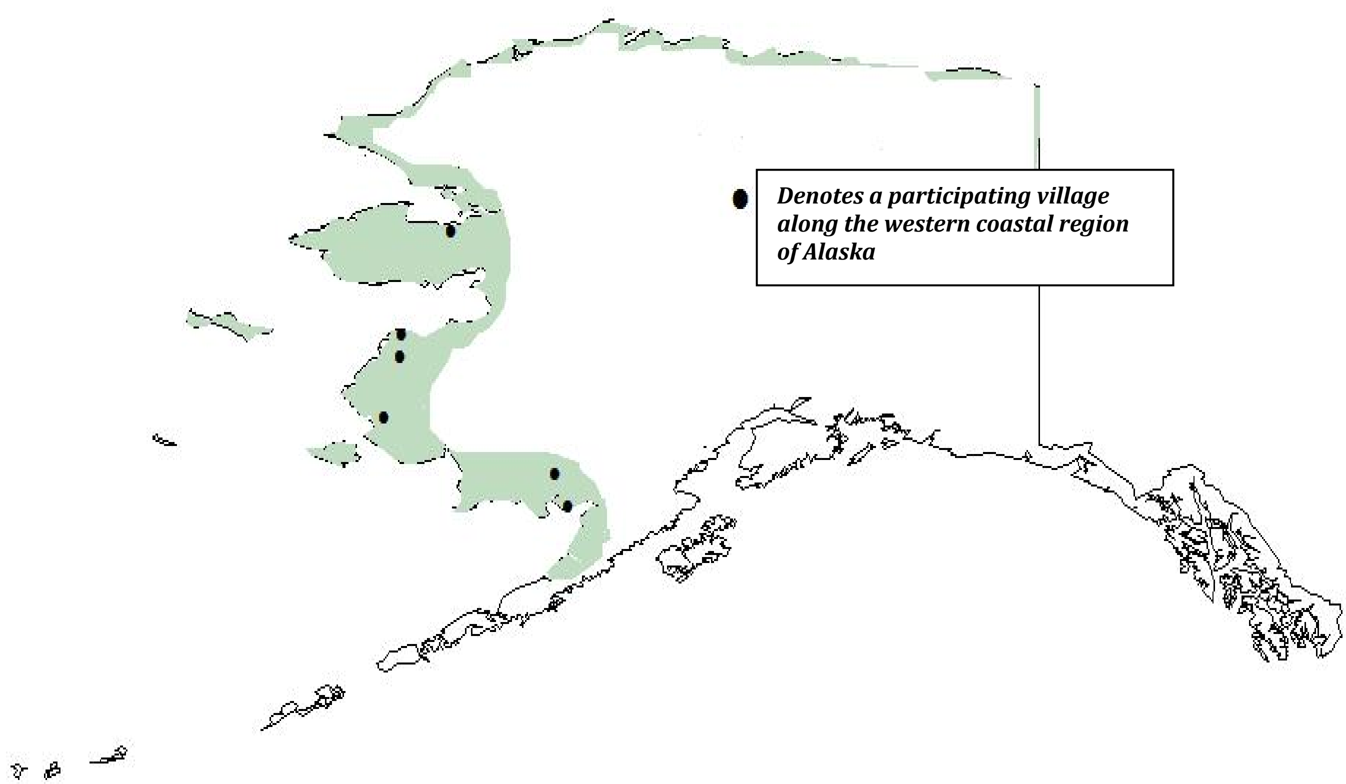
If you have questions or concerns about the contents of this report, contact EPHP at (907) 269-8000. You can also call ATSDR at 1-800-CDC-INFO and ask for information on the Alaska Traditional Diet Project.

Background and Statement of Issues

In 2001, in response to a request from Congress, ATSDR initiated the Alaska Traditional Diet Project (ATDP) to collect information about dietary patterns in rural Alaskan villages. Alaska Natives wanted information to help them make informed decisions regarding traditional food use, such as eating less of the foods that may present health risks, while preserving the important benefits associated with a subsistence lifestyle. Previous reports of contaminants in the environment and the food chain had raised questions about the safety of eating subsistence foods.

This health consultation evaluates data gathered by ATSDR for the ATDP.[1] Dietary histories that included the types and amounts of traditional foods and store-bought foods eaten were collected from thirteen remote rural villages during the first phase of the ATDP[2] in the summer of 2001. During Phase 2 of the ATDP, the Alaska Native Health Board and Alaska Native Science Commission received supplemental funding from ATSDR to collect a limited number of subsistence food samples from six participating villages and have them tested for contaminants (Figure 1). This report uses dietary information from Phase 1 of the ATDP in conjunction with contaminant data collected during Phase 2 of the ATDP. The purpose of this health consultation is to assess whether contaminants in the tested subsistence foods are at levels of health concern for people who eat them.

Figure 1. General location of the six villages participating in Phase 2 of the ATDP.



Of the six villages donating subsistence foods for contaminant testing, one is Inupiat Eskimo and the other five are of Yup'ik descent. There are approximately 2,450 residents in these six villages, with 94%

Alaska Native or part Native.[3] Children (up to18 years of age) represent between 17-37% of the individual village populations, with 761 children enrolled in village schools.[3] The percentage of residents living in poverty ranges from 12% to 46% among the six villages.[1] The names of the participating villages are not mentioned in this health consultation because some of the villages wished to remain anonymous. The general locations of the six villages are noted in Figure 1.

Most families in the six villages depend to some extent on subsistence activities. State and federal laws define subsistence as "the customary and traditional uses of wild resources for food, clothing, fuel, transportation, construction, art, crafts, sharing, and customary trade."[4] These villages are considered isolated in that the only way into or out of the community is by plane or boat; there is no road access.

The availability and cost of store-bought foods are prohibitive in small, isolated communities with high poverty rates. Shipping costs for goods (such as groceries) to these isolated communities has increased as fuel and postage costs have increased. For instance, in 2004, weekly food costs for a family of four residing in Bethel were 87% higher than in the metropolitan area (Anchorage).[5] In 2008, the food costs rose even further, with Bethel paying 113% ($270) more for their weekly groceries than Anchorage families ($127).[6] Due to food costs and the amount of poverty in these villages, subsistence foods are likely essential to these residents, and may be providing food security[2] for families.

Both subsistence and store-bought foods contain contaminants.[7] In addition, many market foods are high in fats, carbohydrates, and sodium; and these may lead to increased weight gain, high cholesterol, high blood pressure, and chronic diseases. [8]

Contaminants are substances that are present where they do not belong. Fish and other wildlife can take up environmental contaminants from the water or sediments they live in, or from the foods they eat. Metals are naturally occurring chemicals found in the earth's crust. As trace elements, some heavy metals (e.g. copper, selenium, zinc) are essential nutrients for proper body functioning. However, at higher concentrations they can lead to poisoning, and some metals, such as mercury, can damage the developing brain. Chlorinated hydrocarbons such as pesticides and polychlorinated biphenyls (PCBs) are man-made chemicals. These organochlorine chemicals, collectively called Persistent Organic Pollutants or "POPs", are persistent chemicals that resist degradation, meaning that they remain in the environment for a long time, often for decades. POPs can get into the environment from industrial parts of the world, then travel to the arctic on wind or ocean currents, where colder temperatures cause them to "distill" and settle in the environment.[9] Laboratory and environmental impact studies in the wild show that POPs can cause hormone disruption, learning and behavior changes in children, immune system suppression, and cancer. For a number of years, POPs like chlordane, dichlorodiphenyltrichloroethane (DDTs), dieldrin, and mirex were used as pesticides, but have since been banned from use in the U.S. because they can harm the health of wildlife and humans. Mirex was also used as a flame retardant, while PCBs were used to insulate electronics. The manufacture and use of PCBs was banned in the U.S. in 1976, as they can also cause adverse health effects. Concentrations of POPs that were banned in the U.S.decades ago have been slowly decreasing in the environment, but are still present in the food chain.

POPs are not only persistent; they are also lipophilic or "fat-loving". This results in the bioaccumulation (build up) of POPs in the fatty tissues of marine organisms, and an increase in concentration at each level

[1] The United States Census Bureau's poverty thresholds are based on a methodology that defines a family as living in poverty if it has an income of less than three times a "food budget."

[2] Food security is defined as having access to enough food, at all times. Food security includes nutritionally adequate and safe foods and the ability to get personally acceptable foods in a socially acceptable way.

of the food chain. In Alaska, the highest concentrations of POPs are found in the blubber and fatty tissues of marine mammals near the top of the marine food chain, such as polar bears, orcas, and beluga whales. In contrast, methylmercury (a toxic form of mercury) in fish is found mainly in the muscle tissue. Some inorganic elements like cadmium are highest in the liver and kidney of mammals. This report discusses a variety of contaminants in a number of tissue types.

Balancing the Risks and Benefits of Eating Subsistence Foods

It is important to consider both the risks of contaminants and the nutritional and cultural benefits of subsistence foods when deciding whether to change consumption (the act of eating, drinking, or otherwise ingesting something) levels of subsistence foods. Both market (store-bought) and subsistence foods contain trace levels of contaminants, so a person cannot avoid all contaminant exposures by substituting store-bought foods for subsistence foods. The subsistence diet makes up approximately 13% of the top 150 foods eaten in this region, with fish being a food staple for most individuals.[2] Subsistence foods provide between 24% to 98% of the energy, protein, omega-3 fatty acids, iron, and vitamins A and B_{12} needs of people in the participating villages.[2] Thus, the role of subsistence foods in providing these important nutrients must be considered.

