Health Consultation

EVALUATION OF SEAFOOD AND PLANT DATA
COLLECTED FROM COOK INLET NEAR THE NATIVE VILLAGES OF
PORT GRAHAM, NANWALKE, SELDOVIA, AND TYONEK, ALASKA

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

Health Consultation: A Note of Explanation

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

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

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HEALTH CONSULTATION

EVALUATION OF SEAFOOD AND PLANT DATA COLLECTED FROM COOK INLIET NEAR THE NATIVE VILLAGES OF PORT GRAHAM, NEANWALEK, SELDOVIA, AND TYONEK, ALASKA

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Agency for Toxic Substances and Disease Registry

Table of Contents

Summary

Introduction

The native villages of Port Graham, Nanwalek, Seldovia, and Tyonek requested that ATSDR evaluate whether or not eating traditional foods could harm their health. The Agency for Toxic Substances and Disease Registry (ATSDR) is committed to helping Native Alaskans protect their native foods and culture.

ATSDR reviewed seafood and plant data collected by the U.S. Environmental Protection Agency (EPA), the Alaska Department of Environmental Conservation (ADEC), and the Environmental Monitoring Program (EMP). Environmental data were available on salmon and other saltwater fish, mussels, clams, snail, chiton (badarki), octopus, kelp, seaweed, and goose tongue.

Metals, pesticides, polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH), and one dioxin compound were detected in native foods from Cook Inlet. Small amounts of chemicals were found in many native foods, often at levels that are found in fish from other parts of Alaska and from grocery stores in the U.S.

CONCLUSIONS

ATSDR reached five important conclusions in the health consultation.

Conclusion 1

ATSDR concludes that lead in chiton (badarki) could harm children's health. Preschool and elementary-age children should only eat 3 ounces or less of chiton a week to help prevent high blood lead levels. Adults eating chiton are not at risk of high blood lead levels because adults absorb less lead from food than children. The small amount of lead found in other native foods will not cause elevated blood lead levels in children or adults.

Basis for Decision

Eating 3 or more ounces of chiton a week could raise blood lead levels in preschool and elementary-age children and could result in the following harmful effects:

- small decreases in IQ,
- reduced attention span,
- decreased height,
- small delays in puberty,
- small changes in kidney function, and
- an increase in attention deficit hyperactivity disorder,

It should be noted that a blood lead survey of children from the Village of Port Graham in 1994 did not find any children with blood lead levels above 10 micrograms per deciliter (µg/dL), the Centers for Disease Control and Prevention's action level for case management.

Continued on next page

Summary, Continued

Next Steps

1. Parents concerned about their children's blood lead levels should have them tested at their local health clinic.
2. Parents can find health prevention information about how to avoid lead exposures in children at their local clinics.
3. Information about the state's lead surveillance program is available at this website: http://www.epi.hss.state.ak.us/eh/default.stm or you may contact a staff person at the state's lead surveillance program at 907-269-8000.

Conclusion 2

ATSDR concludes that the other chemicals detected in native foods from Cook Inlet and evaluated in this health consultation are not expected to harm people's health.

Basis for Decision

Metals, pesticides, PCBs, one dioxin compound, and PAHs were detected in native foods from Cook Inlet in small amounts. The chemical levels were often at levels that are found in fish from other parts of Alaska and from grocery stores in the U.S. ATSDR's conclusion concerning these chemicals was reached because (a) the amount of exposure from eating fish and native foods was below levels of health concern or (b) in some cases, the chemicals were found occasionally in just a few samples.

Next Steps

1. Villages are encouraged to keep a dietary journal about native foods throughout the year. Future sampling of fish in Cook Inlet for human health-related purposes should target specific parts of native fish, such as eggs and liver, which are important to traditional dietary customs of Alaskan Natives.

2. The State of Alaska provides much information about the health benefits and risk of consuming native foods. Comprehensive reviews of polychlorinated biphenyls and mercury along with fish consumption advice for Alaskans are available at this State of Alaska website: http://www.epi.hss.state.ak.us/eh/subsistence.htm.

Continued on next page

Summary, Continued

Conclusion 3

ATSDR concludes that eating fish and other native foods is not expected to cause a noticeable increase in cancer.

Basis for Decision

Several chemicals that are known to cause cancer in humans or animals, such as arsenic, certain pesticides, certain polycyclic aromatic hydrocarbons, and Aroclor 1260 were infrequently detected and when detected were only at low levels in some native foods.

Most village residents eat about one fish meal a day along with small amounts of other native foods, such as mussels, clams, chiton, snail, octopus, and plants. A range of theoretical excess cancer risks was calculated for these chemicals depending upon how much native food people eat. For every 100,000 residents who eat one fish meal daily, the total cancer risk from all pesticides is increased above background by 0 to 3 cases. The cancer risk is slightly higher for village residents who eat 2 fish meals daily.

The risk of cancer from these chemicals in native food is very low and could be zero. Stated another way, the risk of <u>not</u> getting cancer from eating native foods is 99.997%. This cancer risk is similar to the risk that can be calculated for eating the same amount of fish from other parts of Alaska and from fish purchased from grocery stores in the U.S.

Conclusion 4

ATSDR cannot currently conclude whether eating eggs and organs from Cook Inlet fish could harm people's health.

Basis for Decision

There was not enough information on chemicals in eggs and organs, such as liver and kidney to make a decision about health effects in humans.

Next Steps

Future sampling of fish in Cook Inlet for human health-related purposes should target specific parts of native fish, such as eggs and liver, which are important to traditional dietary customs of Alaskan Natives**.**

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Summary, Continued

Conclusion 5	ATSDR could not adequately evaluate several polycyclic aromatic hydrocarbons (PAHs) that were detected in some seafood samples because very little information is available about their harmful effects.
Next Steps	Until more research is conducted on these PAHs, ATSDR cannot determine whether these PAHs could harm people's health. ATSDR will provide the findings of this health consultation to the village chiefs for Port Graham, Nanwalek, Seldovia, and Tyonek; the State of Alaska; and the EPA.
For More Information	If you have concerns about your health, you should contact your health care provider. For more information about chemicals in native foods, you should contact ATSDR at 1-800-CDC-INFO (1-800-232-4636) and ask to be transferred to Dr. David Mellard.

Statement of Issues

In 2003, the Native Villages of Port Graham, Nanwalek, Seldovia, and Tyonek requested assistance from ATSDR to evaluate the public health implications of contaminants present in traditional foods consumed by village residents in the Cook Inlet area. Of particular concern were contaminants potentially released from oil and gas operations into Cook Inlet. The residents of these and several other native villages along Cook Inlet rely on its wide variety of fish, wildlife, and plant resources in Cook Inlet to support subsistence diets, customs, and lifestyles. These natural resources also support local industries, such as commercial fishing, seafood processing, sport fishing, and tourism.

The initial scope of this consultation was to evaluate data reported by the U.S. Environmental Protection Agency (EPA) (USEPA 2000a, 2003) for whole fish, mussel/clam, other invertebrate, and plant samples collected from Cook Inlet. To provide a better perspective on contaminant exposures, we also included data reported by the Alaska Department of Environmental Conservation (ADEC) for fish fillet samples (ADEC 2005a). In addition, we reviewed data reported by Lees *et al*. for clam/mussel samples collected by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) during their Environmental Monitoring Program (EMP) (Lees 1999, 2001).

ATSDR also listened to concerns expressed by village residents, and met regularly with residents and village leaders in person or by telephone and email. ATSDR and the Alaskan Native Health Board assisted the native Village of Port Graham in developing a survey to determine traditional foods eaten by residents. ATSDR conducted a data analysis of the survey results and provided the village with the data analysis report. We recognize that native Alaskans have a keen interest in their environment and the changes that are occurring in it, including concerns about impacts to plants and animals used as traditional subsistence foods (Kruse et al. 2004).

Background

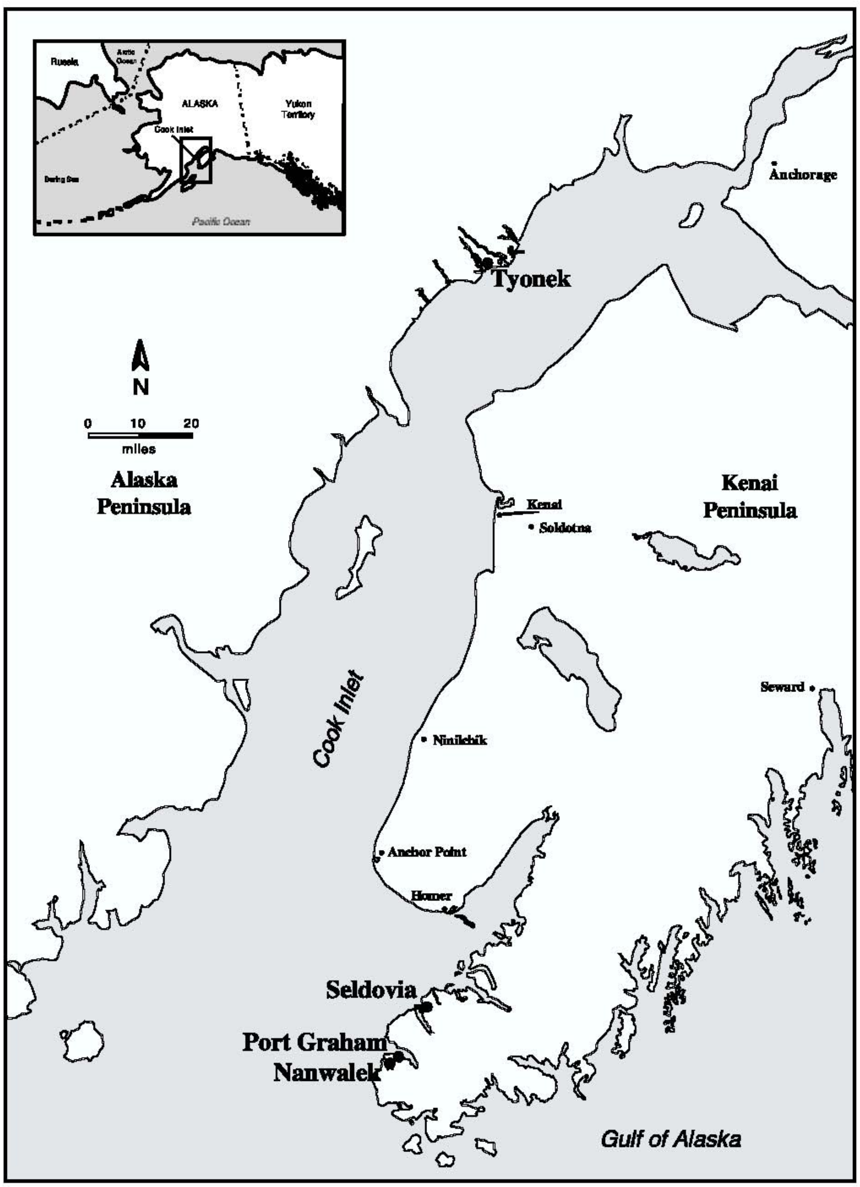
Cook Inlet is a large tidal estuary in south-central Alaska that connects to the Gulf of Alaska. It extends northeast from the Gulf of Alaska along the south-central Alaskan coast between the Kenai and Alaska Peninsulas (USEPA 2003). The inlet is about 170 miles long. It varies from 12-56 miles in width. Cook Inlet is divided into three regions: the head (Knik and Turnagain Arms), upper Cook Inlet (West Forelands to Point Woronzof), and lower Cook Inlet (West Forelands to the Gulf of Alaska) (ADL 1998).

Cook Inlet water depths range from 65–165 feet along the northern (upper) inlet to as deep as 490 feet in the southern (lower) inlet. Rapid currents associated with large tides, reported at speeds as high as 12 knots in some areas, strongly influence water circulation in Cook Inlet and appear to cause contaminant and debris mixing (MMS 2003). These currents can form migrating sand waves, and transport and deposit large amounts of eroding glacial sediments from surrounding mountains. According to the Mineral Management Service (MMS), 90 percent of contaminants currently present in Cook Inlet will be flushed out of the inlet over a 10-month period because of the strong currents. At least 23 rivers and streams empty an average rate of

2,223 cubic meters per second (m^3/sec) of freshwater into Cook Inlet annually. The Susitna River discharges more than half of this volume (MMS 2003).

The village of Tyonek is located along the northwest shore of upper Cook Inlet. Seldovia, Port Graham, and Nanwalek are located along the southwest portion of the Kenai Peninsula in lower Cook Inlet (Figure 1). Other native villages include Knik and Eklutna, which are located on the shores of the Knik arm at the head of Cook Inlet. The native villages of Kenaitze, Salamatoff, and Ninilchik are located on the upper portion of the Kenai Peninsula along the eastern shores of lower Cook Inlet. Native villages from the Iliamna, the Alaska Peninsula, and Kodiak Island also depend on subsistence resources from Cook Inlet.

Figure 1. Cook Inlet, Alaska



Source: USEPA 2003

Potential Contamination Sources

On and offshore oil and gas activities occur primarily in state and federal lease areas in the upper portions of Cook Inlet, where a total of 15 multi-well platforms are located. Thirteen of these platforms were productive in 1996, and had a combined average daily production of 37,400 barrels of oil and 385 million cubic feet of gas (USEPA 1996a). Since drilling operations began in the 1960s, off-shore drilling for oil and gas in Cook Inlet has generated more than 1,030 million barrels of oil and 978 million barrels of treated wastewater. As recently as 2002, 15 oil production platforms and one gas production platform were active in upper Cook Inlet.

Discharges from these facilities are authorized through National Pollutant Discharge Elimination System (NPEDES) permits issued by EPA pursuant to the Clean Water Act section 402 and Effluent Limitation Guidelines (ELGs) for coastal oil and gas point sources promulgated at 40 CFR Part 435 subpart D.

Five of the Cook Inlet platforms separate and treat production fluids (i.e., oil, gas, and water) at the platform and discharge production water directly to Cook Inlet. The remaining eight platforms pipe production fluids to three shore-based facilities (Granite Point, Trading Bay, and East Foreland) for separation and treatment. Production water from these three shore-based facilities is discharged to Cook Inlet following treatment. Trading Bay and East Foreland discharge treated water directly from the on-shore facility. Granite Point pipes treated production water back to a platform for discharge (USEPA 1996a). These three facilities treat and discharge 96 percent of the production water generated from all platforms in Cook Inlet (USEPA 1996a).

Contaminants generated from these operations have primarily entered Cook Inlet through treated wastewaters and drilling mud released directly from off-shore platforms or on-shore production facilities. Chemicals found in treated wastewater and drilling mud include oil, grease, mercury, cadmium, barium sulfite, and chemical additives such as flocculants, oxygen scavengers, biocides, cleansers, and scale corrosion inhibitors. About 253 tons of oil are discharged into Cook Inlet from treated wastewaters each year (MMS 2003).

Tyonek is within 10 miles from the nearest oil and gas operation in Cook Inlet. Seldovia is 117 miles from the closest platform. Nanwalek and Port Graham are located about 128 miles from the nearest platform (USEPA 2000a, 2003).

Cook Inlet also receives an average of 182.4 thousand cubic meters per day (m^3/d) of wastewater from 10 municipalities, and roughly 2.52–8.58 million kilograms (kg) of discarded organic matter from seafood processors during the fishing season (MMS 2003).

Studies of Cook Inlet Native Foods

EPA Survey of Chemical Contaminants in Fish, Invertebrates, and Plants—1997

EPA collected whole fish, mussels/clams, other invertebrates (i.e., snail, chiton, and octopus) and plants (i.e., kelp, seaweed, and goose tongue) from Cook Inlet in 1997 (USEPA 2000a, 2003). Fish samples were composites of multiple whole-fish specimens (including gut contents) of the same species. Mussel/clam, snail, and chiton samples were composites of the edible part (no shells) from the same type of animal. Three individual octopus samples were analyzed. Because results were comparable with other invertebrates, octopus results were combined with the other invertebrate biota group (snail, chiton) for this health consultation. Plant samples consisted of edible portions (bulbs or blades) from multiple specimens of the same type of plant. To the extent possible, composite samples were limited to one species. Mixing of species may have inadvertently occurred with clam samples, but is not considered to be a major concern for the purposes of this health consultation. Average contaminant concentrations for Cook Inlet biota samples are provided in Tables 1, 2, and 3.

ADEC Fish Monitoring Study--2002

Between June and August 2002, ADEC collected 65 fish, which included Pacific cod, Chinook salmon, pink salmon, chum salmon, red salmon, silver salmon, pollock, and halibut, from lower Cook Inlet. Skinless fillets and halibut roasts from 47 fish were analyzed for heavy metals (arsenic, cadmium, chromium, lead, nickel, selenium, and methylmercury). Fillets from six Chinook salmon were also analyzed for pesticides, dioxins, and polychlorinated biphenyls (PCBs). Analytical results were subject to varying degrees of data validation. ADEC Environmental Health Laboratory informally validated the metals data. A third party contractor—AXYS Laboratories in Sydney, British Columbia—formally validated pesticides, dioxins, and PCBs data. According to ADEC, the informal metals data validation may have limitations, but the extent of these limitations is not known. Tables 2 and 3 list the contaminant levels detected in fish from Cook Inlet by ADEC in 2002 (ADEC 2005a).

CIRCAC Environmental Monitoring Program (EMP)--1993, 1996, 2000

In 1993, CIRCAC began a series of preliminary studies to assess impacts of oil and gas operations on Cook Inlet. Initial studies traced the movement of contaminants discharged by oil and gas industry operations through the environment. Only a small number of marine tissues were collected for analysis. Subsequently, CIRCAC collected samples in 1996 and 2000.

In 1993 and 1996, total polycyclic aromatic hydrocarbons (PAHs) were measured in mussels (*Mytilus trossulus*) and deposit-feeding clams (*Macoma balthica*) from seven locations in Cook Inlet and one location in Shelikof Strait. In 1993, samples were collected from subtidal sediments near oil and gas facilities or sediment depositional areas in upper Cook Inlet. Mussels were suspended in cages in the water column for 30 days in Trading Bay and near the Beluga River prior to analysis, and deposit-feeding clams were sampled from Kachemak Bay and Kamisha Bay. In 1996, mussels from Shelikof Strait and deposit-feeding clams from Cook Inlet at Tuxedni Bay and Chinitna Bay were collected from intertidal sediments (Lees 1999).

In 2000, PAH concentrations were measured in 3 razor clams (*Siliqua patula*), 2 mussels, and 3 deposit-feeding clams from the east side of upper Cook Inlet (Clam Gulch, Kalifornsky Bay, Bishop Creek, and Chickaloon Bay); 4 soft shell clams (*Mya arenaria*), 1 razor clam, and 2 deposit-feeding clams from the middle of upper Cook Inlet (Oldmans Bay and Kalgin Island); and 5 deposit-feeding clams, 1 mussel, 2 razor clams, and 1 softshell clam from the west side of upper Cook Inlet (Tuxedni Bay, Redoubt Creek, and West Foreland). All samples were collected from intertidal sediments (Lees 2001).

PAH concentrations in bivalves collected during 1993 and 1996, ranged from 29.4 to 534.3 parts per billion (ppb) dry weight. In both 1993 and 1996, results for the majority of samples were reported as below detection limits. Only one 1993 sample contained PAH concentrations above 100 ppb—a caged mussel from Trading Bay reported at 163 ppb dry weight. Higher levels (132.2–534.3 ppb dry weight) were reported in 1996. Lees et al. attributed differences in PAH levels observed between 1993 and 1996 to result from significant changes in sampling and analytical methodology, and to differences between subtidal and intertidal habitats (Lees 1999).

Lees et al. reported PAHs ranging from 84–960 ppb along the east side of upper Cook Inlet (results reported as below detection limits in 6 of 8 samples), 50–220 ppb along the middle of upper Cook Inlet (below detection limits in 3 of 7 samples), and 24–1,300 ppb along the west side of upper Cook Inlet (results reported as below detection limits in 1 of 9 samples) (Lees 2001).

Table 1. Average Chemical Concentrations in Seafood and Plants Collected From Cook Inlet by EPA or ADEC

Chemicals	ADEC 2005a	EPA 2003			
	Fish Fillets ppb	Whole Fish (All species Combined) ppb*	Mussels/ Clams ppb	Other Inverte-brates ppb	Plants ppb
Aroclor 1260	NS	1.79	ND	ND	ND
PCB Congener 77	0.00489	0.0046	0.0096	ND	ND
PCB Congener 105	0.094	0.166	ND	ND	ND
PCB Congener 118	0.317	0.251	ND	0.024	0.045
PCB Congener 123	0.006	0.043	ND	ND	ND
PCB Congener 156	0.022	0.025	ND	ND	ND
PCB Congener 167	0.013	0.026	ND	ND	ND
PCB Congener 170	0.031	0.073	ND	0.023	ND
PCB Congener 180	0.114	0.203	ND	0.050	ND
Dioxin (OCDD)	0.00046	0.005	ND	ND	ND
Total PAHs	NS	75	10	17	51
Chlordane	0.999 (cis+trans)	2.975	ND	ND	ND
DDD Isomers	0.22 (o,p)	0.578	ND	ND	0.218
DDE Isomers	4.04	3.784	ND	ND	ND
DDT isomers	1.146	1.309	ND	ND	ND
Total DDT (DDD, DDE, DDT)	NR	5,275	ND	ND	NR
Dieldrin	0.532	0.343	ND	ND	ND
Endosulfan	ND	0.224	ND	ND	ND
Endrin	0.138	0.381	ND	0.266	ND
Heptachlor epoxide	0.315	0.099	ND	0.207	ND
Hexachlorobenzene (HCB)	1.506	1.142	0.301	0.624	ND
Lindane (gamma-HCH)	0.121	0.114	ND	ND	0.165
Mirex	0.067	0.162	ND	ND	ND
Total Arsenic	7,125 (cod) 2,056 (all)	1,477	2,341	2,529	2,715
Inorganic Arsenic (3+)	NS	1	8	17	3.7
Dimethyl arsenic acid (DMA)	NS	43	112	70	113
Monomethyl arsenic acid (MMA)	NS	13	ND	ND	ND
Barium	NS	472	565	426	238
Cadmium	8 (chum) 4.7 (all)	59	236	2,128	406
Chromium	62 (cod) 20 (all)	599	756	182	392
Lead	31 (halibut) 22 (all)	24	41	32 225(chiton)	12
Total Mercury	NS	34.5	13.4	ND	ND
Methylmercury	101 (halibut)	34.6	3.94	5.14	ND
Selenium		523	334	364	77

To calculate averages for the EPA and ADEC data, non-detects were substituted with a value equal to half the detection limit (USEPA 2003, ADEC 2005a).
* ppb = parts per billion (e.g., 1 ppb chlordane = 1 part chlordane for every billion parts of fish)
ND = not detected
NS = not sampled
NR = not reported

Table 2. Concentrations of Pesticides, Dioxins, and PCBs in Chinook Salmon Fillets from Cook Inlet (ppb, ug/kg wet weight)

Chemical	Min ppb	Max ppb	Average[1] ppb	Detects	CV ppb	Chemical	Min ppb	Max ppb	Average ppb	Detects	CV[2] ppb
Chinook Salmon Skinless Fillets (Homer Spit)[3,4]											
Aldrin	ND	ND	0.05	ND	NA	HCB	0.898	1.82	1.506	6	0.0018(c)
cis-Chlordane	0.448	0.86	0.741	6	0.0084(c)	α-HCH	0.357	1.84	0.948	6	NA
Trans-Chlordane	0.183	0.32	0.258	6	NA	β-HCH	0.401	0.987	0.468	4	NA
o,p'-DDD	0.113	0.377	0.22	6	NA	γ-HCH	0.341	0.341	0.121	1	0.0023(c)
o,p'-DDE	0.129	0.273	0.187	5	NA	δ-HCH	0.22	0.22	0.115	1	NA
p,p'-DDE	1.94	5.39	3.853	6	NA	Heptachlor	ND	ND	0.128	ND	NA
o,p'-DDT	0.284	0.83	0.579	6	0.0086(c)	Heptachlor Epoxide	0.157	0.428	0.315	6	0.00032(c)
p,p'-DDT	0.255	0.693	0.567	6	0.0086(c)	Hexachlorobutadiene	ND	ND	0.019	ND	NA
Dieldrin	0.271	0.77	0.532	6	0.00018(c)	Methoxychlor	ND	ND	0.403	ND	NA
Dioxin/Furan TEQ[5]	1.05E-05	2.85E-05	1.77E-05	6	0.019(c)	Mirex	0.081	0.098	0.067	4	0.059(nc)
α-Endosulphan	ND	ND	0.033	ND	1.8	cis-Nonachlor	0.207	0.316	0.285	6	NA
β-Endosulphan	ND	ND	0.071	ND	1.8	trans-Nonachlor	0.73	1.09	0.984	6	NA
Endosulphan sulphate	ND	ND	0.097	ND	NA	Oxychlordane	ND	ND	0.692	ND	NA
Endrin	0.132	0.201	0.138	4	0.088	Total PCBs[6]	2.071	3.262	2.828	6	0.0015(c)
Endrin aldehyde	ND	ND	0.154	ND	NA	Total Toxaphene	10.1	17.7	10.043	3	0.0027(c)
Endrin ketone	ND	ND	0.109	ND	NA						

Source: ADEC 2005a

[1]To calculate averages, non-detects were substituted with a value equal to half the detection limit.

[2]CV= comparison value; EPA risk-based consumption limits (unrestricted monthly fish consumption) (EPA 2000b); (c)=cancer health endpoint, (nc)=non-cancer endpoint.

[3]A total of six chinook salmon were collected for analysis.

[4]Fish collected ranged between 1.7–8.0 kg in weight and 50-89 cm long; individual ages were not reported.

[5]Total relative concentrations were calculated using the toxic equivalency factor (TEF) approach for dioxins. The TEF approach compares the relative potency of individual dioxin congeners with that of tetrachlorodibenzo-p-dioxin (TCDD), the best-studied member of this chemical class. The concentration or dose of each dioxin-like congener is multiplied by its TEF to arrive at a toxic equivalent (TEQ). The TEQs are added to give the total toxic equivalency. ATSDR used the 2005 WHO TEFs (WHO 2008).

[6]Total PCBS equal the sum of congeners above detection limits from the following congener list: 18,28,37,44,49,52,66,74,77,81,87,95,99,101,105,110,115,118,123,126,128, 137,138,146, 149,151,153,156,157,167,169,170,172,177,178,180,183,187,189,194,195,196,201,206,209.

ND = not detected

NA = not available

Table 3. Concentrations of Metals in Fish from Cook Inlet (ppb wet weight)

Chemical	Min ppb	Max ppb	Average[1] ppb	n[2]	Min ppb	Max ppb	Average ppb	n	Min ppb	Max ppb	Average ppb	n	Min ppb	Max ppb	Average ppb	n	CV[3] ppb
Chinook salmon fillet[4] (Homer Spit)					**Chum salmon fillet (Homer)**				**Pink salmon fillet (Homer)**				**Red salmon fillet (Homer)**				
Arsenic	230	880	472	6/6	220	280	244	5/5	120	290	205	6/6	220	330	293	3/3	2(c)
Cadmium	3	7	5	5/5	5	19	8	6/6	2	3	2	4/4	3	8	5	6/6	NA
Chromium	6	7	4	2/6	7	62	20	6/6	8	27	16	6/6	6	16	8	4/6	NA
Lead	20	30	27	6/6	30	30	30	6/6	20	30	25	6/6	20	30	18	4/6	NA
Methyl-mercury	44	94	48	5/6	27	41	33	6/6	12	20	17	6/6	22	41	32	6/6	29(nc)
Nickel	ND	ND	ND	0/6	ND	ND	ND	0/6	ND	ND	ND	0/6	90	90	23	1/6	NA
Selenium	70	130	95	6/6	180	220	202	6/6	110	180	140	6/6	110	170	142	6/6	NA
Silver salmon fillet (Homer Spit)					**Cod fillet (Kachemak Bay)**				**Pollock fillet (Kachemak Bay)**				**Halibut roast (throughout lower Cook Inlet)**				NA
Arsenic	280	510	402	6/6	4,090	13,400	7,125	6/6	810	7,060	3,598	11/11	670	4,010	1,745	8/8	2(c)
Cadmium	4	6	5	6/6	2	4	3	6/6	3	8	5	7/7	3	3	3	1/1	NA
Chromium	ND	ND	ND	0/6	10	320	62	4/6	6	104	37	11/11	8	8	4	1/8	NA
Lead	ND	ND	ND	0/6	20	30	17	3/6	20	40	19	5/11	30	40	31	8/8	NA
Methyl-mercury	19	47	31	6/6	31	75	56	6/6	17	109	38	8/11	26	337	101	18/18	29(nc)
Nickel	ND	ND	ND	0/6	130	130	30	1/6	30	30	14	2/11	ND	ND	ND	0/8	NA
Selenium	140	190	163	6/6	150	250	193	6/6	90	210	139	11/11	250	610	406	8/8	1,500

Source: ADEC 2005a

[1] To calculate averages, non-detects were substituted with a value equal to half the detection limit.

[2] n = number of detections per individuals sampled.

[3] CV= comparison value; EPA risk-based consumption limits (unrestricted monthly fish consumption) (EPA 2000b); (c)=cancer health endpoint, (nc)=non-cancer endpoint.