Human studies have shown that eating fish has many health benefits. Fish is a good source of lean protein, low in saturated fats and high in omega-3 fatty acids.[10] Fish and marine mammals, and to a lesser extent shellfish, are the only significant direct dietary sources of two important types of the omega-3 fatty acids called eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). EPA and DHA protect against heart disease and possibly diabetes[11]. In addition, an increasing amount of research suggests that omega-3 fatty acids also help protect against arthritis and inflammation, depression, skin disorders, eye disorders, and cancer. Omega-3 fatty acids are also important for optimal neonatal growth and development, and for healthy immune function. Fish contains all of the essential amino acids, and is an excellent source of vitamins A and D, as well as selenium and iodine. Selenium is an essential trace mineral important for the proper functioning of antioxidant enzymes, the immune system, and thyroid. It also protects against the toxic effects of methylmercury. Alaska subsistence communities are noted to obtain up to 97% of the omega-3 fatty acids through a subsistence diet.[2] There are few commercially based foods that can provide low fat content and high omega-3s. The replacement of a subsistence diet that is low in fat and high in omega-3s with a market-based Western diet has increased the risk of cardiovascular disease and diabetes in Alaska Natives.[12]

Because of the numerous health benefits and that fish in Alaska are relatively clean, Alaska health officials generally conclude that consumption of Alaska fish outweigh the potential associated with chemical contaminants in fish.[11] More information on the risks and benefits of eating traditional foods is available in the State of Alaska *Epidemiology Bulletins* at: http://www.epi.hss.state.ak.us./bulletins/catlist.jsp?cattype=Subsistence+Foods or the EPHP website at: http://www.epi.hss.state.ak.us./eh/subsistence.htm.

Discussion

Environmental Data Collected

The subsistence foods that were sampled included a variety of fish, bird, mammal and one plant species (Table 1). The fish samples included three species of salmon (chum, coho, and sockeye), lush (burbot), grayling, whitefish, pike, dolly varden and rainbow trout. The bird and mammal samples included duck, ptarmigan, moose, caribou, and bearded seal. A single beluga whale and a single plant sample of red berries were also assessed. Two laboratories analyzed the food samples consisting of items such as marine mammal blubber, fish, and organs from terrestrial wildlife. The Center for Indigenous Native Environmental Studies laboratory analyzed metals (arsenic, cadmium, lead, mercury) in all 97 food samples. The Northwest Fisheries Science Center (The National Oceanic and Atmospheric Administration Fisheries Service) laboratory measured the amount of POPs in 54 of the 97 food samples. POP results include the measurement of eight chlordanes, six DDTs, dieldrin, three endosulfans, hexachlorobenzene (HCB), three hexachlorocyclohexanes (HCHs), heptachlor epoxide (a type of chlordane), lindane (a type of HCH), mirex, and 44 PCB congeners. The sample analyses passed quality assurance and quality control procedures established by these two laboratories. We accepted all data for use in determining whether exposure to a contaminant might pose a health risk.

Contaminant levels were reported in units of nanograms per gram (ng/g) wet weight, which is the same as parts per billion (ppb). Not every subsistence food sample contained all of the tested contaminants. For some food types, lead, lindane and/or mirex were detected in only one of the samples of a given food type. All other samples of that food type did not have detectable levels of those contaminants. For example, only one of the 18 whitefish samples had a detectable level of lead. Likewise, only one of the six sockeye salmon muscle samples had a detectable level of mirex. These cases of single, low-level detections of lead, lindane and/or mirex are shown in Table 2.

Study Limitations

More than half of the foods had small sample sizes (between one and four samples each), thus caution should be used when interpreting data from these samples because they may not represent that food type. In addition, all of the foods were analyzed in their unprocessed (uncooked, raw, frozen) forms, and this evaluation does not consider possible changes in contaminant levels (increases or decreases) due to different cooking or preparation methods. For instance, depending on the food and the way it is prepared, levels of chemicals such as PCBs, mercury, and cadmium can either increase, decrease or stay the same following cooking.[13,14] Levels of contaminants in animals also vary by age, sex and location. Samples present in small numbers from this project may or may not be representative of the area from which it was taken. Because there is natural variation in the animals sampled, a low sample size can result in a lack in statistical power; meaning that you cannot draw reliable conclusions from the results. For these and other reasons, consumption decisions should not be based on the contaminant profile of a single animal. In addition, EPHP was not provided the sampling plan used in the study, which limits our ability to evaluate the methodology of sampling design and collection procedures.

It should also be noted that arsenic was not speciated in these analyses, thus we had to rely on an estimated, calculated value to assess risk of exposure to inorganic arsenic, the more toxic form. In addition, mercury was not speciated so we used the measure of total mercury as a surrogate for assessing risk from exposure to methylmercury. This approach is more conservative because some of the total mercury is also present in the less bioavailable, organic form. In other words, we are overestimating the potential harm that could result from exposure to the amount of mercury in these food samples.

Exposure Pathways

Assessing exposure requires identifying pathways (*e.g.,* water, food, soil, air) by which people can come in contact with chemicals in the environment – in this case metals and POPs. This consult focuses on eating subsistence food as the main route by which residents can be exposed to metals and POPs. An exposure pathway consists of the following five components: 1) a source of contamination, 2) a media, such as food, air or soil through which the contaminant is transported, 3) a point of exposure where people can contact the contaminant, 4) a route of exposure by which the contaminant enters or contacts the body, and 5) a receptor population. An exposure pathway is considered complete if all five elements are present and connected. If one of these elements is missing, then the pathway is considered incomplete, and human exposure is not possible. For village residents who eat subsistence foods, all 5 components of the pathway are present, so the exposure pathway is considered complete.

Methods for Toxicological Evaluation

In the first step of our toxicological analysis, we compared average contaminant levels (concentrations) in the subsistence food samples to levels commonly found in market foods and to the U.S. Environmental Protection Agency (EPA) fish advisory guidelines for unlimited consumption[15]. We used these EPA guidelines, or "health guidelines (see box below)," to evaluate the risk posed by eating other types of meats besides fish (e.g. caribou, moose, duck, ptarmigan), because there are no established health guidelines for these other food items. In addition, we expect that the bioavailability (how much of a substance in a food item is absorbed by the body) of these chemicals is similar for meats from fish and land animals because both are muscle tissue.

We did not use the EPA fish consumption guidelines for mercury, because the State of Alaska has developed its own guidelines for mercury in fish. We compared the levels of total mercury in the sampled foods to Alaska's fish consumption guidelines for methylmercury[11], which take into account both the risks and benefits of eating Alaska-caught fish. The state guidelines offer specific consumption advice based on age and gender, and the acceptable daily intake value is derived from ATSDR's minimal risk level (MRL) for mercury (see page 11 for explanation of State of Alaska fish consumption guidelines). For contaminants for which there are no EPA or ATSDR guidelines, such as lead, we used World Health Organization (WHO[16]) and American National Standards Institute (ANSI) limits.[17]

The State of Alaska has not developed Alaska-specific consumption guidance for contaminants other than mercury.

What are health guidelines?

- Indicate a level below which the contaminant poses little to no risk of ill (harmful) effects for most people.
- Include, but are not limited to, ATSDR's minimal risk levels (MRLs) and EPA's reference doses (RfDs).
- If no health guidelines are available, or the guideline has been exceeded, then the contaminant is further evaluated. This is done by comparing estimated site-specific doses with doses observed in toxicological experiments with animals.

Depending on the chemical, the EPA fish consumption guidelines may have screening endpoints for chronic disease (non-cancer), cancer, or both. We used the chronic disease end points (or intermediate if no chronic MRL was available) to evaluate all contaminants found in this study. We also compared levels of contaminants in subsistence foods to cancer endpoints (chemicals that can cause cancer). Our consumption advice for contaminants is based on the chronic disease endpoints because these values are more appropriate for a number of reasons explained in the box on the next page.

Foods that had contaminant levels above EPA guidelines for unlimited consumption, or that had no EPA guidelines, were further evaluated. To do this, we calculated the dose of the contaminant a person would be exposed to from eating that food at the levels measured (either average or maximum level depending upon the contaminant) at the rates people reported eating them. The likelihood of ill effects from a contaminant is dependent upon the contaminant amount, the amount a person eats, and how often a person eats a food containing the contaminant. These factors are important for calculating a dose. In this evaluation, the exposure dose (ED) is a measure of exposure to metals or POPs relative to body weight; duration of exposure measured in years and the amount of subsistence foods consumed (measured in grams per day-g/day). We based consumption estimates (how much people eat measured in grams per day) on the dietary survey information collected by interviewing village residents in the first phase of the ATDP. In doing so, we can more accurately evaluate the amount of a chemical that a person would actually be exposed to from eating that food. We estimated doses for both children and adults for the median (middle) and maximum (highest) amount each subsistence food was eaten. Next, we compared these estimated doses to various chronic disease guidelines (see box above) in order to determine whether eating foods containing this level of contaminant posed a risk for chronic disease.

In most cases we compared values to ATSDR minimal risk levels (MRLs), but for mercury we used the guideline developed by Alaska state public health officials that is specific for Alaska residents.[11] After careful consideration, the Alaska Scientific Advisory Committee for Fish Consumption determined that the EPA fish advisory for methylmercury is too restrictive for Alaskans because it does not adequately factor in the relatively low levels of mercury in most Alaska fish species and the important health benefits of fish consumption. Alaska's health guideline is derived from ATSDR's No Observed Adverse Effect Level (NOAEL: 0.0013mg/kg/body weight/day) for methylmercury, but excludes one of the uncertainty factors they used for calculating their MRL, which was based on the Seychelles Islands Epidemiologic study.[18] This uncertainty factor was included to account for potential domain-specific findings in another study which evaluated the neurological effects of mercury exposure on the Faroe Islands[19]. Alaska public health officials did not use this uncertainty factor for calculating the mercury health guideline because subsequent studies performed in the Seychelles using the same neurobehavioral tests that were used in the Faroe Islands study, demonstrated no negative associations at these of levels mercury exposure[20]. The Alaska specific guideline does include a modifying factor of 3 to account for human pharmokinetic and pharmodynamic variability. The three-fold uncertainty factor applied to ATSDR's NOAEL provides sufficient protection against any subtle neurodevelopmental effects from mercury exposure. Additional uncertainty factors are not warranted and would result in fish consumption restrictions that would likely be more harmful than beneficial to the health of Alaskans. Therefore, the Alaska-specific chronic oral Acceptable Daily Intake for methylmercury for women who are or can become pregnant, nursing mothers, and young children is 0.0004 mg/kg body weight/day.

Why do cancer risk guidelines often over-estimate actual risk for people?

- Cancer risk guidelines are often developed by exposing laboratory animals to very high levels of a contaminant over the course of an animal's lifetime.
- Humans exposed to chemicals through food are usually exposed to a far lower amount than that given to lab animals during cancer studies. Therefore, using high-dose animal studies for evaluating low-dose human exposures is often questionable.
- Different animal species have different reactions to cancer-causing chemicals, and the most sensitive laboratory species are used for risk evaluation. Thus the risk of a chemical to cause cancer in humans is often over-estimated.
- People usually do not eat foods contaminated with high levels of the specific carcinogen on a daily basis.
- Mathematical models used to calculate cancer risk at exposure levels below the lowest dose given to laboratory animals use conservative assumptions designed to be over-protective.
- Cancer risk guidelines are however, good for screening out chemicals that may be of health concern due to their conservative nature.
- BUT they do not incorporate health benefits of traditional and wild foods.