[4] Weight (kg), length (cm), and age (years) of individuals reported by species as a range. Age reported for halibut only. Chinook salmon: 1.7–8.0 kg, 50-89 cm. Chum salmon: 1.4–3.4 kg, 50-68 cm. Pink salmon: 1.4–2.0 kg, 49–55 cm. Red salmon: 1.4–3.0 kg, 54–65 cm. Silver salmon: 3.2–4.2 kg, 64–68 cm. Cod: 0.8–3.2 kg, 43–66 cm. Pollock: 0.4–1.4 kg, 37–54 cm. Halibut: 3.2–37.6 kg, 65–140 cm, 6–20 years old.

ND = not detected

NA = not available

Port Graham Dietary Information

The Village of Port Graham conducted food frequency interviews in 2004 to identify the types and amounts of traditional foods eaten by residents of the Village of Port Graham over the previous 12 months. ATSDR assumed that residents of nearby native villages have similar eating patterns for consumption of native foods. The Village Council provided ATSDR with an Excel file containing responses from the 44 individuals participating in the survey. ATSDR's Division of Health Studies evaluated these data for the Village Council (Wang and Inserra 2005). Twenty-three females and 21 males participated in the survey and consisted of the following three groups: elders (12), adults (28) and teenagers (4). Seven females and five males were in the elder group (65 years of age or older). Fifteen females and 13 males were in the adult group (ages 20–64 years). Four teenagers (one female and three males) participated in the food consumption survey.

The main traditional food consumed was fish, which ranged from 68 percent of the traditional foods for teenagers to 76 percent of the traditional foods for elders. Overall, fish was 70 percent of the traditional native foods. For this consultation, ATSDR used data from the Port Graham dietary survey as a guide in estimating the dose that residents might receive from eating fish taken from Cook Inlet. Table 4 provides some statistics from the survey.

The average fish ingestion rates for the various age groups ranged from 5 to 9 ounces per day (oz/day) (142–256 grams/day), with an overall average for the village of 7 oz/day. This roughly equates to about 1 fish meal a day for the average village resident. This also means that some village residents are likely to eat 2 fish meals a day. At the request of village residents, ATSDR used a range of daily fish consumption rates to estimate residents' exposures from eating Cook Inlet fish. Specifically, ATSDR used a daily fish ingestion rate of 7 oz, 14 oz, and 18 oz for adults. While the average for the village was 7 oz per daily, the upper estimates of 14 oz and 18 oz likely represent the fish consumption rate for some residents in the village who eat two fish meals a day.

EPA also collected samples of mussels, clams, octopus, snail, and plants; therefore, ATSDR used information from the village survey to estimate daily intakes of these other foods. Overall, average individual consumption of these foods was about 0.1 oz/day for clams/mussels, and 0.9 oz/day for other invertebrates (chiton, snails, octopus). Since the native food survey may have underreported consumption of some foods, ATSDR used the following ingestion rates for adults:

Clams/mussels	0.1 oz/day, 0.5 oz/day and 1 oz/day, and
Chiton/snails/octopus	1 oz/day, 2 oz/day, and 3 oz/day.

Children were assumed to have eaten about half to one-third as much as adults.

The Port Graham Village Council is very concerned about the use of the data collected from the traditional food frequency survey conducted by the Village of Port Graham in 2004. They are very skeptical about the information collected in this survey because the project was a volunteer basis and required residents to estimate the amount of foods eaten for the entire year. The available resources to collect the information were not familiar with their traditional harvesting and gathering practices and as a result the Village Council believes the information collected is imprecise and is likely to have under-reported the consumption of native foods. Other concerns are that the survey was a "one time" data collection and thus relied on a resident's memory of fish eating habits for the year. Therefore, the results are only an estimate of how much seafood and plant is consumed as part of their traditional lifestyle. Council members point out that it is very difficult to estimate all the different foods and quantities that they consume over a one year period and as a result the survey is only a guess of annual and daily consumption rates. These concerns are supported by what is known of the limitations of recall bias in collecting information about food consumption. For this reason, ATSDR used the daily average determined by the survey but also included higher daily intakes to account for under-reporting in the survey.

A detailed analysis of the food consumption surveys has been provided to the Village of Port Graham. In accordance with the data-sharing agreement between the Village Council and ATSDR, all food survey data have been returned to the Council.

Table 4. Fish Consumption Rates Estimated Using Port Graham Dietary Survey Data

Village Groups	**Total Yearly Fish Consumption**	**Total Daily Fish Consumption**	**Daily Fish Consumption per Person**
Overall/Combined (44)	113,503 oz (7,094 lbs)	311 oz (19.44 lbs)	**7.1 oz (202 grams/day)**
Elders (12)	38,215 oz (2,388 lbs)	105 oz (6.6 lbs)	**9 oz (256 grams/day)**
Adults (28)	68,039 oz (4,252 lbs)	186 oz (11.6 lbs)	**7 oz (199 grams/day)**
Teenagers (4)	7,249 oz (453 lbs)	20 oz (1.25 lbs)	**5 oz (142 grams/day)**

Exposure Evaluations

Assessing exposure requires identifying pathways (*e.g.*, water, food, soil) by which people can come in contact with chemicals in the environment. This consult focuses on native foods as the main route by which Native Alaskans can be exposed to chemicals. 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 residents who eat food from Cook Inlet, all 5 components of the exposure pathway are present, so the biota pathway is considered complete.

We evaluated the potential for Native Alaskans to be exposed to chemicals from eating native food from Cook Inlet. For each chemical evaluated, we estimated the dose of chemical that village residents ingested from eating food taken from Cook Inlet by using a range of food intakes. When evaluating fish, we used the average concentration of chemical in each fish species and information from the Port Graham food survey. We assumed that all of the chemicals ingested were absorbed (i.e., 100% bioavailable) and that people would be exposed every day. In the final step, we compared the estimated dose of each chemical to health guidelines and when necessary to human and animal studies to decide if harmful effects might be possible. We also estimated the risk of cancer for each known carcinogen using a method developed by the EPA.

Estimating Human Exposure to Contaminants in Seafood and Plants

Exposure assessment requires estimating the amounts of chemicals to which people can be exposed (ATSDR 2005a). For our evaluations, we used either the average contaminant concentration in all fish or the average contaminant concentrations in each fish species or plant group to estimate the dose of chemical that residents ingested. Contaminants were usually lowest in plant samples and highest in the whole fish samples. The average concentration in fish is summarized in Table 1 for EPA and ADEC samples (USEPA 2003, ADEC 2005a).

Non-cancer evaluation

Once a dose is estimated from eating seafood or plants, it is compared to a health guideline for non-cancerous effects. Two health guidelines commonly used in the United States are ATSDR's Minimal Risk Level (MRL) and EPA's Reference Dose (RfD). MRLs and RfDs are daily exposure estimates (or doses) below which adverse non-cancer health effects are unlikely. MRLs and RfDs are usually 100 to 1000 times below levels that cause harmful effects. For oral exposures, MRLs are expressed in units of milligrams of chemical per kilogram of body weight per day (mg/kg/day). MRLs can be developed for three exposure periods: acute (less than 14 days), intermediate (15 days to 1 year), or chronic (greater than 1 year to lifetime). RfDs are similar to MRLs but are only developed for chronic exposures. Health guideline values for non-cancerous effects are shown in Table 5.

When a health guideline is not available, the estimated dose is compared directly to doses identified from animal or human studies that are known to cause harmful effects or to doses that are not known to cause harmful effects, depending upon what is available and known about a chemical's harmful effects. A detailed explanation of estimating exposure doses is given in Appendix A.

To make the comparison of the estimated dose to a MRL or RfD easy to interpret, a hazard quotient (HQ) was calculated. The formula for determining the HQ follows:

$$HQ = \text{estimated dose of a chemical from eating native food} \div \text{MRL or RfD.}$$

Therefore, if the HQ is greater than 1, then the estimated dose for a chemical exceeds the MRL or RfD for that chemical. If the HQ is less than one, the estimated total dose for a chemical from eating native food is below the MRL or RfD. Using the HQ allows the reader to look at a table showing all the calculations and to easily see if the estimated dose is greater than or lower than the MRL or RfD. If the HQ is less than 1, then non-cancerous effects are unlikely. If the HQ is greater than 1, then more detailed toxicological evaluations are necessary to determine if and what health effects might be possible.

In addition to determining the HQ for a chemical from each particular food group, such as fish, mussels/clams, plants, a total dose can also be estimated by adding the dose of each of these food groups. This total dose from all native food groups can be compared to the MRL or RfD and a HQ can be calculated. If the combined HQ from all food groups is below 1 then the estimated dose is less than the health guideline and non-cancerous harmful effects are not likely. If the combined HQ exceeds 1, then further toxicological evaluation is needed to determine if a risk for harmful effects exists.

Cancer evaluation

The risk of cancer is evaluated using a method developed by the EPA. A chemical that causes or might cause cancer in people is called a carcinogen. When people are exposed to a known carcinogen from eating food, the method for estimating their cancer risk involves estimating the intake of a carcinogen from their diet, which is called a dose, and then multiplying that dose by what is called a cancer slope factor. The resulting number is the cancer risk. The equation for estimating cancer risk follows:

Oral Cancer Risk = Chronic oral dose (in mg/kg/day) x cancer slope factor (in 1 / mg/kg/day).

The resulting risk of cancer is called an excess cancer risk because it is the risk of cancer above the already existing background risk of cancer. The EPA also states that the risk could be zero. Therefore, one interprets the excess cancer risk as being between 0 and some number for every 100,000 people who eat fish from Cook Inlet for their lifetime. The background risk of cancer in the US population is about 1 in every 2 men or 1 in every 3 women over a lifetime. The estimated cancer risk from EPA's equation is in addition to this background cancer risk.

Numerical estimates of cancer risk can only be made for those carcinogens for which EPA has developed a cancer slope factor. The cancer slope factors developed by EPA for known carcinogens are shown in Table 5.

Fish Ingestion Rates

Accurate estimates of how much seafood or plants people eat can be difficult to obtain. It can vary by age, sex, lifestyle, season, tribal custom, or health status. At the request of village residents, ATSDR used daily fish ingestion rates of 7 oz/day, 14 oz/day, and 18 oz/day for adults. The survey that the Village of Port Graham conducted showed that adults on average eat about 7 oz of fish per day, which equates to about 1 fish meal per day. It is reasonable to assume that the fish ingestion rates of 14 oz/day and 18 oz/day apply to some residents who have higher than average daily fish intakes. These higher intake rates equate to about 2 fish meals per day.

Table 5. Health Guideline Values and Cancer Slope Factors for Chemicals Detected in Cook Inlet Seafood and Plants

Chemical	Chronic MRLs* mg/kg/day	Chronic RfDs* mg/kg/day	Cancer Slope Factors 1/mg/kg/day	Comments
Aroclor 1260	0.00002	0.00002	2.0	MRL/RfD Aroclor 1254 values CSF for Aroclor
PCB Congeners	0.000000001	---	---	TCDD toxicity equivalents used
Dioxin**	0.000000001	---	---	TCDD MRL used
Acenaphthene	0.06	0.06	---	Intermediate MRL
Fluoranthene	0.4	0.04	---	Intermediate MRL
Fluorene	0.4	0.04	---	Intermediate MRL
Naphthalene	0.6	0.02	---	Intermediate MRL
Pyrene	---	0.03	---	
Chlordane	0.0006	0.0005	0.35	
DDD (p,p')	---	---	0.24	
DDE (p,p')	---	---	0.34	
DDT (p,p')	0.0005	0.0005	0.34	Intermediate MRL
Dieldrin	0.00005	0.00005	16	
Endosulfan	0.002	0.006	---	
Endrin	0.0003	0.0003	---	
Heptachlor epoxide	---	0.000013	9.1	
Hexachlorobenzene	0.00005	0.0008	1.6	
Lindane (g-HCH)	0.00001	0.0003	---	Intermediate MRL
2-methylnapthalene	0.04	---	---	
Mirex	0.0008	0.0002	---	
Arsenic (inorganic)	0.0003	0.0003	1.5	
Barium	---	0.2	---	
Cadmium	0.0002	0.001	---	The RfD for food is listed
Chromium III+	---	1.5	---	
Lead	---	---	---	Used ATSDR model for blood lead
Methylmercury	0.0003	0.0001	---	
Selenium	0.005	0.005	---	

*Minimal risk levels (MRLs) and reference doses (RfDs) are daily doses in mg/kg/day below which no adverse non-cancer health effects are likely. MRLs and RfDs are usually 100 to 1000 times below levels that are known to cause harmful effects. Please refer to Appendix A for additional information.
** The MRL for dioxin is used to evaluate the one dioxin compound detected in native foods, octachlorodibenzo-p-dioxin (OCDD). OCDD is converted to dioxin equivalents using TEFs developed by the World Health Organization.

The village survey collected limited information about native food consumption on teenagers since only four teenagers participated in the survey. The average daily fish consumption in teenagers aged 15 to 19 years was 5 oz/day; however, this daily consumption is uncertain because so few teenagers participated in the survey and because the survey is likely to have underestimated residents' fish consumption. The village survey did not collect information on fish consumption in elementary age and preschool children. Because of the high daily fish intake in adults, it is reasonable to assume that teenagers, elementary age children, and preschool children also will have high fish consumption.

Using information from the village survey and professional judgment, ATSDR assumed the following daily intakes of fish for the various age groups:

	Average Villager	Above Average Villager	Highest Villager
Adults	7 oz/day,	14 oz/day,	18 oz/day,
Teenagers	6 oz/day,	12 oz/day,	14 oz/day,
Elementary age children	3.5 oz/day,	7 oz/day,	9 oz/day, and
Preschool children	2 oz/day,	4 oz/day,	6 oz/day.

For the purpose of this evaluation, these three ranges are used to represent average daily intake, above average daily intake, and highest daily intake for residents in the Village of Port Graham, Nanwalek, Seldovia, and Tyonek. They equate to either 1 or 2 fish meals per day, which is consistent with the survey conducted by the Village of Port Graham.

In conversations with the chief and the environmental director for the Village of Port Graham, they requested that ATSDR evaluate two seasonal exposures where some villagers might eat higher rates of native foods for a couple of months (e.g., during lent). ATSDR agreed to evaluate the higher exposure from pesticides that might occur during lent, when some villagers might eat fish for each meal as they abstain from other types of meat. For this scenario, ATSDR assumed that some residents ate 3 fish meals a day or 21 ounces of per day for 6 to 8 weeks.

In addition, ATSDR agreed to look at the seasonal consumption of chiton since residents might increase their intake to 1, 2, or 3 ounces daily. Because chiton has higher lead levels than other invertebrates, they are concerned that the increased intake of lead from chiton might increase blood lead levels in children and adults.