Risk Evaluation Using Chronic Disease (Non-Cancer)

Endpoints

Table 3 contains a summary of the maximum number of meals for food items in this study that can be safely eaten based on EPA and State of Alaska guidelines. We include the EPA guidelines for completeness, but do not endorse their use because they do not incorporate the health benefits of subsistence foods or the health risks associated with alternative foods. Some food items had levels of a specific contaminant above EPA guidelines for unlimited consumption. Contaminants in these food items were further evaluated (doses were calculated), as shown in Table 4.

<u>Contaminants in Food Items That Did Not Require Further Evaluation</u>

None of the three types of endosulfans tested for in this study were found in any of the 54 subsistence food samples tested.

Mirex was found in less than 14% of the 54 subsistence food samples tested for POPs (Table 2). Maximum (highest) mirex concentrations ranged from 0.1 ppb (chum salmon muscle) to 4 ppb (beluga whale muscle). None of the samples had mirex levels that were above the EPA guidelines for unlimited consumption (59 ppb). Therefore, **the levels of mirex found in subsistence foods sampled in this study do not pose a health risk.**

Levels of chlordane, dieldrin, and HCB in all sampled subsistence foods were below EPA guidelines for unlimited consumption (see Table 3). Levels of heptachlor epoxide and DDTs in fish, moose livers, burbot livers, land mammals (caribou), and birds were also less than EPA guidelines. Therefore, **the levels of chlordane, dieldrin, HCB, heptachlor epoxide, or DDT in these subsistence foods sampled in this study do not pose a health risk.**

Levels of all contaminants were well below levels of health concern in the sample of red berries. It should be noted however, that only a single sample of berries was analyzed.

Contaminants in Food Items that Required Further Evaluation

Lead

Lead was further evaluated because there are no EPA fish consumption guidelines available for this chemical. Lead was not consistently found in any food type. It was detected in only 7% (7 out of 97) of all subsistence food samples (Table 2). The highest level of lead (253 ppb) occurred in a single sample of whitefish, and is below levels found in other types of store-bought meat (beef, poultry[21]). At the highest concentration (253 ppb), the exposure dose (the amount of contaminant someone is exposed to over a period of time) of lead is below WHO[16] and ANSI limits.[17] We used the highest level of lead detected in a food to calculate the exposure dose (Table 4) because this provides the most protective evaluation of health risk. Modeled[21] (calculated) total blood lead levels based on this estimated dose for adults and children were both below 3 micrograms per deciliter (µg/dL, Table A1). While EPHP recognizes that there is no threshold for lead toxicity, levels observed do not warrant consumption restriction. These levels are low, and similar to the median estimated blood lead level of 2.2 µg/dL in children age six months to six years, observed in other regions of Alaska.[22] Estimated blood lead levels are below the current levels of concern established by the Centers for Disease Control and Prevention (CDC, 10 µg/dL).[23] Health effects are unlikely from the amount of lead eaten in subsistence foods. **Few of the subsistence foods sampled had lead, and no ill effects are likely from eating the few foods that may contain lead.**

Arsenic in fish and marine mammals

Arsenic was further evaluated because there are no EPA guidelines for total arsenic in fish. Arsenic occurs in toxic inorganic forms, and much less toxic organic forms. Most of the total arsenic in fish is in less toxic organic forms. The proportion of inorganic arsenic in fish is only around 1.5%.[24] The organic forms of arsenic in fish (e.g., arsenobetaine and arsenocholine) are not harmful to people because they are easily and quickly removed from the body through the urine. Similarly, most arsenic in marine mammal tissue is in the organic form.[25] It is the inorganic form of arsenic that is harmful to people.[26]

EPA and other government agencies base their risk-based consumption guidelines for arsenic on the toxic, inorganic form of arsenic. Unfortunately, the ATDP only measured total arsenic, and not the specific forms of arsenic, in subsistence food samples. In order to use existing guidelines, we estimated the amount of inorganic arsenic in fish based on other studies which found an average of 1.5%. The highest amount of total arsenic measured in any sample was in burbot liver (1856 ppb). When this value is adjusted to represent the amount of inorganic arsenic present alone (taking 1.5% of 1856 ppb), the amount of inorganic arsenic is 3 times lower than the EPA guideline for unrestricted consumption based on chronic disease guidelines. Furthermore, the calculated maximum exposure doses for both adults and children were 10,000 times less than the MRL[26] for inorganic arsenic (Table 4, 0.003 mg/kg-day). Therefore**, no consumption restrictions related to arsenic are recommended.**

Cadmium in Moose Liver

Cadmium in moose liver was further evaluated because it was present at levels above the EPA guidelines for unlimited consumption. Cadmium levels were higher in moose liver than in any other subsistence food tested (Table 3). Cadmium levels in five moose liver samples from two villages ranged from 440 ppb to 1300 ppb, with an average concentration of 754 ppb. These cadmium concentrations are similar to those documented in moose liver from other parts of Alaska.[27]

Results from previous public health evaluations conducted in Canada and Alaska show that the highest potential exposure to cadmium is from terrestrial (land) mammal-based diets, particularly moose and caribou liver and kidney.[27] These evaluations concluded that consumption of liver was low, and in most cases, total dietary exposure was below the WHO provisional tolerable weekly intake (PTWI) of 450 µg (micrograms) cadmium. The researchers encouraged continued harvest and consumption of traditional foods because of the many associated health benefits.

During Phase 1 of the ATDP, 60% of surveyed residents of the Bristol Bay Health Corporation service area consumed moose liver, with a median consumption rate of two pounds per year and a maximum consumption rate of 56 pounds per year.

Cadmium in organ meats or other foods is not well absorbed by the body. Generally, less than 10% of the cadmium ingested from foods is absorbed.[28] Taking this reduced bioavailability of cadmium into account, cadmium doses from long-term consumption of moose liver were below health guidelines (Table 4). **Therefore, the levels of cadmium in subsistence foods are not likely to pose a health risk. In contrast to low bioavailability of cadmium in foods, the cadmium in cigarette smoke is almost completely absorbed by the lungs of smokers. Villagers who are concerned about cadmium exposure are encouraged not to smoke cigarettes or use other tobacco products.**

Mercury in Pike

The State of Alaska has established fish consumption guidance for Alaska-caught fish, which takes into account both the health risks from methylmercury exposure and the nutritional benefits of fish.[11] This guidance was developed by a committee of Alaskan scientific experts in the fields of public health, medicine, toxicology, pediatrics, and fisheries and wildlife. The State of Alaska's guidance differs from the guidance provided by EPA, which is based solely on risk assessment and does not balance risks and benefits. Table 3 shows the guidance of both agencies, with the recommended maximum number of meals per month of each tested subsistence food that would be "safe" for pregnant women to consume. Guidelines are conservative estimates designed to protect the brain and nervous system of a developing fetus, which is most sensitive to the harmful effects of mercury.

The State of Alaska's guidance is based on the chronic oral (eaten on a daily basis) health guideline, called the minimal risk level (MRL), established by ATSDR for methylmercury. We recommend following this guidance when deciding how much fish to eat, as it is balanced yet protective. Using the State of Alaska guidelines, only one tested subsistence species (pike) warrants any potential "restrictions" in consumption. This result is not unusual, because pike is a long-lived predatory fish species, so it tends to concentrate mercury by consuming many smaller fish. Based on the average mercury level found in tested pike, women who are or can become pregnant, children under the age of 12, and nursing mothers should eat no more than 16 pike meals per month (a meal is 6 ounces, fresh weight[3]). All other people, including men, elder women and teenage boys, can enjoy unlimited meals of pike. Village residents often eat pike in a dried form. When moisture is removed, mercury is concentrated in the remaining dried fish. This is important because people tend to eat a greater quantity of dried fish at a meal as compared to when they eat them fresh. Therefore, mercury exposure is generally greater when eating dried fish. The preparation method should be taken into consideration when deciding how much pike to eat. **When following Alaska's fish consumption guidance, levels of mercury in pike are not expected to cause adverse health effects. Those choosing to restrict their consumption of pike according to these**

[3] Food preparation methods impact mercury concentration in traditional foods. For example, mercury concentrations are greater in dried fish as compared to raw or cooked because as moisture is removed, the weight of the sample decreases but the total amount of mercury stays the same. In addition, people typically consume dried fish in greater quantities than fresh or cooked fish. As a result, mercury exposure is generally greater when eating dried fish.

guidelines should know that salmon are a nutritious, low-mercury fish choice. Alaskan health officials encourage unlimited consumption of all five species of Alaskan salmon.

PCBs in Burbot Liver

We further evaluated PCBs in burbot liver because the average concentration measured (20 ppb) was above the EPA guidelines for unlimited consumption (Table 3). However, doses for both adults and children were well below levels of health concern, based on the amount of this food that was reported eaten in the dietary survey using ATSDR's minimal risk level (0.00002 mg/kg-day, Table 4). Sixty-six percent of people reported eating burbot at a median amount of one pound per year and a maximum amount of 34 pounds per year. There is no need to decrease consumption of burbot liver. **The levels of PCBs in burbot liver do not pose a health risk at the rates people reporting eating them in the dietary survey.**

Persistent Organic Pollutants (POPs) in Marine Mammals

We further evaluated POPs in marine mammal samples (beluga whale and bearded seal blubber). Marine mammals contained POPs at levels higher than EPA chronic disease health guidelines. Specifically, levels of DDTs (>52 ppb), PCBs (>5.9 ppb), and heptachlor epoxide (>3.8 ppb) were above the guidelines for unlimited consumption (Table 4). People can bioaccumulate POPs when they eat foods that contain POPs, such as marine mammals and fish.

The contaminant levels found in the single beluga whale sample are consistent with those from other Alaskan belugas[29]. The levels of POPs in marine mammals vary by age, sex and location of the animal, and the beluga sample from this project may or may not be representative of the area from which it was taken. For these and other reasons, consumption decisions should not be based on the contaminant profile of a single animal.

Hexachlorocyclohexane (HCH)

Marine mammals (beluga whale and bearded seal sample data were combined) had the highest average concentration of HCHs (10 ppb of alpha-HCH, and 13 ppb of beta-HCH). The fat in store-bought meats like chicken, turkey, beef, lamb, and pork have been noted to contain up to 32 ppb of a single form of HCH[30]. Eating market meat products may provide HCH exposures similar to those encountered from eating marine mammal muscle and blubber.

HCH occurs in three different forms (alpha, beta, and gamma). There are no health screening guidelines for summed (total of all three forms combined) HCHs. We calculated doses of alpha-HCH and beta-HCH in marine mammal samples for both children and adults, and these levels were below their respective health guidelines (Table 4; ATSDR minimal risk level: 0.008 mg/kg-day and 0.0006 mg/kg-day, respectively), as shown in Table 4. Lindane, or gamma-HCH, was detected in less than 14% of the 54 subsistence food samples (Table 2). All foods were below EPA's chronic health guideline for unlimited consumption (88 ppb lindane). Thus, **the levels of HCHs, including lindane, in subsistence foods evaluated in this study do not pose a health risk.**

DDTs

Median and maximum chronic DDT exposure doses were calculated for children and adults, using consumption information from Phase 1 of the ATDP[2] (Table 4). Calculated doses did not exceed the intermediate (no guideline for chronic exposure was available) ATSDR minimal risk level of 0.0005 mg/kg/day, so **consumption of sampled marine mammals is not expected to cause DDT-related adverse health effects**.

Heptachlor epoxide
Median and maximum exposure doses of heptachlor epoxide were calculated for children and adults, using consumption information from Phase 1 of the ATDP[2] (Table 4). Exposure doses were below the health guidelines for children or adults who eat the median quantity of marine mammals reported in the ATDP. However, heptachlor epoxide doses (0.0003 mg/kg-day and 0.00004 mg/kg-day respectively) for both children and adults based on the maximum quantity of marine mammal reported, was slightly higher than the health guideline (ATSDR minimal risk level: 0.000013 mg/kg-day) for chronic disease effects. Further evaluation revealed that this is unlikely to be of health concern because the calculated maximum exposure dose of heptachlor epoxide was more than 300 times lower than the dose that caused a health effect in laboratory animals (increased liver weight). Therefore, **consumption of sampled marine mammals is not expected to cause heptachlor epoxide-related adverse health effects at the rates people reported eating them in the dietary survey**.

Hazard Index Assessment for Effects of HCHs, DDT, and Heptachlor Epoxide on the Liver
Because HCH alpha and beta, DDT and heptachlor epoxide can all impact the liver we needed to assess potential risks from combined exposure. When exposure to chemicals with the same target organ is of concern, a hazard index (HI) should be evaluated. To do so, we used the median doses that a child and adult would be exposed to from eating foods containing these chemicals at the rates reported (Table 4). In order to calculate an HI, the dose is divided by the MRL or comparable value to determine a hazard quotient. The sum of the hazard quotients is the HI. If the quotient is greater than or equal to 0.1 for any of the chemicals, then further evaluation of additivity and interactions is necessary. The calculated HIs for both children and adults were less than 0.1 (Table 5). Therefore, **consumption of sampled marine mammals is not expected to cause adverse impacts to the liver from combined exposure to HCHs, DDT, and heptachlor epoxide.**

Polychlorinated Biphenyls (PCBs)
Median and maximum exposure doses of PCBs were calculated for children and adults, using consumption information from Phase 1 of the ATDP[2] (Table 3). The PCB exposure dose for children or adults eating the median amount of marine mammals reported was below the health guideline. However, the PCB doses for children or adults eating the greatest amount of marine mammal tissue reported (0.0004 and 0.0006 mg/kg-day, respectively) were above the health guideline (ATSDR minimal risk level: 0.00002 mg/kg-day) for chronic disease effects. Although the age of the person who reported eating the largest amount of marine mammal is unknown, it is unlikely that it was reported by a child, because these food items are typically reserved in greater amounts for elders (anecdotal information). Furthermore, it should be noted that there is a large difference between the reported median amount consumed (two pounds per year) and the highest amount consumed (272 pounds per year). In reality, the number of people actually eating the maximum amount is probably low. A person eating the maximum amount of marine mammal reported would have to eat 0.75 pounds (lbs) every day in order for their exposure dose to exceed the screening guideline. It should also be noted that the exposure doses for people eating the largest amount of marine mammal reported were about ten times lower than doses that caused subtle health effects in chronically-exposed laboratory monkeys (a change in immune response, and subtle changes in eyelids and toe/fingernails of offspring). **Consumption of sampled marine mammals is not expected to cause PCB-related adverse health effects at the median rate people reported eating them in the dietary survey.**

Bottom Line for Marine Mammal consumption
We do not recommend eating less marine mammal meat and fat because replacing these foods with market foods that are less nutritious can be harmful to your health.[8, 12] For example, the replacement of these foods with store-bought alternatives that are high in saturated fat (such as vegetable shortening, fat products from cattle and pigs, and dairy products such as butter and cheese) have increased the rates of heart disease, diabetes, and certain cancers in Alaska Natives.[8, 12] Although marine mammal samples contain some POPs, marine mammal blubber is an excellent source of retinol and omega-3 fatty acids[31]. **State of Alaska health officials recommend continued consumption of marine mammals as a healthy part of a balanced diet.**

Results for Risk Evaluations using EPA's Cancer Risk Guidelines

We compared levels of chemicals classified by the International Agency for Research on Cancer (IARC) as carcinogens and those reasonably anticipated to be carcinogens[32] in subsistence foods to EPA's cancer guidelines. Detection limits for HCB, DDT, and inorganic arsenic were below the EPA cancer health endpoint for unlimited consumption (<1.8 ppb, <8.6 ppb, and < 2 ppb, respectively), and therefore, levels of these pesticides are not a cause for cancer concern.

The levels of PCBs in burbot liver and marine mammals exceeded EPA's cancer guideline for *unlimited* consumption, so we calculated the Excess Lifetime Cancer Risk (ELCR) associated with eating these foods at the median ("average") rates people reported eating them in the dietary survey. The ELCR is defined as the excess, or additional risk of a cancer in a population as a result of exposure to that chemical. An estimated increased ELCR is not a specific estimate of expected cancers. Rather, it is a plausible upper bound estimate of the probability that a person may develop cancer sometime in his or her lifetime following exposure to that contaminant. There is general consensus among the scientific and regulatory communities on what level of estimated excess cancer risk is acceptable. An ECLR of one in one million or less is generally considered an insignificant increase in cancer risk. This value is calculated by multiplying the Exposure Dose (defined on page 7 and in the glossary) by the Cancer Slope Factor (see glossary) for that chemical. We calculated ELCRs using the median consumption rate of a food item, as opposed to the maximum consumption rate, to reflect more realistic scenarios of average daily intake by a community over a lifetime.

The ELCR, or excess cancer risk, for both children and adults who eat the median amount of burbot liver (one pound per year) containing PCBs are both less than one in one million (Table 6). In other words, the chance that someone eating one pound of burbot liver per year over a lifetime would develop cancer as a result of the PCBs in the burbot liver would be less than one in one million for both children and adults.

Similarly, adults eating the median amount of marine mammals reported in the dietary survey (two pounds per year) have a 3 in one million chance of getting cancer from eating marine mammals containing PCBs measured in this study. The ELCR for children eating the median amount of marine mammals is six in one million.

Fish roe/head (2.95 ppb) was the only sampled food that slightly exceeded EPA's cancer health guideline for lindane (2.3 ppb or less for unlimited consumption).[12] However, when excess cancer risk was determined based on the amount of these foods people reported eating in the dietary survey, the excess cancer risk was less than one in one million for both adults and children (Table 6).

The amounts of heptachlor epoxide in marine mammals, burbot liver, and king salmon eggs/sockeye head exceeded the EPA's guidance for unlimited consumption, but the calculated ECLRs were all less than one in one million for both children and adults (Table6). Therefore eating these foods is not a cause for cancer concern with respect to exposure to heptachlor epoxide.

Levels of both chlordane and dieldrin in marine mammals were also above the EPA's guidance for unlimited consumption; however, the calculated ECLRs were less than one in one million for both chemicals for both children and adults (Table 6). Therefore, eating these sampled marine mammals is not a cause for cancer concern with respect to exposure to dieldrin and chlordane.

None of the foods sampled in this study had levels of contaminants that are a cause for cancer concern for most people.

Evaluation for Village A Subsistence Foods

Village A wanted to find out whether a historical mining site might be affecting contaminant levels in fish. We do not have a record of the distance between sampling sites. If the sampling sites were too close together, we would not be able to make a valid comparison for a mobile species like fish. Fish may travel throughout a water body and therefore, overlap in habitat range (where they live and eat). A fish collected from a suspected non-contaminated area may actually reside near a potentially contaminated site. It is important to understand a fish's range when creating a sampling plan; sampling locations should be far enough apart to ensure that distinct fish populations are sampled. Without further information regarding the sampling plan, we cannot assess whether levels of contaminants in fish are associated with the old mine site.

We did analyze levels of contaminants for fish sampled near Village A separately from samples collected from other villages in order to determine if they were safe to eat. To analyze these data, statistical packages (ProUCL, EPA[33] or Minitab, State College, PA[34]) were used. When samples had contaminant concentrations below the detection limit, ProUCL was used to interpolate missing data points. The concentrations reported in this evaluation are the mean values for the data.

Fish samples collected from Village A included grayling (n=5), whitefish (n=8), rainbow trout (n=11), dolly varden (n=7) and pike (n=10). Fish from Village A were only analyzed for metals and not POPs. Cadmium was not found in any of the fish samples; lead was found in one fish sample (Table 2). As described in the section evaluating cadmium in moose liver, this level was below lead levels found in other types of store bought foods and well below the WHO and ANSI limits.