These scenarios focusing on the risk of short-term increases in native foods are discussed in the appropriate subsections on lead and pesticides.

Discussion

The discussion section of this report has two main sections, one describing non-cancer evaluations and the other describing cancer evaluations. The non-cancer section presents information and ATSDR's evaluation of each chemical or group of chemicals, including elements, methylmercury, pesticides, polychlorinated biphenyls (PCB), dioxins, and polycyclic aromatic hydrocarbons (PAH).

Results of Non-cancer Evaluations

Elements

EPA or ADEC measured for the following elements and compounds: arsenic, barium, cadmium, chromium, lead, selenium, and methylmercury.

Arsenic

Arsenic in seafood

Fish and shellfish absorb inorganic arsenic from water and sediment, and rapidly convert most of it to organic forms of arsenic. This is a natural process and many fish and shellfish have high levels of organic arsenic. The organic forms of arsenic in fish (e.g., arsenobetaine and arsenocholine) are not harmful to people because they are easily and quickly eliminated through the urine without being converted to inorganic arsenic. It is the inorganic form of arsenic that is harmful to people. (ATSDR 2000a).

Most fish from Cook Inlet were non-detectable for inorganic arsenic (i.e., chinook, chum, cod, halibut, sea bass, and sockeye). Three of 14 flounder were found to contain inorganic arsenic from 11 to 16 ppb while the other flounder samples were non-detectable for inorganic arsenic. The average inorganic arsenic level in the 14 samples was 6 ppb (USEPA 2003). The average inorganic arsenic level in all fish (whole body) was 1 ppb.

In the survey conducted by the Village of Port Graham, village residents reported a very low consumption rate for flounder. The average daily consumption rate for flounder was calculated to be 0.01 oz/person/day.

Dose estimates for all age groups using average <u>inorganic</u> arsenic levels for flounder and for all fish combined were well below the chronic MRL of 0.0003 mg/kg/day for inorganic arsenic. Therefore, the small amount of inorganic arsenic found in flounder is not harmful to people.

> MRLs and RfDs have built-in safety factors, making these values considerably lower than doses at which health effects have been observed. Therefore, exposure to doses above these health guideline values does not automatically imply that adverse health effects will occur. Rather, it is an indication that ATSDR should conduct a more detailed toxicological evaluation to decide if or what harmful effects might be possible.

EPA also sampled other native foods, including clams and mussels as well as other invertebrates (chiton or badarki, snails, and octopus). Small amounts of inorganic arsenic were found in these foods ranging up to 41 ppb in snails. The average concentration in clams and mussels was 8 ppb while the average concentration in other invertebrates was 17 ppb. All the estimated doses in adults and children from eating shellfish, snails, and octopus were well below the chronic MRL for inorganic arsenic; therefore, harmful effects are not likely.

ADEC reported total arsenic for the fish samples they collected (ADEC 2005a). While cod had the highest average total arsenic levels (7,125 ppb), cod were not identified as a specific food item in the food frequency survey conducted by Port Graham. For all fish samples analyzed by ADEC, the average total arsenic level was 2,056 ppb. Because ADEC did not analyze for inorganic arsenic, it is not possible to estimate the inorganic arsenic content of their samples. Since total arsenic in fish is almost entirely organic arsenic, harmful effects are not expected.

Arsenic in plants

EPA sampled kelp, seaweed, and goose tongue and analyzed them for various forms of arsenic, including total arsenic, inorganic arsenic, monomethylarsenic acid, and dimethylarsenic (USEPA 2003). Total arsenic was 9 ppb in goose tongue, 2,556 ppb in kelp, and 2,872 ppb in seaweed; however, most of the arsenic was in the non-toxic organic form. Small amounts of inorganic arsenic were detected in 3 of 6 goose tongue samples (average = 3.7 ppb), while inorganic arsenic was not detected in kelp and seaweed. Goose tongue, kelp, and seaweed comprise about 1 to 2 percent of the traditional foods reported by adults and elders who participated in the Port Graham survey. On average, the residents eat about 9 oz of goose tongue per year or about 0.02 oz/day. The estimated dose from eating goose tongue is below health guidelines; therefore, the level of inorganic arsenic in goose tongue is not harmful to people.

Dimethylarsenic acid (DMA) was found in small amounts in kelp and seaweed. Some scientists report that DMA could represent a high percentage of the arsenic found in plants (Moore and Ramoorthy 1979). This form of arsenic is likely to be rapidly excreted in urine and feces, and is not likely to be de-methylated to form inorganic arsenic (ATSDR 2000a). For these reasons, DMA levels in plants were not used for making health-related conclusions about inorganic arsenic.

Total Inorganic Arsenic Dose

In addition to evaluating each food individually, ATSDR also evaluated the total dose of inorganic arsenic from native foods (fish, shellfish, and plants). For all age groups, the estimated total (or combined) doses from fish, shellfish, and plants are below ATSDR's chronic health guideline of 0.0003 mg/kg/day. Therefore, there is no risk of harmful effects in adults or children from inorganic arsenic in native foods. See Appendix B, Table B-1a and Table B-1b for individual and combined dose estimates from native foods and comparison to health guidelines.

Barium

Average barium levels reported by EPA ranged from 238 ppb in plants to 565 ppb in mussels/clams (Table 1) (EPA 2003). ADEC and Lees et al. did not analyze for barium (ADEC 2005a, Lees et al. 1999, 2001). Exposure estimates for barium for all age groups were below ATSDR's chronic MRL of 0.2 mg/kg/day. Harmful effects in residents from eating native foods containing barium are not expected based on these data.

Cadmium

Most ingested cadmium passes through the gastrointestinal tract without being absorbed. Studies on oral absorption of cadmium from food have generally indicated absorption rates ranging from 1% to 10% for healthy adults (ATSDR 2009). A review of information related to the EPA RfD for cadmium (http://www.epa.gov/iris/subst/0141.htm) indicated that an absorption rate of 2.5% was assumed in deriving the RfD for food (0.001 mg/kg/day). ATSDR (1999b) indicated an oral absorption rate of 5% for cadmium when developing the chronic MRL (0.0002 mg/kg/day). For this health consultation, we selected an oral bioavailability factor of 5% to estimate cadmium absorption in adults. Because children tend to absorb more metals than adults, ATSDR conservatively estimated cadmium absorption at 10% for children eating native foods since this is the higher range identified in some human studies (ATSDR 2009).

Average cadmium levels were highest for invertebrates (2,128 ppb) and lowest for whole-body fish (59 ppb) samples analyzed by EPA (USEPA 2003) (Table 1). ADEC fish fillets averaged 4.7 ppb cadmium (ADEC 2005a). Cadmium was not reported by Lees et al. (1999, 2001). In fish, cadmium can accumulate in bone, liver, and kidney. Sufficient information was not available to evaluate exposures from using specific organs, or other fish portions, in traditional subsistence diets. In general, cadmium levels in fillets are likely to be lower (as exhibited by the ADEC data) than in whole fish; levels in bone, liver, and kidney may be higher.

Using cadmium levels in whole fish, adult and child exposure estimates were below the chronic oral MRL and are not likely to result in adverse health effects (Appendix B, Table B-2a and B-2b). The estimated dose of cadmium from eating plants (i.e., kelp, seaweed, and goose tongue) also was below ATSDR's chronic MRL. It is unlikely that cadmium in fish and plants will cause harmful effects in village residents.

The traditional foods survey conducted by the Village of Port Graham (Wang and Inserra 2005) indicated that invertebrates (snail, chiton, and octopus) accounted for about 8% of total traditional diet. Estimated average individual consumption of these invertebrates for adults was about 1 oz/day (28 grams/day) or about one 7 oz meal per week. To ensure that adults with higher intakes were protected, ATSDR also estimated doses for adults who ate 2 oz and 3 oz of invertebrates each day. Of the three invertebrates, snail had the highest cadmium levels at 4,493 ppb while chiton had the lowest at 769 ppb. The average cadmium level for these invertebrates was 2,128 ppb. The estimated doses in adults were below the MRL; therefore, adverse health effects are not likely.

Children were assumed to eat 0.3 oz/day, 0.5 oz/day, and 1 oz/day of invertebrates. Most of the estimated doses in elementary-age children eating these amounts were below the health guideline. The estimated dose in preschool children and 1-year-old children who eat 1 oz/day of snail, chiton, and octopus was slightly above the health guideline of 0.0002 mg/kg/day (Appendix B, Table B-2b). These estimated doses, however, were still well below the no effect level identified in human studies. In addition, the harmful effects of cadmium comes from cadmium accumulating in the kidney following decades of dietary exposure; therefore short periods of slightly exceeding a health guideline are not harmful.

Because dietary cadmium accumulates in the kidneys throughout a person's lifetime, ATSDR estimated the lifetime dose for people in the village who eat native foods both as children and as adult. For all three groups (average native food intake, above average, and the highest intake group), the lifetime dose of cadmium is below the health guideline as indicated by the hazard quotient of a less than 1 (Appendix B, Table B-2a). Therefore, harmful effects to the kidneys are not likely.

Chromium

Our evaluation of chromium was based on the trivalent form (Cr^{+3}), which is considered the most likely form found in biota. Hexavalent chromium (Cr^{+6}) is more toxic, but less stable. It is easily converted to Cr^{+3} by environmental and biological processes (Moore and Ramoorthy 1979; ATSDR 2000b). We assumed that the total chromium results reported by EPA were 100 percent trivalent chromium and used the following averages to estimate chromium doses: 599 ppb (whole fish), 756 ppb (mussel/clam), 182 ppb (other invertebrates), and 392 ppb (plants) (Table 1) (USEPA 2003).

Exposure estimates for trivalent chromium were well below the RfD of 1.5 mg/kg/day for all age groups, for average, above average, and highest intake groups, and for lifetime doses. Therefore, harmful effects from chromium in native foods are not likely. It is important to remember that chromium is an essential trace element and is required in small amounts for normal body functions (ATSDR 2000b).

Lead

Average lead levels were 24 ppb (whole fish), 41 ppb (mussel/clam), 32 ppb (other invertebrates), 225 ppb (chiton), and 12 ppb (plants) (Table 1). ADEC reported averages of 31 ppb in halibut and 22 ppb in all fish (ADEC 2005a). Lees et al. did not analyze lead (Lees et al. 1999, 2001). The Food and Drug Administration (FDA) has established an action level of 80 ppb for fruit beverages and 250 ppb for foods packaged in lead soldered cans. There are no standards for lead in fish or shellfish (FDA 1994).

Daily estimated doses from lead in food ranged up to 0.0005 mg/kg/day for children and 0.0003 mg/kg/day for adults. There are no MRLs or RfDs available for lead to allow direct comparison to estimated exposure doses. Therefore, our evaluation of lead focused on the potential for dietary lead to increase blood lead levels.

ATSDR used dietary slope factors for lead to estimate blood lead increases. These dietary slope factors are summarized in ATSDR's Toxicological Profile for Lead, Appendix D (ATSDR 2007). The premise of dietary slope factors is that blood lead levels will increase incrementally as dietary lead increases.

These dietary slope factors are presented as a specified increase in blood lead level for each microgram of lead in the diet. The units used to express this relationship are microgram lead per deciliter (µg/dL) of blood and microgram (µg) lead ingested daily. Dietary slope factors exist for men, women, and children.

The dietary slope factor for toddlers is 0.24 µg lead / dL blood for every µg lead ingested daily. This means that for each µg of lead ingested daily from food, preschool children's blood lead level will increase by 0.24 µg/dL. The dietary slope factor for women is 0.034 µg/dL per microgram lead and the dietary slope factor for men is 0.027 µg/dL per microgram of lead.

To use an example, if preschool children ingest 10 µg of lead a day from food, their blood lead level will increase by 2.4 µg/dL. The actual formula for children looks like this:

$$\frac{0.24\ \mu g\ \text{lead/dL}}{1\ \mu g\ \text{lead/day}} = \frac{\text{blood lead level}}{\text{dietary lead intake}}$$

$$\text{Blood lead level} = \frac{0.24\ \mu g\ \text{lead/dL} \times \text{dietary lead intake}}{1\ \mu g\ \text{lead/day}}$$

$$\text{Blood lead level} = \frac{0.24\ \mu g\ \text{lead/dL} \times 10\ \mu g\ \text{lead/day}}{1\ \mu g\ \text{lead/day}}$$

$$\text{Blood lead level} = 2.4\ \mu g/dL$$

Estimated blood lead levels can be compared to averages obtained from two national surveys of the U.S. population conducted by the CDC. The first National Health and Nutrition Survey (NHANES) was conducted from 1991 to 1994 and the second NHANES was conducted from 1999 to 2002. The results are shown in Table 6.

Table 6. Blood lead levels (µg/dL) reported by CDC from two national surveys (CDC 2005).

Age Groups (years of age)	US Average Blood Lead Level 1991-1994 µg/dL	US Average Blood Lead Level 1999-2002 µg/dL
1 – 5	2.7	1.9
6 – 19	1.7	1.1
20 – 59	2.2	1.5
60 and older	3.4	2.2

Using average lead levels in native foods from Table 1, estimated blood lead increases were calculated for preschool children and adults (Tables 7 and 8). Blood lead levels are estimated for three groups: average native consumption, above average native food consumption, and highest native food consumption. The three food consumption rates shown in Tables 7 and 8 were determined from the food frequency survey conducted by the Village of Port Graham, discussions with village representatives, and professional judgment.

Estimated blood lead levels increase by 0.4 µg/dL in adults who have average native food consumption, that is, adults who eat about 1 fish meal a day along with smaller amounts of other native foods (see Table 6). For adults who eat about 2 fish meals a day along with higher amounts of other native foods, their estimated blood lead levels might increase by 1 µg/dL in men and 1.3 µg/dL in women. These blood lead levels are similar to the national average of 1.5 µg/dL for 20 to 59 year old adults and 2.2 µg/dL for adults 60 years and older (see Table 6). These blood lead levels do not present any additional risk of harmful effects in adults.

The estimated blood lead level in preschool children ranges from 1.1 µg/dL to 2 µg/dL from eating native foods (Table 8). These estimated blood lead levels for preschool children are similar to the national average of 1.9 µg/dL in children 1 to 5 years old and 1.1 µg/dL in children 6 to 19 years old (see Table 6). They are also below the level of concern of 10 µg/dL established by the CDC for case management. These blood lead levels do not present any additional risk of harmful effects in children.

During conversations with representatives of the Village of Port Graham, they raised concern about whether the short-term increase in chiton consumption during spring and summer might raise blood lead levels in children and adults. This concern was raised because chiton contained lead levels that were higher than other foods tested, with concentrations ranging from 140 ppb to 461 ppb. The average concentration of nine chiton samples was 255 ppb. It is unclear why chiton have significantly higher lead levels compared to other native foods in Alaska. Mussel and clams, which are also bottom dwellers, showed much lower lead levels at 41 ppb. It may be that sediment particles adhered to the meat while the sample was being processed or that chiton accumulate lead more readily than other shellfish.

From discussions with representatives from the Village of Port Graham, we used a daily intake of 1, 2, and 3 ounces of chiton during several months in late spring and summer. Blood lead levels in adults who eat 1 to 3 ounces of chiton daily is estimated to increase by 0.2 µg/dL to 0.6 µg/dL. When combined with lead from other native foods, the resulting blood lead levels range from 0.35 µg/dL to 1 µg/dL. These blood lead levels do not present any additional risk of harmful effects in adults.

This is not the case, however, for children who eat 3 ounces of chiton every day during chiton season. Blood lead levels in children who eat 3 ounces of chiton daily is estimated to increase by 5 µg/dL. When combined with eating other native foods, the estimated blood lead level increases to 6.5 µg/dL. While 6.5 µg/dL is still below CDC's level of concern of 10 µg/dL for case management, this level is significant and is cause for concern. Studies have shown that lead levels below 10 µg/dL can cause small decreases in IQ, an increase in attention deficit hyperactivity disorder, reduced attention span, decreased height, small delays in puberty, and small changes in kidney function (Braun 2006, Lanphear 2000, Lanphear 2005, Bellinger 1992, Bellinger 2003, Selevan 2003, Walkowiak 1998, and Burbure 2006, ATSDR 2007).

Table 7. Estimated blood lead levels in adults

Native Foods	Lead Concentration µg/kg or ppb	Ingestion Rate Adults oz/day	Ingestion Rate kg/day	Adult Daily Intake ug/day	Adult Dose mg/kg/day	Slope Factor Women µg/dL per µg lead	Estimated Blood Lead Women µg/dL	Slope Factor Men µg/dL per µg lead	Estimated Blood Lead Men µg/dL
Whole fish	24	18	0.51030	12.2472	0.00017	0.034	0.42	0.027	0.33
Whole fish	24	14	0.39690	9.5256	0.00014	0.034	0.32	0.027	0.26
Whole fish	24	7	0.19845	4.7628	0.00007	0.034	0.16	0.027	0.13
Mussels/Clams	41	1	0.02835	1.1624	0.00002	0.034	0.04	0.027	0.03
Mussels/Clams	41	0.5	0.01418	0.5812	0.00001	0.034	0.02	0.027	0.02
Mussels/Clams	41	0.1	0.00284	0.1162	0.00000	0.034	0.0040	0.027	0.0031
Other Invertebrates	32	3	0.08505	2.7216	0.00004	0.034	0.09	0.027	0.07
Other Invertebrates	32	2	0.05670	1.8144	0.00003	0.034	0.06	0.027	0.05
Other Invertebrates	32	1	0.02835	0.9072	0.00001	0.034	0.03	0.027	0.02
Chiton	255	3	0.08505	21.6878	0.00031	0.034	0.74	0.027	0.59
Chiton	255	2	0.05670	14.4585	0.00021	0.034	0.49	0.027	0.39
Chiton	255	1	0.02835	7.2293	0.00010	0.034	0.25	0.027	0.20
Plants	12	0.2	0.00567	0.0680	0.000001	0.034	0.002	0.027	0.0018
Plants	12	0.1	0.00284	0.0340	0.000000	0.034	0.0012	0.027	0.0009
Plants	12	0.05	0.00142	0.0170	0.000000	0.034	0.0006	0.027	0.0005
Total daily Pb intake for highest native food consumption ------------->				37.89	0.00054	0.034	1.2882	0.027	1.0
Total daily Pb intake for above average native food consumption -->				26.41	0.00038	0.034	0.8981	0.027	0.7
Total daily Pb intake for average native food consumption ----------->				13.03	0.00019	0.034	0.4431	0.027	0.35

Table 8. Estimated blood lead increases for children

						Estimated Increase in Blood Lead Children µg/dL
Whole fish	24	6.0	0.1701	4.0824	0.24	0.980
Whole fish	24	4.0	0.1134	2.7216	0.24	0.653
Whole fish	24	2.0	0.0567	1.3608	0.24	0.327
Mussels/Clams	41	0.3	0.0071	0.2906	0.24	0.070
Mussels/Clams	41	0.125	0.0035	0.1453	0.24	0.035
Mussels/Clams	41	0.025	0.0007	0.0291	0.24	0.007
Other Invertebrates	32	1.0	0.0284	0.9072	0.24	0.218
Other Invertebrates	32	0.5	0.0142	0.4536	0.24	0.109
Other Invertebrates	32	0.3	0.0085	0.2722	0.24	0.065
Chiton	255	0.4	0.0120	3.0724	0.24	0.737
Chiton	255	0.4	0.0120	3.0724	0.24	0.737
Chiton	255	0.4	0.0120	3.0724	0.24	0.737
Plants	12	0.05	0.0014	0.0170	0.24	0.004
Plants	12	0.03	0.0009	0.0102	0.24	0.002
Plants	12	0.01	0.0003	0.0034	0.24	0.001
Total daily Lead intake for highest native food consumption ----->				8.37	0.24	2
Total daily Lead intake, above average native food consumption ->				6.40	0.24	1.5
Total daily Lead intake for average native food consumption---->				4.74	0.24	1.1

Because native foods are an important source of nutrition and culture for native Alaskans, ATSDR evaluated the risk from eating chiton less frequently during chiton season, for example, once a week instead of daily. Preschool children who eat 3 ounces of chiton <u>a week</u> could increase their blood lead levels by 0.7 µg/dL. When combined with eating other native foods, the estimated blood lead level increases to 1.5 µg/dL. This level is similar to the national average of 1.9 µg/dL for children 1 to 5 years old and similar to the national average of 1.1 µg/dL for children over 6 years. Therefore, eating one 3 ounce chiton meal a week will not present any additional risk of harmful effects in preschool children. It is important to remember that children in the Village of Port Graham were tested for lead and no children were found to have blood lead levels above CDC's level of concern of 10 µg/dL. Therefore, our suggestion that preschool children eat no more than one 3 ounce chiton meal a week is being provided as a precaution to prevent excessive exposure to lead in preschool children. Because dietary slope factors for lead are not available in elementary-age children, we are also including this age group as a concern. As stated previously, adults are not at risk of excessive lead exposure from eating chiton because adults absorb much less lead from food than children do.

It may be unlikely to find many children in Alaska with blood lead levels above 7 µg/dL, which is the 95th percentile reported by CDC. Blood samples (venipuncture) from 967 Medicaid eligible children in 33 Alaska communities during September 1993 through March 1994 had an overall arithmetic average of 2.4 µg/dL and an average of 2.0 µg/dL (State of Alaska 1994a), which is similar to national average at that time of 2.7 µg/dL reported by CDC from the first NHANES during the same time period (Table 6) (CDC 2005). Children were tested in all seven Medicaid regions and about 60 percent lived in rural villages. Six children (or about 2%) exceeded 10 µg/dL. The highest blood lead level detected was 21 µg/dL. The others were below 13 µg/dL. Blood samples were taken from children 2–6 years old in villages and 2–3 years old in urban areas. No differences in blood lead levels were attributed to age, race, sex, or place of residence (State of Alaska 1994a).

In 1994, blood samples from 30 of 39 children at the school in Port Graham had a geometric average lead level of 1.4 µg/dL, which is below the national average of 2.7 µg/dL at that time. The highest blood lead level among children was 5 µg/dL (State of Alaska 1994b).

A statewide blood lead surveillance program and targeted screening effort is being implemented in Alaska to ensure the protection of children in the state from childhood lead exposures. Preliminary studies indicate that Alaska is a low prevalence state for elevated childhood blood lead levels. Present efforts are being directed towards screening targeted populations potentially at risk for lead exposures (http://www.epi.hss.state.ak.us/eh/default.stm, last accessed December 2008).

Selenium

Selenium, an essential element for life, was found in all fish samples and in most other foods sampled as part of the Cook Inlet survey. Average selenium levels for samples collected by EPA were highest in whole fish samples (523 ppb) and lowest in plants (77 ppb). Average selenium levels in mussels and clams was 334 ppb and in octopus and snail was 364 ppb (Table 1) (USEPA 2003). Lees et al. did not analyze selenium (Lees 1999, 2001). Average selenium levels for data reported by ADEC were 406 ppb for halibut roasts and 189 ppb for all fillet samples (Table 1) (ADEC 2005a).

For adults and most children, the estimated exposures to selenium from eating fish and other native foods from Cook Inlet were below the chronic oral MRL (0.005 mg/kg/day) established by ATSDR except for preschool children with the highest consumption of native foods. The estimated dose in preschool children with the highest consumption rate is slightly above the chronic oral MRL (0.006 mg/kg/day vs. 0.005 mg/kg/day) but still well below harmful levels. Therefore, the estimated dose for preschool children with the highest consumption rates of fish is not likely to cause harmful effects.

The estimated doses using selenium levels in whole fish probably overestimate selenium exposure. A comparison of fillet vs. whole fish shows that selenium levels are lower in fillet (406 ppb, halibut; 189 all fillets) compared to whole fish (527 ppb) (Table 1). Selenium often accumulates in bone, liver, and kidney. Because entire fish were analyzed, we could not evaluate exposures for dietary use of specific tissues or organs. In general, selenium levels in fillets are likely to be lower (as exhibited by the lower selenium levels in ADEC's fillet samples, Table 1).

In addition, selenium in seafood is often beneficial because it reduces mercury toxicity when selenium doses are similar to or higher than mercury doses. The estimated doses of selenium are about 10 times higher than the estimated doses of methylmercury, thus reducing the potential for mercury toxicity.

Methylmercury

Mercury was measured as total mercury and as organic mercury. Methylmercury data were used to estimate exposures because it is highly bioavailable and more toxic to humans (ATSDR 1999a).

The EPA did not detect methylmercury in plant samples (kelp, seaweed, goose tongue) (Table 1). Based on data reported by the EPA , average methylmercury levels were highest in whole fish (34.6 ppb) and lowest in mussels/clams (3.94 ppb) (USEPA 2003). ADEC reported higher methylmercury levels for halibut fillets (average 101 ppb) and for fillets of all samples combined (average 54 ppb) (Table 1) (ADEC 2005a).

From the dietary survey conducted by Port Graham, halibut makes up about 12 percent of fish eaten by elders and adults. On average, elders consumed about 24 pounds of halibut per year while adults reported eating about 21 pounds.

Methylmercury was 1.5–3 times higher in fillet samples analyzed by ADEC as compared to whole fish samples analyzed by EPA (ADEC 2005a, USEPA 2003). Using the methylmercury level from the ADEC fillet samples, the estimated exposures in adults and children is slightly above ATSDR's chronic MRL of 0.0003 mg/kg/day. The estimated doses in the highest consumption group from all native foods range from 0.00048 mg/kg/day in adults to 0.00095 mg/kg/day in preschool children. The estimated dose for adults in the average consumption group is below the chronic MRL; the estimated dose for preschool children in the average consumption group just exceeds the chronic MRL (0.00032 mg/kg/day vs. 0.0003 mg/kg/day). These estimated doses are still well below the no effect level of 0.0013 mg/kg/ and far below the effect level of 0.04 mg/kg/day day identified in a human study ATSDR (1999a). Harmful effects from methylmercury are not likely.

ATSDR's methylmercury MRL is based on the Seychelles Child Development Study of more than 700 mother-infant pairs in the Seychelles Islands. Like native Alaskan residents along Cook Inlet, the Seychelle population eats a large quantity and variety of fish, with 12 fish meals/week being typical. Mercury levels in 350 fish (25 species) ranged from 500–750 ppb, which is far higher than the 101 ppb measured in halibut fillets and the average of 54 ppb measured in all fish fillets by ADEC. In the Seychelle study, developing fetuses were exposed *in utero* through maternal fish ingestion during pregnancy. Newborn children continued to be exposed during breast feeding and after their shift to a fish diet (ATSDR 1999a). In the 66-month evaluation period of the Seychelles study, multiple developmental domains were assessed with six tests. None of these indicated adverse effects from methylmercury exposure. The study also mentioned positive benefits of the fish diet. ATSDR derived a NOAEL of 0.0013 mg/kg/day from the highest exposure group in this study. The MRL was derived by applying an uncertainty factor of 3 for human variability and a modifying factor of 1.5 to account for domain-specific findings in another mercury-exposed group from the Faroe Islands study (ATSDR 1999a).

These adjustments result in ATSDR's chronic, oral MRL of 0.0003 mg/kg/day. The State of Alaska adopted ATSDR's MRL for methylmercury when developing fish consumption advice for Alaskans. Their advice can be found at this website: http://www.epi.hss.state.ak.us/bulletins/docs/rr2007_04.pdf. The State of Alaska also has a statewide monitoring program for mercury in hair. This program has never found elevated mercury levels that resulted from consumption of Alaska fish. Details about this program can be found at this website: http://www.epi.hss.state.ak.us/eh/biom/default.htm.

EPA's RfD (0.0001 mg/kg/day) is based on a benchmark dose analysis of developmental and neurological impairment. The RfD and the MRL differ by a factor of three, but they are in the same concentration range. Although derived by different methods, the RfD and the MRL are both relevant to Cook Inlet, especially given concerns about preventing adverse effects in infants from exposures to methylmercury.

Average methylmercury levels were 3–30 times higher in halibut roasts analyzed by ADEC than in other fish, seafood, and plant samples analyzed by EPA (ADEC 2005a, USEPA 2003) (Table 1). Exposure estimates in adults using EPA's whole fish average of 34.6 ppb were below ATSDR's chronic oral MRL of 0.0003 mg/kg/day. Exposure estimates in preschool children just barely exceeded the MRL (0.00039 mg/kg/day vs. 0.0003 mg/kg/day) but were below the no effect level (i.e.,NOAEL) of 0.0013 mg/kg/day identified by the Seychelles study (ATSDR 1999a).

In conclusion, while a few of the exposure estimates were slightly above ATSDR's chronic oral MRL for methylmercury, the estimated doses were still below the no effect level identified in human studies and well below harmful levels. Therefore, harmful effects in residents who eat fish and other native foods daily are not expected.

Pesticides

In the initial public release of this health consultation in December 2005, ATSDR used the overall average concentration of pesticide for all fish to estimate doses and compared these estimated doses to health guidelines, such as ATSDR's MRL and EPA's RfD. After receiving comments from residents with concerns about using one average pesticide concentration for <u>all</u> fish, we revised our approach by using the average pesticide concentration in <u>each</u> fish species to estimate a pesticide dose from eating each species. The individual doses for each fish species were then combined to obtain a total dose for each pesticide, which was compared to health guidelines. Because chlorinated pesticides accumulate in fish, this evaluation focus on that group of pesticide, which includes such well-known pesticides as DDT, chlordane, mirex, lindane, and dieldrin.