Arsenic

Dolly varden (220 ppb) and pike (167 ppb) had the highest levels of arsenic. Grayling, whitefish, and rainbow trout were all similar in arsenic levels (<61 ppb). When the proportion of inorganic arsenic is determined from this total value, levels in all fish are well below the EPA guideline for unlimited consumption. Since most arsenic in fish is in the less toxic organic forms[23], the levels found in these fish species are not of health concern. Therefore, **no ill effects are likely from eating fish from Village A with the reported arsenic levels.**

Mercury

Village A residents were concerned about getting cancer from eating fish contaminated with mercury. Mercury is not a carcinogen (a substance that causes cancer[18]). Although mercury is not a carcinogen, it is still of health concern for other reasons. For example, it can damage the developing brain. Too much mercury may affect how children behave, learn, think and solve problems[11]. There were significant differences in mercury concentrations among fish species. Mean concentrations of mercury in fish species were: pike (186 ppb), dolly varden (163 ppb), rainbow trout (125 ppb), whitefish (98 ppb), and grayling (70 ppb).

Dolly varden and pike had mercury levels above the Alaska fish consumption guideline for unlimited consumption (150 ppb, Table 3). Dolly varden, like pike, typically have higher levels of mercury because they eat other fish and are long-lived (See Figure 3). The levels of mercury observed in these fish do not indicate that mercury is coming from the old mining site because these levels are similar to those seen in these fish in other parts of the state.[11] The calculated exposure dose for the median consumer was at the Alaska health guideline for mercury in fish[11] (0.0004 mg/kg-day); however, the dose for someone eating the maximum amount of pike and dolly varden that was reported in the study was slightly above the guideline (0.0006 mg/kg-day, Table 4). State of Alaska fish consumption guidance[11] recommends that children less than 12 years old, women who are or can become pregnant, and nursing mothers limit their consumption of fish with mercury levels between 150 ppb and 320 ppb (in this case, pike and dolly varden) to four meals per week. Everyone else, including adult men, teenage boys and elders, may consume as many meals of these species as they like. Everyone can eat unlimited quantities of rainbow trout, whitefish, and grayling from Village A, which do not contain mercury at levels of health concern. **The amount of mercury found in fish from Village A is unlikely to cause ill health effects when following the State of Alaska fish consumption guidelines.**

Child Health Considerations

ATSDR focuses special attention on the health of children because they are more vulnerable to the harmful effects from contaminants than adults are. Striving to make healthy food choices for children can be a balancing act. This is especially true for Alaskan subsistence consumers, who must weigh the risk of contaminants against the important health and cultural benefits of traditional foods.

Children are dependent on adults, and caregivers should help children to identify and avoid things that may cause harm. Childhood exposures were evaluated in this health consultation to aid caregivers in decision-making regarding diet.

Children differ from adults in how they come in contact with contaminants and how their bodies remove contaminants. For example, children eat more food and breathe more air per unit of body weight than adults. These differences sometimes result in a greater relative dose of a contaminant entering the body. Also, the systems that change and remove contaminants from children are not as well developed as in adults.

Fish and other wildlife can take up environmental contaminants from the water or sediments they live in, or the foods they eat. Mercury and POPs are contaminants of concern present in fish and marine mammals. Mercury and PCBs are toxic chemicals that can damage the developing brain. Too much mercury or PCBs can affect how children behave, learn, think, and solve problems later in life. Thus, babies in the womb, nursing babies, and young children are at greatest risk for adverse health effects from mercury or PCB exposure. Adverse health effects associated with POPs exposure include hormone disruption, learning and behavior changes, immune system suppression, and cancer. It is important to remember that fish is an important part of a healthy diet for pregnant and nursing women, and young children, as the omega-3 fatty acids in fish improve maternal nutrition and brain development in unborn and young children. In addition to the direct health benefits gained from consuming omega-3 fatty acids, the exercise and cultural benefits (the passing on of tradition) of participating in subsistence activities also promote the well-being of both adults and children.

Some mothers worry about the safety of breast feeding. Although mothers can pass on PCBs to her child during breastfeeding, the levels of PCBs measured in the blood of Alaskan women in other studies has been low, and Alaska state health officials strongly encourage women to breast feed their babies[12]. Breast feeding provides optimal infant nutrition, strengthens the infant immune system, and promotes strong mother-child bonding.

In conclusion, parents should consider both the risk of contaminants and the health benefits of traditional foods when choosing foods for their children. Some may choose traditional foods that are lower in contaminants for their daily diet and choose foods with higher contaminant levels, such as marine mammal blubber, for special occasions.

Conclusions

1. Metals (arsenic, cadmium, lead, and mercury) and persistent organic pollutants (pesticides and polychlorinated biphenyls) were present at different levels in sampled foods.

2. EPHP determined that generally, if the samples collected were representative of the area from which they were taken, eating subsistence foods with these contaminant levels is not expected to harm people's health, and continues to recommend the consumption of these healthy, nutritious traditional foods as part of a balanced diet. The reasons for this conclusion are:

    - Lead was detected in only 7 out of 97 food samples. When possible blood lead levels were predicted using computer modeling, blood lead levels were not elevated, even when the most conservative (protective) exposure assumptions were used.

    - Most of the total arsenic in fish and marine mammals is in the much less toxic organic form. When this was taken into consideration (through an estimate obtained through a calculation), levels of arsenic in all foods were well below the EPA fish consumption guidelines for unlimited consumption which are based on the toxic inorganic form of arsenic.

    - Although cadmium levels in moose liver samples were above EPA health guidelines for unlimited consumption, cadmium in organ meats and other foods is not well-absorbed by the body (generally less than 10% is absorbed) and generally not eaten in large amounts.

    - Mercury levels in sampled fish species were low, except for pike. Women of child-bearing age and young children should follow the state's fish consumption guidelines for Alaska-caught fish, and limit their meals of pike to no more than 16 meals per month (if eaten fresh). All other groups, including teenage and adult males, and older women may eat pike in unlimited amounts.

- The levels of pesticides and PCBs that were tested in fish, land mammals, and birds were below EPA health guidelines for unlimited consumption. The one exception was PCBs in burbot liver. Although PCB levels in burbot liver were above EPA guidelines, dietary survey data suggest that most children and adults do not eat enough burbot liver to exceed the recommended exposure dose for PCBs.

- Although the levels of some POPs in marine mammal samples were above EPA health guidelines for unlimited consumption, they were not at levels of health concern, upon further evaluation, because:
    i. The calculated doses for exposure to the contaminant were below EPA guidelines, based on consumption data from the dietary survey for the median consumer.
    ii. Eating less marine mammal meat and fat is generally not recommended because replacing these foods with market foods that are less nutritious can be harmful to health. The health and cultural benefits of eating traditional foods outweigh the potential risks from contaminants.

3. Village A had a specific concern about whether an old mining site located upstream from the village might have contaminated local fish. Another concern was getting cancer from eating fish contaminated with mercury. Forty-one samples of five types of fish were collected upstream, downstream, and near the old mining site and tested for metals (arsenic, cadmium, lead, mercury). EPHP determined that eating fish with the contaminant levels found is not expected to harm the health of Village A residents because:

    - None of the fish samples had detectable levels of cadmium.
    - Only one fish sample contained lead.
    - Although two fish species (dolly varden and pike) had elevated levels of total arsenic, most of the arsenic in fish is in the organic form, which is much less toxic than the inorganic form of arsenic. As a result, the levels of arsenic in these fish are not of health concern.
    - Mercury levels in three fish species (rainbow trout, whitefish, and grayling) were below the Alaska fish consumption guidelines for unlimited consumption. Thus, everyone can eat unlimited amounts of these fish from Village A.
    - Two fish species (dolly varden and pike) had higher levels of mercury. However, eating dolly varden and pike from Village A is unlikely to harm health, as long as women of child-bearing age and young children limit their consumption of these fish to no more than four meals per week. Everyone else, including teenage and adult males, and older women, can eat unlimited amounts of these fish. In addition, mercury is not considered a cancer-causing agent (carcinogen).

4. EPHP could not determine whether differences in contaminant levels among fish samples collected from the three sampling locations were a result of the old mining site. Information on the distances between each of the sampling sites was not available. Two fish species (dolly varden and pike) had elevated levels of mercury, but these levels are similar to those found in dolly varden and pike from other parts of the state.

Recommendations

1. People should continue to enjoy their subsistence foods, which provide many nutritional and health benefits. Alaska health officials recommend that people eat a variety of traditional foods as part of a balanced diet.

2. Alaska health officials also recommend that everyone eat at least two fish meals per week in order to maximize the health benefits associated with fish consumption. There are no suggested consumption limits for any species of Alaskan fish advised for adult men, teenage boys, and elder women.

3. Women of child-bearing age and young children should choose the types of fish they eat wisely, following the state's fish consumption guidelines for Alaska-caught fish[11]. Choose fish high in omega-3 fatty acids and low in contaminants more often, like all five species of Alaska salmon and Alaska black cod (sablefish). Limit consumption of pike from western Alaska to no more than 16 meals per month (if eaten fresh). All other groups, including teenage and adult males, and older women can eat all species of Alaska fish, including pike, in unlimited amounts.

4. People who are concerned about cadmium exposure should not smoke cigarettes or use other tobacco products.

Public Health Action Plan

Actions planned

<u>DHSS will conduct the following outreach activities within three months of the release of this health consultation:</u>

- Share this report with participating villages and stakeholders.
- Prepare and distribute a fact sheet summarizing this report.
- Conduct an informal needs assessment with the communities to ensure that the results of the report have been disseminated appropriately, and to identify any potential health education needs or ongoing concerns.
- Conduct outreach and education activities as warranted by the needs assessment.

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Certification

This Health Consultation (Contaminants in Subsistence Foods from the Western Alaska Coast Region) was prepared by the Alaska Department of Health and Social Services, under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodology and procedures existing at the time the health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.

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

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Table 1. Food type and number of samples (n = 97) for subsistence food items collected in this study. Meat samples were muscle tissue unless otherwise noted. *Denotes a small sample size (less than 5 samples). Values reported for these foods in the following tables should be interpreted with caution because they may not be similar to levels commonly present in that food item. ¥ Denotes the 54 samples that were analyzed for both POPs and metals (all 97 samples were tested for metals). Note that only 10 of the 18 whitefish samples were analyzed for POPs.