How to estimate pesticide dose

In this health consultation, ATSDR determined the average concentration of <u>each</u> pesticide in <u>each</u> fish species. Using information about the frequency that each fish species is eaten by village residents, ATSDR estimated the pesticide dose for each species and then combined the doses for each species to obtain a total pesticide dose for all fish. The total dose for each pesticide was compared to MRLs or RfDs, the health guidelines developed by ATSDR and the EPA.

Doses were determined for adults, elementary age children, and preschool children. The following parameters were used for the different age groups:

	Body Weight	Daily fish consumption
Adults	70 kg or 154 lbs	7 oz, 14 oz, and 18 oz,
Elementary age children	35 kg or 77 lbs	3.5 oz, 7 oz, and 9 oz,
Preschool children	16 kg or 35 lbs	2 oz, 4 oz, and 6 oz.

What follows is an explanation of how to estimate a pesticide dose from eating fish. The general formula for estimating the dose from eating fish looks like this:

Pesticide Dose =

pesticide concentration in fish species x percent of fish diet x amount fish eaten each day divided by body weight.

A sample calculation follows showing how to estimate a dose of dieldrin for adults who eat 7 oz of Chinook salmon daily.

Dose (from eating 7 oz/day) Chinook salmon =

0.000649 mg dieldrin/kg fish x 0.294 x 0.19845 kg fish /day ÷ 70 kg = 0.000000541 mg/kg/day.

The dose of dieldrin can be calculated for other fish species in a similar manner. Table 12 shows the dose of dieldrin for each fish species. To obtain the total dose of dieldrin from eating a varied fish diet, the individual doses from eating each species are summed. The total dose of dieldrin from all fish is 0.00000122 mg/kg/day, which is divided by the MRL or RfD to obtain the HQ for dieldrin for people who each 7 oz Chinook salmon per day.

How to calculate a hazard quotient

To make the comparison easy to interpret, a hazard quotient (HQ) for each pesticide was calculated using the total dose. The formula for determining the HQ follows:

HQ = estimated total dose of pesticide from eating fish ÷ MRL or RfD

Therefore, if the HQ is greater than 1, then the estimated total dose for a pesticide exceeds the MRL or RfD for that pesticide. If the HQ is less than one, the estimated total dose for a pesticide from eating fish is below the MRL or RfD. Using the HQ allows the reader to look at a table for all the pesticides and to easily see if the estimated total dose is greater than or lower than the MRL or RfD. If the HQ is less than 1, then non-cancerous effects are unlikely. If the HQ is greater than 1, then a more detailed toxicological evaluation is necessary to determine if and what health effects might be possible.

Results from estimating pesticide dose

The HQs for adults shown in Table 9 are below 1, indicating that adults who eat up 18 ounces of fish each day are not at risk of harmful effects from the small amount of pesticides in fish. The HQs for adults can also be presented graphically (see Figure 2) and clearly show that the estimated doses for each pesticide is below the health guideline.

ATSDR also determined the HQ for elementary age children and for preschool children (Tables 10 and 11). The HQs for elementary age and preschool children also are below 1. Like adults, children who eat large amounts of fish daily are not at risk of harmful effects from pesticides. The HQs for preschool children are shown graphically in Figure 3.

Because it is difficult to read the very small numbers reported in Table 12, Table 13 shows the same information with the units changed to nanograms (ng). A nanogram is 1/1,000,000 (1 millionth) of an mg. As shown in Table 13, the total dose from eating one 7 to 18 oz fish/day is 1.2 to 3.1 ng/kg/day. These total doses are well below the MRL of 50 ng/kg/day. The HQ is 0.02 to 0.06 (the same as Table 12), also indicating that the total dose is below the MRL. Therefore non-cancerous effects are not likely.

Using the approach just described, the hazard quotient (HQ) for each pesticide is presented for adults (Figure 2) and preschool age children (Figure 3). The range of adult HQs for each pesticide (Figure 2) represents groups that eat 7 to 18 oz of fish daily. The range of preschool children HQs represents groups that eat 2 to 6 oz of fish daily. All HQs are below 1 indicating that adults and children will not experience (non-cancerous) harmful effects from the small amount of pesticide in fish.

The levels of some pesticides were slightly higher in fillet samples collected by ADEC when compared to whole fish collected by EPA. Specifically, the level of DDE, dieldrin, heptachlor epoxide, and hexachlorobenzene were higher in fillet samples (see Table 1). ATSDR estimated the dose from eating fish with these slightly higher concentrations for village residents who eat 7 oz, 14 oz, and 18 oz fish daily. As shown in Figures 2 and 3, the estimated doses are well below the health guideline; therefore, non-cancerous effects are not likely.

As mentioned previously, ATSDR agreed to evaluate the pesticide risk from seasonally high fish consumption. One scenario discussed with the environmental director and village chief was that some residents might eat fish for each meal during Lent as they abstain from other meats. Therefore, ATSDR evaluated the pesticide risk for an adult who eats three fish meals a day (or 21 ounces of fish daily) for 6 to 8 weeks.

Table 14 shows the estimated pesticide doses in adults who eat three fish meals daily during Lent. These estimated doses can be compared to ATSDR's intermediate MRL for each pesticide. The intermediate MRL was developed for exposure scenarios of two weeks to 1 year. As mentioned previously, an easy way to see if the health guideline is exceeded is to divide the estimated dose by the intermediate MRL. If the resulting HQ is less than one, then the estimated dose is less than the intermediate MRL and non-cancerous health effects are unlikely. As can be seen in Table 14, all the HQs for the various pesticides are less than 1; therefore, non-cancerous health effects are not likely.

An intermediate MRL does not exist for mirex so the estimated dose of 0.0000000002 mg/kg/day can be compared directly to levels that are known to cause harmful effects. For mirex, the lowest level known to cause harmful effects from intermediate exposures is 0.05 mg/kg/day. Harmful effects to the liver (specifically, fatty degeneration) were seen in rats exposed to 0.05 mg/kg/day for 28 days. The estimated dose of mirex in residents who eat three fish meals daily during Lent is 250 million times below the dose that caused harmful effects in rats. Therefore, harmful effects in people are not likely.

We recognize the importance of salmon and other fish in the diets of Alaskan Natives. Our exposure estimates were based on data for whole fish or fillet samples, whichever was higher. These estimates indicated that non-cancerous adverse health effects from exposure to the small amounts of pesticides in fish are unlikely. We could not evaluate exposures from fish portions such as kidneys, livers, eyes, or roe in traditional subsistence diets because the concentration of pesticide in these organs was not measured.

Table 9. Hazard Quotients (HQs) for adults who eat fish taken from Cook Inlet as part of a subsistence lifestyle. All HQs are below 1 indicating no harmful effects.

Pesticide	HQ, 7 oz fish daily	HQ, 14 oz fish daily	HQ, 18 oz fish daily
Dieldrin	0.02	0.05	0.06
Hexachlorobenzene	0.07	0.15	0.19
DDT/DDD/DDE	0.01	0.01	0.02
Chlordanes	0.01	0.02	0.03
Heptachlor epoxide	0.02	0.04	0.05
Lindane (g-HCH)	0.03	0.07	0.08
Endrin	0.003	0.01	0.01
Endosulfan	0.0004	0.0007	0.0009
Mirex	0.000001	0.000002	0.000002

Table 10. Hazard Quotients (HQs) for elementary age children who eat fish taken from Cook Inlet as part of a subsistence lifestyle. All HQs are below 1 indicating no harmful effects.

Pesticide	HQ, 7 oz fish daily	HQ, 14 oz fish daily	HQ, 18 oz fish daily
Dieldrin	0.02	0.05	0.06
Hexachlorobenzene	0.07	0.15	0.19
DDT/DDD/DDE	0.01	0.01	0.02
Chlordanes	0.01	0.02	0.03
Heptachlor epoxide	0.02	0.04	0.05
Lindane (g-HCH)	0.03	0.07	0.08
Endrin	0.003	0.01	0.01
Endosulfan	0.0004	0.0007	0.0009
Mirex	0.000001	0.000002	0.000002

Table 11. Hazard Quotients (HQs) for preschool children who eat fish taken from Cook Inlet as part of a subsistence lifestyle. All HQs are below 1 indicating no harmful effects.

Pesticide	HQ, 7 oz fish daily	HQ, 14 oz fish daily	HQ, 18 oz fish daily
Dieldrin	0.03	0.06	0.09
Hexachlorobenzene	0.09	0.18	0.28
DDT/DDD/DDE	0.01	0.02	0.03
Chlordanes	0.01	0.03	0.04
Heptachlor epoxide	0.02	0.05	0.07
Lindane (g-HCH)	0.04	0.08	0.13
Endrin	0.004	0.01	0.01
Endosulfan	0.0004	0.00009	0.0013
Mirex	0.0000001	0.0000002	0.0000003

Table 12. Dose estimates for dieldrin in mg/kg/day and the HQ for each consumption group (i.e., 7 oz/day, 14 oz/day, and 18 oz/day).

	Average Pesticide Concentration In mg/kg	% of Fish Eaten	Estimated Dose** 7 oz fish/day (0.19845 kg/d) In mg/kg/day	Estimated Dose 14 oz fish/day (0.39689 kg/d) In mg/kg/day	Estimated Dose 18 oz fish/day (0.51029 kg/d) In mg/kg/day
Chinook	0.000649	0.294	0.000000541	0.00000108	0.00000139
Chum	0.00019	0.059	0.0000000317	0.0000000634	0.0000000815
Cod	0.000174	0.007	0.00000000346	0.00000000692	0.0000000089
Flounder	0	0.005	0	0	0
Halibut	0.000293	0.131	0.000000109	0.000000217	0.00000028
Sea bass	0.000156	0.0001	4.43E-11	8.86E-11	1.14E-11
Sockeye	0.000345	0.141	0.000000138	0.000000276	0.000000355
Pink*	0.000395	0.184	0.000000199	0.000000399	0.000000513
Silver*	0.000395	0.171	0.000000191	0.000000383	0.000000492
Total Dose Dieldrin from all fish	(in mg/kg/d)		0.00000122	0.00000244	0.00000314
MRL for Dieldrin	(in mg/kg/d)		0.00005	0.00005	0.00005
HQ for Dieldrin = Total dose / MRL			0.02	0.05	0.06

* Pink and silver (Coho) salmon were not sampled as part of EPA's fish survey of Cook Inlet. Since these two species make up about 35% of the fish eaten by residents', ATSDR estimated the pesticide concentration in these two salmon species by taking the average pesticide level in the other three salmon species for which data are available (Chinook, Chum, and Sockeye).

** The estimated dose is determined using the following formula:
Dose = pesticide concentration x % fish diet x daily fish consumption ÷ body weight
Example: 0.000649 mg/kg x 0.294 x 0.19845 kg/day ÷ 70 kg = 0.000000541 mg/kg/day

Table 13. Dose estimates for dieldrin in ng/kg/day and the HQ for each consumption group (i.e., 7 oz/day, 14 oz/day, and 18 oz/day)

	Average Pesticide Concentration In ng/kg	% of fish eaten	Estimated Dose** 7 oz fish/day (0.19845 kg/d) In ng/kg/day	Estimated Dose 14 oz fish/day (0.39689 kg/d) In ng/kg/day	Estimated Dose 18 oz fish/day (0.51029 kg/d) In ng/kg/day
Chinook	649	0.294	0.541	1.082	1.392
Chum	189	0.059	0.032	0.063	0.082
Cod	174	0.007	0.003	0.007	0.009
Flounder	0	0.005	0.0	0.0	0.0
Halibut	293	0.131	0.109	0.217	0.28
Sea bass	156	0.0001	0	0.0	0.0
Sockeye	345	0.141	0.138	0.276	0.355
Pink*	395	0.184	0.206	0.412	0.529
Silver*	395	0.171	0.191	0.383	0.492
Total Dose Dieldrin From all fish	(in ng/kg/d)		1.22	2.441	3.138
MRL for Dieldrin	(in ng/kg/d)		50	50	50
HQ for Dieldrin	Total dose / MRL		0.02	0.05	0.06

* Pink and silver (Coho) salmon were not sampled as part of EPA's fish survey of Cook Inlet. Since these two species make up about 35% of the fish eaten by residents', ATSDR estimated the pesticide concentration in these two salmon species by taking the average pesticide level in the other three salmon species for which data are available (Chinook, Chum, and Sockeye).

** The estimated dose is determined using the following formula:

Dose = pesticide concentration x % fish diet x daily fish consumption ÷ body weight

Example: 649 ng/kg x 0.294 x 0.19845 kg/day ÷ 70 kg = 0.541 ng/kg/day

Table 14. Hazard Quotients for Adults Who Eat Three Fish Meals Daily During Lent.

Pesticide	Estimated Dose in mg/kg/day (21 ounces fish daily)	Intermediate MRL in mg/kg/day	Adult HQ
Dieldrin	0.00000366	0.0001	0.04
Hexachlorobenzene	0.000011	0.0001	0.1
DDT/DDD/DDE	0.000011	0.0005	0.02
Chlordanes	0.00002	0.0006	0.03
Lindane	0.000001	0.00001	0.1
Endrin	0.00000274	0.002	0.001
Endosulfan	0.00000211	0.005	0.004
Heptachlor Epoxide	0.00000074	0.0001*	0.01

* An intermediate MRL does not exist for heptachlor epoxide so ATSDR used the intermediate MRL for heptachlor, a precursor to heptachlor epoxide.

Figure 2. Hazard Quotient (HQ) for adults. The HQ is an estimated of dose in relation to the health guideline. The HQs for adults that were determined for pesticides, Aroclor 1260, and dioxin are below the health guideline indicating that non-cancerous harmful effects are not likely.