Sample name (Number of samples)
Bearded seal blubber (4)*¥
Beluga whale (1)*¥
Beluga whale flipper (1)*¥
Caribou (2)*¥
Chum salmon (12)¥
Coho salmon (6)¥
Sockeye salmon head (1)¥
Sockeye salmon (6)¥
Dolly varden (9)
Duck (1)*¥
Grayling (5)
King salmon eggs (1)*¥
Burbot (lush) liver (2)*¥
Moose liver (5)¥
Pike (10)
Ptarmigan (1)*¥
Rainbow trout (10)
Red berries (1, type not given)*¥
Trout (1, type not given)*
Whitefish (18)¥

Table 2. Subsistence food types that had a single detection of lead, lindane, and/or mirex.

Subsistence Food Type	Number detected/Number sampled	Maximum lead level (ppb)	Maximum lindane level (ppb)	Maximum mirex level (ppb)
Whitefish muscle	1/18	**253**	< DL	< DL
Grayling muscle	1/5	**100**	NT	NT
Sockeye salmon muscle	1/6	< DL	< DL	**0.15**
Coho salmon muscle	1/6	< DL	**0.099**	< DL
Coho salmon muscle	1/6	**73**	< DL	< DL
Chum salmon muscle	1/12	< DL	**0.084**	< DL
Chum salmon muscle	1/12	< DL	**0.33**	**0.1**
Burbot (lush) liver	1/2	< DL	< DL	**0.49**
Burbot (lush) liver	1/2	< DL	**0.13**	**0.43**
King salmon eggs	1/1	< DL	**0.42**	< DL
Sockeye salmon head	1/1	**55**	**0.27**	< DL
Moose liver	1/5	**69**	< DL	< DL
Moose liver	1/5	**54**	< DL	< DL
Red berries	1/1	**55**	< DL	< DL
Beluga whale muscle	1/1	< DL	< DL	**4**
Bearded seal blubber	1/4	< DL	< DL	**2.4**
Bearded seal blubber	1/4	< DL	< DL	**2**
EPA fish advisory guidelines: non-cancer effects		NA	88	59
EPA fish advisory guidelines: cancer effects		NA	2.3	NA
ppb = parts per billion wet weight; NT = Not Tested; NA = Not Applicable; < DL means less than the detection limit (DL) amount; **Bold indicates detected contaminant.**				

Table 3. Maximum number of subsistence* meals per month calculated from fish consumption guidelines of the EPA and the State of Alaska. EPA guidelines are based on chronic health risk, and do not consider the benefits of subsistence food consumption. State of Alaska guidance is specific for mercury, and provides a balanced risk/benefit assessment.

Subsistence Food (number of samples)	Contaminant	Contaminant Level: Average (ppb)	Contaminant Level: Standard Deviation	Meals/month†: EPA	Meals/month†: AK Fish Consumption
Dolly varden (9)	arsenic	168	160	>16	NFCA
	cadmium	<50	NA	>16	
	chlordanes, DDTs, dieldrin, heptachlor epoxide, HCB, HCHs, and PCBs	NT	NA	NA	
Dolly varden/lake trout (7)	mercury	148.79	80.99	>16	>16
Grayling (5)	arsenic	34	48	>16	NFCA
	cadmium	<50	NA	>16	
	chlordanes, DDT, dieldrin, heptachlor epoxide, HCB, HCHs, and PCBs	NT	NA	NA	
	mercury	80.3	26.06	8	>16
Pike (10)	arsenic	101	108	>16	NFCA
	cadmium	<50	NA	>16	
	chlordanes, DDT, dieldrin, heptachlor epoxide, HCB, HCHs, and PCBs	NT	NA	NA	
	mercury	203.5	66.91	4	16
Rainbow trout (10)	arsenic	20	38	>16	NFCA
	cadmium	<50	NA	>16	
	chlordanes, DDT, dieldrin, heptachlor epoxide, HCB, HCHs, and PCBs	NT	NA	NA	
	mercury	41.36	60.3	16	>16

* Subsistence food is from muscle unless otherwise noted; ppb=parts per billion (ng/g); DDT= dichlorodiphenyltrichloroethane; HCB=hexachlorobenzene; HCH=hexachlorocyclohexane; PCB=polychlorinated biphenyl. † Denotes non-cancer guidelines, EPA meals are 8 ounces per meal; Alaska (AK) fish consumption based on 6 ounce meal size; NFCA=No Fish Consumption Advice is provided; NT= Not Tested; NA=Not Applicable; < = less than detection limit (DL); values <DL are treated as zero for AK Western Coast average and standard deviation; note that EPA and AK fish consumption advice does not address non-fish foods but based on the contaminant level the same advice should apply to non-fish foods. ‡ Denotes measurement for whale muscle only. ¥ Denotes the value is not an average, but a single measurement of one sample.

Table 3 (Cont'd). Maximum number of subsistence* meals per month calculated from fish consumption guidelines of the EPA and the State of Alaska. EPA guidelines are based on chronic health risk, and do not consider the benefits of subsistence food consumption. State of Alaska guidance is specific for mercury, and provides a balanced risk/benefit assessment.

Subsistence Food (number of samples)	Contaminant	Contaminant Level		Meals/month†	
		Average (ppb)	Standard Deviation	EPA	AK Fish Consumption
Salmon, chum (12)	arsenic	421	177	>16	NFCA
	cadmium	<50	NA	>16	
	chlordanes	1.32	0.93	>16	
	DDTs	2.73	1.44	>16	
	dieldrin	<DL	0.37	>16	
	heptachlor epoxide	0.12	0.12	>16	
	HCB	1.02	0.73	>16	
	HCHs	0.58	0.82	NFCA	
	mercury	13	23.56	>16	>16
	PCBs	5.63	1.93	>16	NFCA
Salmon, coho (6)	arsenic	516	189	>16	NFCA
	cadmium	<DL	NA	>16	
	chlordanes	1.43	0.72	>16	
	DDTs	3.22	3.14	>16	
	dieldrin	0.16	0.13	>16	
	heptachlor epoxide	0.08	0.08	>16	
	HCB	0.91	0.26	>16	
	HCHs	0.38	0.2	NFCA	
	mercury	69	15.14	12	>16
	PCBs	6	2.05	>16	NFCA
Salmon, sockeye (6)	arsenic	364	201	>16	NFCA
	cadmium	<DL	NA	>16	
	chlordanes	1.74	1.77	>16	
	DDTs	6	8.26	>16	
	dieldrin	0.25	0.2	>16	
	heptachlor epoxide	0.2	0.34	>16	
	HCB	0.77	0.35	>16	
	HCHs	0.3	0.34	NFCA	
	mercury	37.17	28.98	16	>16
	PCBs	6.8	5.39	16	NFCA

* Subsistence food is from muscle unless otherwise noted; ppb=parts per billion (ng/g); DDT= dichlorodiphenyltrichloroethane; HCB=hexachlorobenzene; HCH=hexachlorocyclohexane; PCB=polychlorinated biphenyl. † Denotes non-cancer guidelines, EPA meals are 8 ounces per meal; Alaska (AK) fish consumption based on 6 ounce meal size; NFCA=No Fish Consumption Advice is provided; NT= Not Tested; NA=Not Applicable; < = less than detection limit (DL); values <DL are treated as zero for AK Western Coast average and standard deviation; note that EPA and AK fish consumption advice does not address non-fish foods but based on the contaminant level the same advice should apply to non-fish foods. ‡ Denotes measurement for whale muscle only. ¥ Denotes the value is not an average, but a single measurement of one sample.

Table 3 (Cont'd). Maximum number of subsistence* meals per month calculated from fish consumption guidelines of the EPA and the State of Alaska. EPA guidelines are based on chronic, non-cancer health risk, and do not consider the benefits of subsistence food consumption. State of Alaska guidance is specific for mercury, and provides a balanced risk/benefit assessment.

Subsistence Food (number of samples)	**Contaminant**	**Contaminant Level**		**Meals/month†**	
		Average (ppb)	**Standard Deviation**	**EPA**	**AK Fish Consumption**
Land mammal/bird combined, caribou (2), ptarmigan (1), duck (1)	arsenic	<DL		>16	
	cadmium	<DL	NA	>16	
	chlordanes	<DL		>16	
	DDTs	0.05	0.1	>16	NFCA
	dieldrin	<DL	NA	>16	
	heptachlor epoxide	0.14	0.05	>16	
	HCB	0.07	0.14	>16	
	HCHs	<DL	0.14	NFCA	
	mercury	<DL	NA	>16	
	PCBs	3.38	0.75	>16	NFCA
Moose liver (5)	arsenic	<DL	NA	>16	
	cadmium	754	356	3	
	chlordanes	<DL	NA	>16	
	DDTs	0.22	0.18	>16	NFCA
	dieldrin	<DL	NA	>16	
	heptachlor epoxide	<DL	NA	>16	
	HCB	0.1	0.08	>16	
	HCHs	0.14	0.07	NFCA	
	mercury	<DL	NA	>16	
	PCBs	6.04	0.91	16	NFCA
Bearded seal, blubber (4)	arsenic	184	52	>16	
	cadmium	<DL	NA	>16	
	chlordanes	71	12.29	4	
	DDTs	51.73	29.27	8	NFCA
	dieldrin	1.93	1.01	>16	
	heptachlor epoxide	7.88	0.9	12	
	HCB	3.4	1.89	>16	
	HCHs	19.5	5.45	NFCA	
	mercury	<DL	NA	>16	
	PCBs	75.25	30.06	2	NFCA

* Subsistence food is from muscle unless otherwise noted; ppb=parts per billion (ng/g); DDT= dichlorodiphenyltrichloroethane; HCB=hexachlorobenzene; HCH=hexachlorocyclohexane; PCB=polychlorinated biphenyl. † Denotes non -cancer guidelines, EPA meals are 8 ounces per meal; Alaska (AK) fish consumption based on 6 ounce meal size; NFCA=No Fish Consumption Advice is provided; NT= Not Tested; NA=Not Applicable; < = less than detection limit (DL); values <DL are treated as zero for AK Western Coast average and standard deviation; note that EPA and AK fish consumption advice does not address non-fish foods but based on the contaminant level the same advice should apply to non-fish foods. ‡ Denotes measurement for whale muscle only. ¥ Denotes the value is not an average, but a single measurement of one sample.

Table 3 (Cont'd). Maximum number of subsistence* meals per month calculated from fish consumption guidelines of the EPA and the State of Alaska. EPA guidelines are based on chronic, non-cancer health risk, and do not consider the benefits of subsistence food consumption. State of Alaska guidance is specific for mercury, and provides a balanced risk/benefit assessment.

Subsistence Food (number of samples)	Contaminant	Contaminant Level		Meals/month†	
		Average (ppb)	**Standard Deviation**	**EPA**	**AK Fish Consumption**
Whitefish (18)	arsenic	239	453	>16	NFCA
	cadmium	<50	NA	>16	
	chlordanes	0.25	0.4	>16	
	DDTs	0.95	0.56	>16	
	dieldrin	0.08	0.12	>16	
	heptachlor epoxide	<DL	NA	> 16	
	HCB	0.48	0.42	> 16	
	HCHs	0.29	0.27	NFCA	
	mercury	72.72	68.2	12	>16
	PCBs	4.17	3.84	>16	NFCA
Burbot liver (2)	arsenic	1856	NA	>16	NFCA
	cadmium	<DL		>16	
	chlordanes	9.3		>16	
				>16	
	DDTs	10.4		>16	
	dieldrin	1.3		>16	
	heptachlor epoxide	0.55		>16	
	HCB	5		>16	
	HCHs	0.96		NFCA	
	mercury	<DL		>16	
	PCBs	20		8	NFCA
King Salmon eggs (1), Sockeye salmon head (2)	arsenic	366	NA	>16	NFCA
	cadmium	<DL		>16	
	chlordanes	3.65		>16	
	DDTs	7.26		>16	
	dieldrin	0.31		>16	
	heptachlor epoxide	0.34		>16	
	HCB	3.05		>16	
	HCHs	2.95		NFCA	
	mercury	<DL		>16	
	PCBs	11		16	NFCA

* Subsistence food is from muscle unless otherwise noted; ppb=parts per billion (ng/g); DDT= dichlorodiphenyltrichloroethane; HCB=hexachlorobenzene; HCH=hexachlorocyclohexane; PCB=polychlorinated biphenyl. † Denotes non-cancer guidelines, EPA meals are 8 ounces per meal; Alaska (AK) fish consumption based on 6 ounce meal size; NFCA=No Fish Consumption Advice is provided; NT= Not Tested; NA=Not Applicable; < = less than detection limit (DL); values <DL are treated as zero for AK Western Coast average and standard deviation; note that EPA and AK fish consumption advice does not address non-fish foods but based on the contaminant level the same advice should apply to non-fish foods. ‡ Denotes measurement for whale muscle only. ¥ Denotes the value is not an average, but a single measurement of one sample.

Table 3 (Cont'd). Maximum number of subsistence* meals per month calculated from fish consumption guidelines of the EPA and the State of Alaska. EPA guidelines are based on chronic, non-cancer health risk, and do not consider the benefits of subsistence food consumption. State of Alaska guidance is specific for mercury, and provides a balanced risk/benefit assessment

Subsistence Food (number of samples)	**Contaminant**	**Contaminant Level**		**Meals/month†**	
		Average (ppb)	**Standard Deviation**	**EPA**	**AK Fish Consumption**
Beluga whale, flipper (1), muscle (1)	arsenic	471.5	NA	>16	NFCA
	cadmium	<DL		>16	
	chlordanes	121.4‡		>16	
	DDTs	266.3‡		1	
	dieldrin	20‡		16	
	heptachlor epoxide	13‡		8	
	HCB	72‡		>16	
	HCHs	38‡		NFCA	
	mercury	110.5		8	>16
	PCBs	340‡		0.5	NFCA
Marine Mammals combined, beluga whale (2), bearded seal (4)	arsenic	1,390	830	>16	NFCA
	cadmium	<DL	NA	>16	
	chlordanes	81.1	24.9	>16	
	DDTs	94.6	99.3	4	
	dieldrin	5.6	8.1	>16	
	heptachlor epoxide	8.9	2.4	12	
	HCB	17.1	30.7	>16	
	HCHs	23.2	9.5	NFCA	
	mercury	36.83	59.47	16	>16
	PCBs	128.2	121.2	1	NFCA
Red berries (1)	arsenic	<DL ¥	NA	>16	NFCA
	cadmium	<DL ¥		>16	
	chlordanes	<DL ¥		>16	
	DDTs	<DL ¥		>16	
	dieldrin	<DL		>16	
	heptachlor epoxide	<DL ¥		>16	
	HCB	<DL ¥		>16	
	HCHs	<DL ¥		NFCA	
	mercury	<DL ¥		>16	
	PCBs	1.1¥		>16	NFCA

* Subsistence food is from muscle unless otherwise noted; ppb=parts per billion (ng/g); DDT=dichlorodiphenyltrichloroethane; HCB=hexachlorobenzene; HCH=hexachlorocyclohexane; PCB=polychlorinated biphenyl. † Denotes non-cancer guidelines, EPA meals are 8 ounces per meal; Alaska (AK) fish consumption based on 6 ounce meal size; NFCA=No Fish Consumption Advice is provided; NT= Not Tested; NA=Not Applicable; < = less than detection limit (DL); values <DL are treated as zero for AK Western Coast average and standard deviation; note that EPA and AK fish consumption advice does not address non-fish foods but based on the contaminant level the same advice should apply to non-fish foods. ‡ Denotes measurement for whale muscle only. ¥ Denotes the value is not an average, but a single measurement of one sample.

Table 4. Doses and chronic disease guidelines for contaminants in subsistence foods requiring further evaluation.

Contaminant	Person	Maximum Consumption rate (kg/d)	Maximum Dose (mg/kg-day)	Median Consumption rate (kg/d)	Median Dose (mg/kg-day)	Health Guideline (mg/kg-day)	Food Type Concentration (mg/kg)	Dose point for MRL derivation (mg/kg-day)	Effect type
Arsenic, Inorganic (calculated as 1.5% of total)	Child (1-6 yrs)	0.005776	0.000007	0.000186	0.0000003		Burbot liver, 0.0278, average	0.014	Hyperpigmentation and keratosis of the skin
	Adult (19+ yrs)	0.038524	0.000015	0.00124	0.0000005	0.0003†			
Cadmium	Child (1-6 yrs)	0.010438	0.00005	0.00037	0.000002		Moose liver, 0.754, average	0.0003	Decreased kidney function
	Adult (19+ yrs)	0.069592	0.00007	0.0025	0.000003	0.0001†			
DDT	Child (1-6 yrs)	0.049932	0.0003	0.00037	0.000002		Marine mammals, 0.09462, average	0.05	Changes to liver cells
	Adult (19+ yrs)	0.333048	0.0004	0.0025	0.000003	0.0005†			
HCH-alpha	Child (1-6 yrs)	0.049932	0.00003	0.00037	0.0000002		Marine mammals, 0.00992, average	0.8	Changes to liver tissue
	Adult (19+ yrs)	0.333048	0.00005	0.0025	0.0000004	0.008†			
HCH-beta	Child (1-6 yrs)	0.049932	0.00004	0.00037	0.0000003		Marine mammals, 0.013, average	0.18	Changes to liver cells
	Adult (19+ yrs)	0.333048	0.00006	0.0025	0.0000005	0.0006†			

D, dose = (C*IR*AF*EF)/(BW); C, concentration in milligrams (mg)/kilograms (kg); IR, intake rate from Phase I survey in kg/day; AF, absorption factor =1; EF, exposure factor = 1 except for cadmium = 0.10; BW, body weight adults = 70 kg , child (1-6 years old) =16 kg; Symbols refer to: † ATSDR minimal risk levels (MRL), *Provisional tolerable daily intake for women developed by WHO and used in Canada health assessments, ♠ Alaska specific health guideline, ♦ MRL for arochlor-1254 is used as a surrogate for PCBs. **Bold indicates a contaminant that exceeds a health guideline**. Exceeding a health guideline does not indicate that a health effect will occur, rather further evaluation is necessary. MRL (ATSDR) and RfD (EPA) are levels that pose no risk of adverse health effects for most individuals; chronic oral MRL used when available, for beta-HCH we used the intermediate MRL since there is no chronic MRL. Marine mammal concentrations are from 1 beluga whale (muscle) and 4 bearded seal (blubber) samples. DDT=dichlorodiphenyltrichloroethane; HCB=hexachlorobenzene; HCH=hexachlorocyclohexane; PCB=polychlorinated biphenyl.

Table 4 (Cont'd) Doses and chronic disease guidelines for contaminants in subsistence foods requiring further evaluation.

Contaminant	Person	Maximum Consumption Rate (kg/d)	Maximum Dose (mg/kg-day)	Median Consumption Rate (kg/d)	Median Dose (mg/kg-day)	Health Guideline (mg/kg-day)	Food, Concentration (mg/kg), Type	Dose point for MRL derivation (mg/kg-day)	Effect type
Heptachlor epoxide	Child (1-6 yrs)	0.049932	**0.00003**	0.00037	0.0000002		Marine mammals, 0.0089, average	0.0125	Increased liver weight
	Adult (19+ yrs)	0.333048	**0.00004**	0.0025	0.0000003	**0.000013•**			
Lead	Child (1-6 yrs)	0.027947	0.00044	0.00056	0.000009		Whitefish, 0.253, maximum	NA	Neurodevelopmental
	Adult (19+ yrs)	0.186408	0.00067	0.00373	0.00001	0.0228*			
Mercury	Child (1-6 yrs)	0.072476	0.0009	0.00056	0.000007		Pike, 0.2035, average	0.0013 (in fetus)	Neurodevelopmental
	Adult (19+ yrs)	0.483417	**0.0014**	0.00373	0.00001	**0.0004♠**			
PCBs	Child (1-6 yrs)	0.005776	0.000007	0.000186	0.0000002		Burbot liver, 1.856, average	0.005	Decreased antibody response; eyelid and toe/ fingernail changes in offspring
	Adult (19+ yrs)	0.038524	0.000011	0.00124	0.0000004	0.00002†♦			
PCBs	Child (1-6 yrs)	0.049932	**0.0004**	0.00037	0.000003		Marine Mammals, 0.128, average	0.005	Decreased antibody response; eyelid and toe/ fingernail changes in offspring
	Adult (19+ yrs)	0.333048	**0.0006**	0.0025	0.000005	**0.00002†♦**			

D, dose = (C*IR*AF*EF)/(BW); C, concentration in milligrams (mg)/kilograms (kg); IR, intake rate from Phase I survey in kg/day; AF, absorption factor =1; EF, exposure factor = 1 except for cadmium = 0.10; BW, body weight adults = 70 kg, child (1-6 years old) =16 kg; Symbols refer to: † ATSDR minimal risk levels (MRL); • EPA RfD; *Provisional tolerable daily intake for women developed by WHO and used in Canada health assessments, ♠ Alaska specific health guideline, ♦ MRL for arochlor-1254 is used as a surrogate for PCBs. **Bold indicates a contaminant that exceeds a health guideline**. Exceeding a health guideline does not indicate that a health effect will occur, rather further evaluation is necessary. MRL (ATSDR) and RfD (EPA) are levels that pose no risk of adverse health effects for most individuals; chronic oral MRL used when available, for beta-HCH we used the intermediate MRL since there is no chronic MRL. Marine mammal concentrations are from 1 beluga whale (muscle) and 4 bearded seal (blubber) samples. DDT=dichlorodiphenyltrichloroethane; HCB=hexachlorocyclobenzene; HCH=hexachlorohexane; PCB=polychlorinated biphenyl.