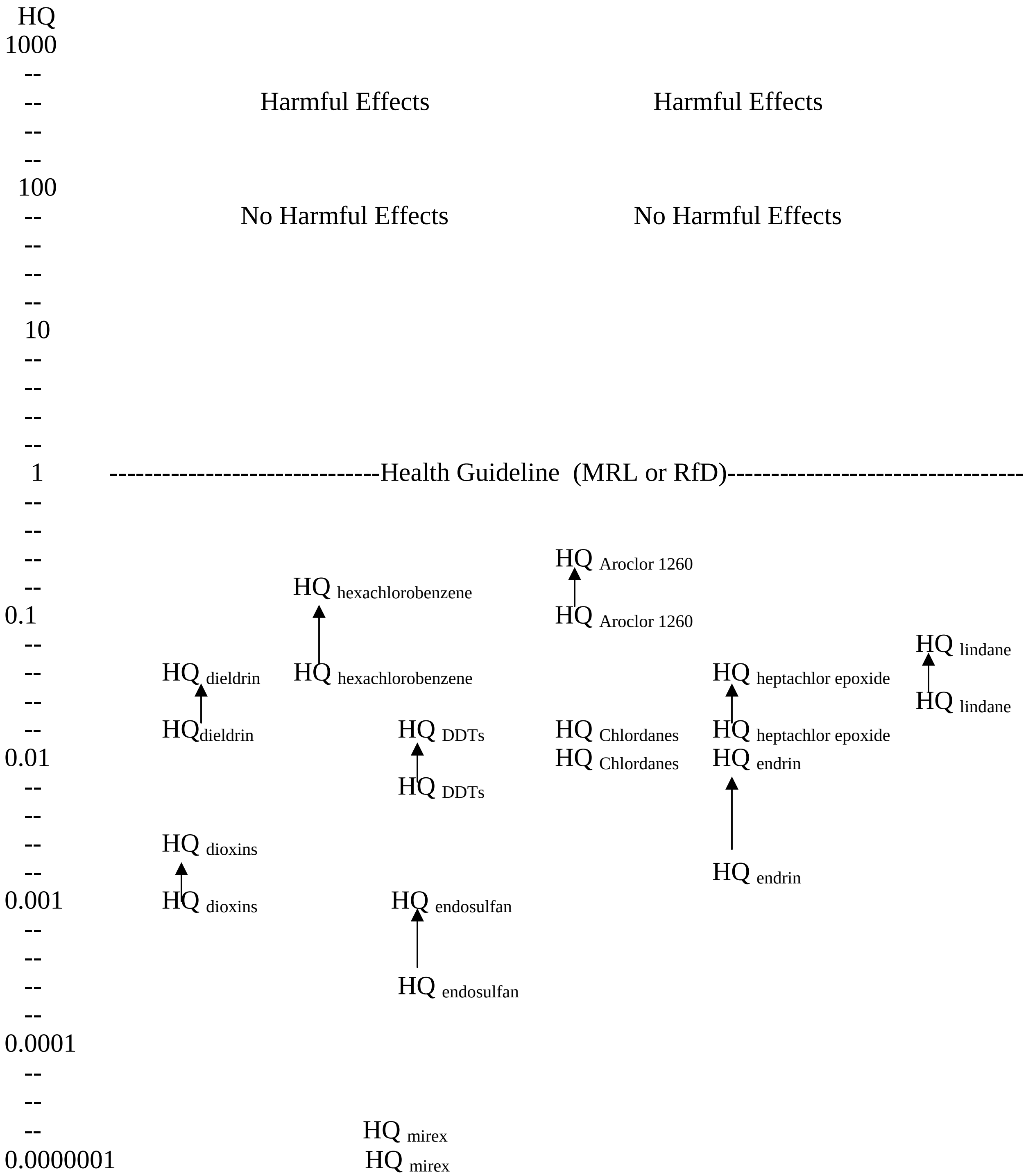
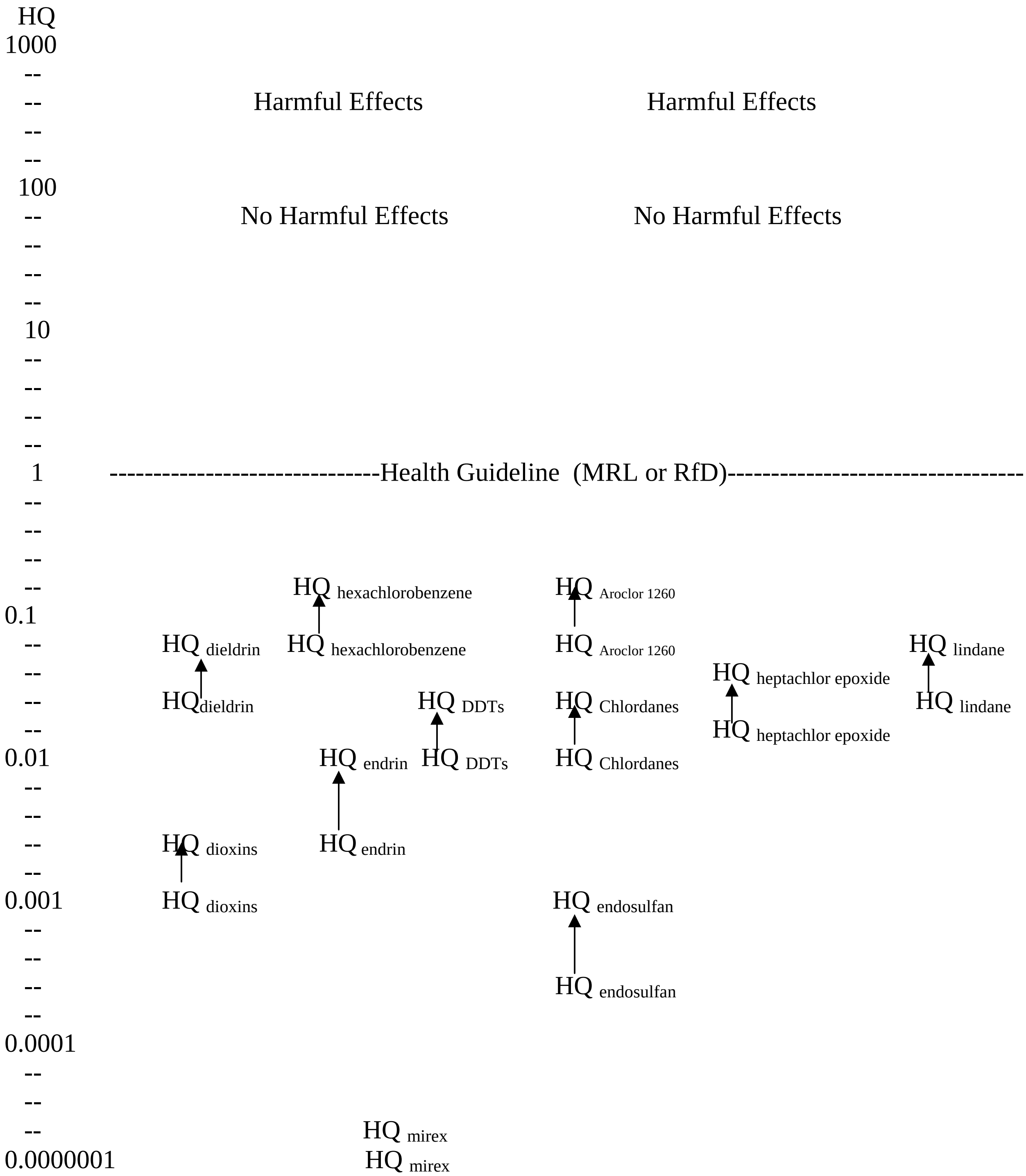


Figure 3. Hazard Quotient (HQ) for preschool children. The HQ is an estimated of dose in relation to the health guideline. The HQs for preschool children that were determined for pesticides, Aroclor 1260, and dioxin are below the health guideline indicating that non-cancerous harmful effects are not likely.



Aroclor 1260, Polychlorinated biphenyl congeners, and Dioxin

The levels of Aroclor 1260, eight PCB congeners, and one dioxin (octachlorodibenzo-p-dioxin, OCDD) were generally higher in whole fish samples analyzed by EPA compared to the mussel/clam, other invertebrate, or plant samples which EPA analyzed (Table 1) (USEPA 2003). Levels of these chemicals were about the same, or lower, in fillet samples analyzed by ADEC, with the exception of PCB congener 118 (ADEC 2005a).

Aroclor 1260

Aroclor 1260, which is also known as polychlorinated biphenyl (PCB 1260), was found in Chinook salmon, chum salmon, and sea bass at levels ranging from 1.4 µg/kg to 6.2 µg/kg (USEPA 2003). Aroclor 1260 was not detected in other fish species nor was it detected in other seafood (e.g., clams, mussels, octopus, and snail). ATSDR estimated the amount of exposure using the average concentration in each fish species to arrive at a total dose of Aroclor 1260 for various age groups (adults, teenagers, and children). The estimated total dose of Aroclor 1260 for all age groups is below ATSDR's chronic MRL of 0.00002 mg/kg/day. Therefore, non-cancerous effects are unlikely. The HQs for Arcolor 1260 can be found in Figure 2.

PCB Congeners and OCDD

Eight PCB congeners and OCDD, a dioxin, were found in fish samples analyzed by EPA and ADEC (Table 1) (USEPA 2003, ADEC 2005a). PCB congener 77 was also found in mussel/clam samples. PCB congeners 118, 170, and 180 were found in other invertebrate samples, and PCB congener 118 was also found in plants. Toxicity equivalency factors (TEFs) for the PCB congeners and OCDD from the World Health Organization (Table 15) were used to convert concentrations to dioxin equivalents. The concentration of each congener as dioxin equivalents was used to estimate exposure doses, which was then compared to the MRL for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (0.000000001, or 1×10^{-9}, mg/kg/day).

ATSDR estimated doses for residents with average fish intake (7 oz/day), above average fish intake (14 oz/day), and high fish intake (18 oz/day), which equates to 1 to 2 fish meals a day. Correspondingly smaller daily intakes were used for children as previously described. The estimated doses in all groups for each congener and for OCDD were below the chronic MRL for dioxin. When the congeners and OCDD were totaled, the lifetime estimated doses were also below the chronic MRL for dioxin; therefore, residents are not at risk of harmful effects from these dioxin-like compounds.

Adverse health effects related to exposures to PCB congeners and dioxin in native foods are not expected based on the contaminant data reviewed, the ingestion rates used, and the estimated exposures calculated. PCBs and dioxins are absorbed by lipids (fats) and tend to accumulate in fish oils and fatty portions of fish, including roe (eggs) (ATSDR 1998, ATSDR 2000c). Village customs may include using roe, organs or other fish portions in traditional subsistence diets. We could not assess exposures for these fish parts because data were only available for organs and roe. Village residents concerned about eating these fish parts may wish to discuss the need for obtaining data on these fish parts, such as roe.

Table 15. Toxic Equivalent Factors (TEFs) for PCB Congeners and OCDD*

PCB Congeners	Toxic Equivalent Factors
77	0.0001
105	0.00003
118	0.00003
123	0.00003
156	0.00003
167	0.00003
OCDD	0.0003

* TEFs for PCB congeners and OCDD were obtained from the World Health Organization, which revised their TEFs in 2005. The TEF can be found at this WHO website: http://www.who.int/ipcs/assessment/tef_update/en/.

Polycyclic Aromatic Hydrocarbons

EPA reports that about half of the 104 PAHs were detected in native foods from Cook Inlet (USEPA 2003, USEPA 2000a). The detected PAHs were divided into carcinogenic PAHs, non-carcingoenic PAHs, and PAHs with unknown health endpoints. Table 16 shows the carcinogenic and non-carcinogenic PAHs along with the frequency of detection of each PAH. Of the eight PAHs known to cause cancer, only two were detected in fish samples. Benz(a)anthracene was detected in one sea bass sample at 1 ppb. Naphthalene was detected in 2 of 6 Chinook salmon samples at concentrations up to 3.8 ppb. The average naphthalene concentration in all Chinook salmon samples was 1.9 ppb. Naphthalene also was detected in one sockeye and one halibut sample at similar concentrations. Table 17 shows the PAHs with unknown health endpoints. It should be pointed out that PAH concentrations in smoked fish are significantly higher than these levels. In addition, PAHs tend not to accumulate in fish and marine animals because these organisms metabolize PAHs, thus excreting them from the body. Shellfish on the other hand do not metabolize PAHs as readily and therefore then to have higher concentrations.

Given the small concentrations detected and limited number of detections in a few samples, significant exposures are considered unlikely to occur; therefore, harmful effects are not likely in residents who eat native foods.

Only the CIRCAC Environmental Monitoring Program (EMP) studies targeted contaminants originating from oil and gas facilities, and locations near off-shore oil rigs. Based on chemical fingerprint analyses, Lees et al. traced PAH levels observed in the clam and mussel tissue samples to multiple natural sources such as coal deposits, peat, and natural oil seeps, but did not find evidence of PAHs being associated with oil and gas industry operations. These findings were supported by modeling studies of oil and gas facility discharges, which determined that plumes dilute and mix rapidly as they move away from discharge sites in upper Cook Inlet and; therefore, should not accumulate in significant amounts (Lees et al. 1999). The EMP study only performed analyses on a small, unspecified number of bivalves. Nevertheless, most of these bivalve samples showed either non-detectable or low levels of PAHs, which appear to have originated from natural, as opposed to industrial, sources in the inlet.

Table 16. PAHs with Cancer or Non-cancer Endpoints (USEPA 2000a, 2003)

PAHs	Detection Frequency	Non-cancer Health Endpoint	Cancer Health Endpoint
2-methylnaphthalene	4/87	Yes	No
Acenaphthene	8/87	Yes	No
Anthracene	0/87	Yes	No
Benzo(g/h/i)perylene	0/87	Yes	No
Dibenzofuran	2/87	Yes	No
Fluoranthene	1/87	Yes	No
Fluorene	4/87	Yes	No
Pyrene	1/87	Yes	No
Phenanthrene	2/87	Yes	No
Benzo(a)anthracene	1/87	Yes	Yes
Benzo(a)pyrene	0/87	Yes	Yes
Benzo(b/j/k)fluoranthenes	0/87	Yes	Yes
Chrysene	0/87	Yes	Yes
Dibenzo(a,h/a,c)anthracene	0/87	Yes	Yes
Indeno(1-2-3-cd)pyrene	0/87	Yes	Yes
Naphthalene	9/87	Yes	Yes

Table 17. PAHs Listed by EPA (USEPA 2000a, 2003) as Not Having Assessment Endpoints

PAHs	Detection Frequency
1,3-Dimethylnaphthalene	2/87
1,3,6-Trimethylnaphthalene	2/87
1,4,6/1,3,5/2,3,6 Trimethlynaphthalenes	2/87
1,7/1,6-Dimethlynaphtalenes	2/87
1-Methylnaphthalene	2/87
1-Methylphenanthrene	1/87
2,3/1,4-Dimethlynaphthalene	1/87
2,6/2,7-Dimethlynaphthalene	21/87
2-Methylphenanthrene	7/87
3,4,7,12a-Tetramethyloctahydrochrysene	4/87
3-Methylphenanthrene	2/87
9/4-Methylphenanthrene-1-methylanthracene	1/87
Benzo(b)fluorene	1/87
C1-Dibenothiophenes	16/87
C1-Fluoranthene/pyrenes	6/87
C1-Naphthalene	4/87
C1-Phenathrene/anthracene	9/87
C2-Dibenzothiophenes	27/87
C2-Fluoranthene/pyrenes	11/87
C2-Naphthalenes	29/87
C2-Phenanthrene/anthracene	16/87
C3-Naphthalenes	59/87
C3-Phenanthrene/anthracene	34/87
C4-Fluoranthene/pyrenes	1/87
C4-Naphthalenes	23/87
C4-Phenanthrene/anthracene	37/87
Cadelene	2/87
Cyclopenta(c,d)pyrene	7/87
Dehydroabietane	2/87
Dehydroabietin	2/87
Dibenzothiophene	1/87
Simonellite	2/87
Tetrahydroretene	2/87

Results of Cancer Evaluations

Background information about cancer

Cancer is a complex subject and some background information is provided before discussing evaluations of the Cook Inlet native food data. The probability that residents of the United States will develop cancer at some point in their lifetime is 1 in 2 for men (44.9 %) and 1 in 3 (38.5%) for women (ACS 2009). This probability is based on medical data collected on all types of cancer, regardless of whether the cause was identified, the case was successfully treated, or the patient died (directly or indirectly) from the cancer.