Table 5 Hazard Index Calculations for Target Organ Liver

Contaminant	Person	Median Dose (mg/kg-day)	Health Guideline (mg/kg-day)	Hazard Quotient (unitless)
DDT	Child (1-6 yrs)	0.000002	0.0005†	0.004
	Adult (19+ yrs)	0.000003		0.006
HCH-alpha	Child (1-6 yrs)	0.0000002	0.008†	0.00003
	Adult (19+ yrs)	0.0000004		0.00005
HCH-beta	Child (1-6 yrs)	0.0000003	0.0006†	0.0005
	Adult (19+ yrs)	0.0000005		0.0008
Heptachlor epoxide	Child (1-6 yrs)	0.0000002	0.000013•	0.02
	Adult (19+ yrs)	0.0000003		0.02

Dose = (C*IR*AF*EF)/(BW); C, concentration in milligrams (mg)/kilograms (kg);
IR, intake rate from Phase I survey in kg/day; AF, absorption factor =1; yrs= years
EF, exposure factor = 1; BW, body weight adults = 70 kg, child (1-6 years old) = 16 kg;
DDT=dichlorodiphenyltrichloroethane; HCH=hexachlorohexane,
Symbols refer to: † ATSDR minimal risk levels (MRL); • EPA Reference Dose

Table 6 Doses and Excess Lifetime Cancer Risk for Carcinogens and Suspected Carcinogens.

Contaminant	Person	Median Consumption Rate (kg/d)	Median Dose (mg/kg-day)	Food, Concentration (mg/kg), Type	Cancer Slope Factor (mg/kg-day)-1	ELCR (unitless)
Heptachlor epoxide	Child (1-6 yrs) Adult (19+ yrs)	0.00037 0.0025	0.0000002 0.0000003	Marine mammals, 0.0089, average	9.1	2 in 1million 1 in 1 million
Heptachlor epoxide	Child (1-6 yrs) Adult (19+ yrs)	0.000186 0.00124	0.000000006 0.0000000001	Burbot liver, 1.856, average	9.1	6 in 100 million 8 in 100 million
Heptachlor epoxide	Child (1-6 yrs) Adult (19+ yrs)	0.00056 0.00373	0.00000001 0.00000002	Eggs/head, 0.34, average	9.1	1 in 10 million 2 in 10 million
PCBs	Child (1-6 yrs) Adult (19+ yrs)	0.000186 0.00124	0.0000002 0.0000004	Burbot liver, 1.856, average	2.0	7 in 10 million 4 in 100 million
PCBs	Child (1-6 yrs) Adult (19+ yrs)	0.00037 0.0025	0.000003 0.000005	Marine mammals, 0.128, average	2.0	6 in 1 million 3 in 1 million
Chlordane	Child (1-6 yrs) Adult (19+ yrs)	0.00037 0.0025	0.000002 0.000003	Marine mammals, 8.1, average	0.35	7 in 10 million 1 in 1 million

D, dose = (C*IR*AF*EF)/(BW); C, concentration in milligrams (mg)/kilograms (kg); IR, intake rate from Phase I survey in kg/day; AF, absorption factor =1; EF, exposure factor = 1 except for cadmium = 0.10; BW, body weight adults = 70 kg , child (1-6 years old) =16 kg; ECLR, excess lifetime cancer risk; PCB=polychlorinated biphenyl.

Table 6 (Cont'd) Doses and Excess Lifetime Cancer Risk for Carcinogens and Suspected Carcinogens.

Contaminant	Person	Median Consumption Rate (kg/d)	Median Dose (mg/kg-day)	Food, Concentration (mg/kg), Type	Cancer Slope Factor (mg/kg-day)-1	ELCR (unitless)
Dieldrin	Child (1-6 yrs) Adult (19+ yrs)	0.00037 0.0025	0.0000001 0.000003	Marine mammals, 0.56, average	16	2 in 1 million 3 in 1 million
Lindane	Child (1-6 yrs) Adult (19+ yrs)	0.00056 0.00373	0.0000001 0.0000001	King salmon eggs/Sockeye head, 2.9, average	1.3	1 in 10 million 2 in 10 million

D, dose = (C*IR*AF*EF)/(BW); C, concentration in milligrams (mg)/kilograms (kg); IR, intake rate from Phase I survey in kg/day; AF, absorption factor =1; EF, exposure factor = 1 except for cadmium = 0.10; BW, body weight adults = 70 kg , child (1-6 years old) =16 kg; ECLR, excess lifetime cancer risk.

APPENDIX A

Calculating a Dose (micrograms per kilogram per day, µg/kg-day):
The concentration (in mg/kg = ppm) of the analyte (chemical) is multiplied by intake rate (milligrams eaten), bioavailability factor (amount absorbed), exposure factor (amount of contact), and a Conversion Factor (in this case 0.001 $kg \cdot \mu g/mg^2$). This number is then divided by an estimated body weight. The equation looks like this:

D, Dose = (concentration)(milligrams eaten) (amount absorbed)(exposure factor)(conversion factor)
Body Weight in kg

A range of doses are possible because different values can be used in the equation. For example, the concentration of the contaminant is not always the same in each sample nor is the amount of food eaten. The amount that a person eats or weighs will also be different. A child between the ages of 1 and 6 years may have an estimated weight of 16 kg while an adult may be estimated to weigh 70 kg. The different values used in the equation will result in several doses by concentration and age. We used a bioavailability factor of 1.

Calculating a Rate (micrograms per day, µg/day):
Doses can be changed to daily rates by multiplying the dose by body weight. This process will effectively remove the weight value in the result. For example, the chromium concentration observed in children between the ages of 7-19 years old is 1.26 µg/kg-day and the assumed weight of these children is 48 kg. 1.26 µg/kg-day multiplied by 48 kg = 60.5 µg/day.

R, Rate = (dose in µg/kg-day)(body weight in kg) = µg/day

Calculating a Blood Lead Level from Environmental Data[21]:
The concentration of lead for the different media is multiplied by media-specific slope factor (m) and the relative time spent (T). Using the equation:

PbB, blood lead level = $(m_s*T*Pb_{s)}+(m_d*T*Pb_d)+(m_w*T*Pb_w)+(m_{ao}*T*Pb_{ao})+(m_{ai}*T*Pb_{ai})+(m_f*T*Pb_f)$

m = respective slope factor for specific media
T = relative time spent
Pb_s = soil lead concentration
Pb_d = dust lead concentration
Pb_w = water lead concentration
Pb_{ao} = outside air lead concentration
Pb_{ai} = inside air lead concentration
Pb_f = food lead concentration

Table A1. Contribution to Blood Lead (PbB)[21]									
Adult					**Child 1-18 years**				
Media	**Concentration (mg/kg)**	**Relative Time Spent (T)**	**Slope Factor (m)**	**PbB (µg/dL)**	**Media**	**Concentration (mg/kg)**	**Relative Time Spent (T)**	**Slope Factor (m)**	**PbB (µg/dL)**
Outdoor Air	0.2	1	1.92	0.38	Outdoor Air	0.2	1	1.92	0.38
Indoor Air	0.06	1	1.92	0.12	Indoor Air	0.06	1	1.92	0.12
		1					1		
Food	0.253	1	0.034	0.01	Food	0.253	1	0.24	0.06
Water	4	1	0.06	0.24	Water	4	1	0.26	1.04
Soil	70	1	0.003	0.21	Soil	70	1	0.0068	0.48
		1					1		
Dust	70	1	0.0096	0.67	Dust	70	1	0.00718	0.50
Total Predicted PbB (µg/dL)				**1.63**					**2.58**
PbB = (m*T*Pb); Total predicted PbB = sum of all PbB; mg/kg = milligrams/kg; µg /dL = micrograms/deciliter.									

Glossary

Acute Exposure	Contact with a substance that occurs once or for only a short time (up to 14 days).
Alaska Department of Health and Social Services (DHSS)	Alaska state government agency with the mission to promote and protect the health and well-being of all Alaskans.
Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.
Cancer Effect Level (CEL)	The lowest dose level observed to produce a significant increase in the incidence of cancer or tumors (as shown in human epidemiologic or experimental animal studies).
Cancer Slope Factor (CSF)	A number assigned to a cancer-causing chemical that is used to estimate its ability to cause cancer in humans.
Chronic exposure	Contact with a substance that occurs over a long time (more than 1 year).
Comparison value (CV)	Concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. These may also be doses (an amount per unit time) that are unlikely to cause harmful adverse health effects.
Consumption	The act of eating, drinking, or otherwise ingesting something.
Contaminant	A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.
Dose	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure.
Environmental Protection Agency (EPA)	United States Environmental Protection Agency. The mission of the Environmental Protection Agency is to protect human health and the environment.

Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be acute (14 days or less), intermediate (15-364 days) or chronic (365 days or more).
Exposure Dose	How much of a substance is encountered in the environment but it is not necessarily the amount that is absorbed.
Exposure Duration (ED)	The amount of time, in years, that a person is exposed to a contaminant.
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 (IR)	The amount of an environmental medium that could be ingested typically on a daily basis.
Intermediate Duration Exposure	Contact with a substance that occurs for more than 14 days and less than a year.
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), non-cancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic).
Reference Dose (RfD)	An amount of chemical that can be ingested daily over the course of a lifetime and not cause serious adverse health effects. RfDs are calculated and published by EPA.

References

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