Factors that play major roles in cancer development include: lifestyle (what we eat, drink, smoke; where we live); natural (including sunlight) and medical radiation; workplace exposures; drugs; socio-economic factors; and chemicals in our air, water, soil, or food. Infectious diseases, aging, and individual susceptibility, such as genetic predisposition, are also important factors in cancer development (NTP 2005).

We rarely know environmental factors or conditions responsible for the onset and development of cancer. For some occupational exposures or for the use of specific drugs, we do have some understanding of cancer development (Tomatis et al. 1997). Overall cancer risks can be reduced by eating a balanced diet, getting regular exercise, having regular medical exams, and avoiding high risk behaviors, such as tobacco use and excessive alcohol consumption. Proper safety procedures, appropriate personal protective equipment, and medical monitoring programs can decrease cancer risks in the workplace.

How to estimate and interpret cancer risk

The EPA has a method for estimating the cancer risk from chemical exposure. The cancer risk is estimated by multiplying the estimated dose for a population by what is called a cancer slope factor. The resulting number is an estimate of the number of cancers in a population over a lifetime that might result from the chemical exposure. The equation for estimating cancer risk follows:

Cancer risk = estimated lifetime dose x cancer slope factor

The resulting risk of cancer is called an excess cancer risk because it is the risk of cancer above the already existing background risk of cancer. The EPA also states that the risk could be zero. Therefore, one interprets the excess cancer risk as being between 0 and some number for every 10,000 or 100,000 or 1,000,000 exposed people.

This additional theoretical cancer risk estimate from chemical exposures is often stated as 1×10^{-4}, 1×10^{-5}, or 1×10^{-6}. Using 1×10^{-6} as an example, it means that a population of one million people exposed to a carcinogen over a lifetime (70 years) may have between zero and one additional case of cancer because of the exposure. This estimated cancer risk is in addition to the 187,500 cases expected in women and the 224,500 cases expected in men over a lifetime. The “one-in-a-million” risk level is generally regarded as a very low risk. If the exposed population is small, it is difficult to prove that cancer cases in a community are the result of chemical exposures, especially given the large number of people that get cancer from unknown causes.

An estimated additional theoretical cancer risk of 1×10^{-4} means that a population of 10,000 people exposed for a lifetime (70 years) may have between zero and one additional cancer case. This one case is in addition to the 4,120 cases expected in this population (i.e., 1,875 cases expected in women and the 2,245 cases expected in men). Although a “one-in-ten thousand” risk level may be viewed as an increased level of risk, it is good to understand the exposure assumptions that went into estimating this risk; and, in the case of fish, to compare this risk with the risk that results from eating store-bought fish. Using all this information will help people decide if they should change their eating habits to reduce the risk of cancer.

Mathematically, the excess cancer risk is a theoretical estimate of the 95% upper confidence limit of additional cancer risk. The true risk is not known, but will likely be lower, and could be zero, which is why the calculated risk should be stated as 0 to some number per 10,000 or 100,000, or 1,000,000 people exposed. When we talk about the additional or excess theoretical cancer risk, we mean the risk above and beyond what is considered background or normal. It is important to remember that we cannot determine an individual’s cancer risk but rather the estimated cancer risk refers to the risk for a population of people with similar dietary habits.

Elements

Arsenic

Arsenic is classified as a known human carcinogen based on human studies showing skin, bladder, and lung cancer in people who drank arsenic-contaminated water for several decades as well as occupational studies showing lung cancer in workers exposed by inhalation (ATSDR 2000a). To estimate exposure to arsenic for various age groups, ATSDR used ingestion rates of 7 oz/day, 14 oz/day, and 18 oz/day for adults, half those amounts for teenagers, and 1/3 those amounts for preschool children. Using the estimated dose for each age group, a lifetime dose was estimated and multiplied by the oral cancer slope factor of 1.5 per mg/kg/day to estimate the additional cancer risk for residents exposed for their lifetime. The excess lifetime cancer risk from eating native foods (fish, shellfish, and plants) with arsenic have the following risk ranges for these groups:

Average native food consumption	1 fish meal/day	0 to 1 extra case per 100,000 people,
Above average native food consumption	2 fish meals/day	0 to 3 extra cases per 100,000 people,
Highest native food consumption	2 fish meals/day	0 to 4 extra cases per 100,000 people.

The State of Alaska reported lung cancer as the most common cause of cancer-related deaths for Alaskans in 1997 and 1998. It was the most commonly diagnosed cancer in men, and the second most common cancer in women (State of Alaska 2000, 2002). Lung cancer is most typically associated with tobacco use. It is unlikely that arsenic in native foods from Cook Inlet contributes to lung cancer incidence in the villages of Tyonek, Seldovia, Port Graham, and Nanwalek.

Ingestion of arsenic in drinking water has been associated with skin cancer. We did not review drinking water data for these four villages. We also did not review information on skin cancer in Alaska. As villages continue to build their capacity to assess specific public health issues, we encourage them to include arsenic in drinking water. This may be an important exposure pathway for arsenic because of the prevalence of naturally occurring arsenic (arsenopyrite) in Alaska (Burgett 2005).

Exposure to inorganic arsenic from eating native foods collected from Cook Inlet poses no apparent health hazard to Alaskan Natives.

Cadmium

Cadmium can be carcinogenic when inhaled, but human or animal studies have not provided sufficient evidence to show that cadmium is a carcinogen by oral routes of exposure (ATSDR 1999b). Thus, ATSDR did not evaluate cancer effects for cadmium as part of this consultation.

Pesticides

In the initial release of this health consultation in December 2005, ATSDR used the average pesticide concentration for all fish to estimate the dose. Because residents were concerned that this approach was inaccurate, ATSDR used two approaches to evaluate cancer risk from pesticides. The first approach involves using the average concentration of a pesticide in <u>each</u> fish species (instead of all fish) to estimate cancer risk. The second approach involves using EPA's fish advisory guidelines. Details on each approach are described in the appropriate subsections that follow.

The first approach: using dose to estimate cancer risk

Average pesticide levels are different for various species of salmon and other fish that residents eat from Cook Inlet. It is possible to estimate cancer risk by doing the following:

1. Estimate the dose of each carcinogenic pesticide for each species
2. Multiply the dose by the dietary percentage of each fish species
3. Multiply the previous term by the cancer slope factor.

The formula for estimating cancer risk follows:

Estimated excess cancer risk =

Pesticide dose in population group x % of fish in diet x cancer slope factor.

To estimate a lifetime dose, it is necessary to estimate the cancer risk for various age groups (e.g., preschool children, elementary age children, teenagers, and adults). Summing the incremental cancer risk for each age group yields a total lifetime cancer risk from eating Cook Inlet fish.

Cancer risk estimates were generated for three fish intake rates for village residents: average fish intake, above average fish intake and highest fish intake. For adults this equates to 1 fish meal per day (7 oz/day) or approximately 2 fish meals days (14 and 18 oz/day). For children, ATSDR varied the intake rate for teenagers (6, 12, and 14 oz/day), for elementary age children (3.5, 7, and 9 oz/day), and for preschool children (2, 4, and 6 oz/day). Like adults, these fish intake rates equate to about 1 or 2 fish meals a day.

Using dieldrin as an example, the estimated excess cancer risk from this pesticide should someone live in the village their entire life follows:

Average fish intake	1 fish meal/day	0 to 2 cancers per 100,000 people
Above average fish intake	2 fish meals/day	0 to 4 cancers per 100,000 people
Highest fish intake	2 fish meals/day	0 to 6 cancers per 100,000 people.

The calculations that go into estimating the cancer risk are shown in Appendix C. It is important to remember that the dieldrin levels in Cook Inlet fish are similar to dieldren levels in fish from other parts of Alaska and from a survey of grocery stores in the US. Therefore, people from other parts of Alaska and the US who eat 1 to 2 fish meals/day have a similar cancer risk.

The cancer risk from other carcinogenic pesticides can also be estimated. These pesticides include chlordanes, heptachlor epoxide, hexachlorobenzene, and DDTs. The cancer risk from these pesticides is much lower than the cancer risk from dieldrin. Instead of presenting the cancer risk for each pesticide, the total cancer risk for all carcinogenic pesticides will be presented:

The total excess cancer risk from <u>all</u> carcinogenic pesticides should someone live in the village their entire life follows:

Average fish intake	1 fish meal/day	0 to 3 cancers per 100,000 people
Above average fish intake	2 fish meals/day	0 to 7 cancers per 100,000 people
Highest fish intake	2 fish meals/day	0 to 9 cancers per 100,000 people.

Stated another way, the risk of <u>not</u> getting cancer ranges from 99.997 for residents with average fish intake to 99.991 for residents with the highest fish intake.

As expected, the cancer risk from all pesticides is slightly higher than the cancer risk from dieldrin alone. For example, the cancer risk from dieldren for residents who eat 1 fish meal per day is 0 to 2 per 100,000 people while the cancer risk from all pesticides combined is increased by 0 to 3 cases per 100,000 people. The small increase in risk from combining all pesticides shows that the other pesticides contribute very little to the overall cancer risk. Most of the cancer risk comes from dieldrin. In addition, about 70% of the risk comes from eating fish for 50 years as an adult and 30% of the risk comes from eating fish for 18 years as a child.

To summarize, the estimated excess cancer risk from pesticides in fish is low and the same risk can be estimated for people who eat 1 to 2 meals per day of fish from other parts of Alaska or the U.S.

The second approach: using EPA's fish advisory guidelines

At the request of Port Graham residents, ATSDR used EPA's fish advisory guidelines to calculate the number of meals someone would need to eat to have a theoretical cancer risk of 1 extra case of cancer for every 100,000 people. While the mathematics are relatively simple, the high number of calculations make the calculation very complicated. For more details on this approach, the reader is referred to EPA's Guidance for Assessing Chemical Contaminant Data for Use In Fish Advisories, which is available at this website: http://www.epa.gov/waterscience/fish/guidance.html.

In September 2007, ATSDR staff met with the chief of the Village of Port Graham, the environmental director, and the village's environmental team to discuss EPA's fish advisory guidelines and the mathematics that go into calculating the number of acceptable meals. What follows is a brief explanation of EPA's fish advisory guidelines and the resulting calculations.

The formula for determining the number of acceptable fish meals per month follows:

$$\text{\# acceptable meals per month} = \frac{\text{Acceptable cancer risk level x body weight}}{\text{sum (chemical concentration in fish x cancer slope factor)}}.$$

The formula can also be written as: CR lim = ARL ÷ sum (Cm x CSF), where

CR lim is the allowable fish consumption rate in kg fish per day
ARL is set at a cancer risk of 1 extra case of cancer for every 100,000 people who eat fish
BW is a body weight of 70 kg
Cm is the average concentration of pesticide in a fish species (e.g., Chinook salmon)
CSF is the cancer slope factor for a pesticide.

CR lim is the amount of fish in kg that someone can eat each day which will result in a cancer risk of 1 extra case of cancer for every 100,000 people. The result in kg fish eaten/day can be converted to ounces fish eaten /day or meals per month.

Using EPA's fish advisory formulas, residents who eat 4 Chinook salmon meals per month have an additional cancer risk of 1 in 100,000. Table 18 shows all the calculations that go into arriving at 4 meals per month. The upper portion of Table 18 shows the Cm x CSF term in the far right column for each pesticide and then the sum of all the pesticides to get a total (Cm x CSF), which is 0.02249. The bottom portion of Table 18 shows the remaining formula where the cancer risk is set at 1 in 100,000 (or 0.00001). The body weight is assumed to be 70 kg or 154 lbs. After solving for CR lim in kg fish/day in the bottom portion of Table 18, the term is converted to fish meals per month to yield 4 eight ounce meals per month. This means that if 100,000 residents eat 4 eight ounce Chinook salmon meals per month somewhere between 0 and 1 extra case of cancer might occur.

The problem with this approach is that it only evaluates the risk from eating Chinook salmon so it is necessary to include the cancer risk from eating other fish that contain cancer-causing pesticides. After including other fish, if 100,000 residents ate 7 eight ounce fish meals per month, somewhere between 0 and 1 extra case of cancer might occur. The same basic formula is used to estimate the number of acceptable meals; however, the math is very complicated and so is not shown in this report. The final formula looks like this:

CR lim = ARL x BW ÷ sum (Cm x % fish in diet x CSF)

CR lim = 0.00001 x 70 ÷ 0.014006997

CR lim = 0.0499750 kg fish/day

CR lim = 0.0499750 kg fish/day x 30.4 days/month ÷ 0.227 kg in 8 oz meal

CR lim = 6.7 meals per month

Cancer risk can also be expressed another way. If someone has a cancer risk of 1 in 100,000, they also have a risk of 99.999% of not getting cancer from eating fish taken from Cook Inlet.

Most of the theoretical cancer risk from eating Cook Inlet fish comes from the pesticide dieldrin. The concentration of dieldrin in Cook Inlet fish was 0.649 ppb (whole fish) and 0.532 ppb (fillet fish). These levels can be compared to 0.69 ppb in fillet fish from other parts of Alaska and 0.57 ppb from a survey of grocery stores in the US conducted by the federal Food and Drug Administration (see http://www.cfsan.fda.gov/~acrobat/tds1byfd.pdf.) The estimated cancer risk from dieldrin is similar regardless of where the fish are caught or purchased. Since there are many benefits from eating wild-caught fish, residents should take this into consideration when deciding whether or not to limit their consumption of native fish because of dieldrin.

Polycyclic Aromatic Hydrocarbons

The majority of the PAHs reported by EPA were found in less than 10 percent of the native food samples (EPA 2003). Likewise, PAHs in most clam and mussel samples collected by CIRCAC were also reported to be below detection limits (Lees et al. 1999, 2001). Cancer risks were not evaluated because of the low frequency of detection of carcinogenic PAHs (see Table 16).

EPA reported several classes of PAHs in numerous native food samples (EPA 2000a). These classes included C3- and C2-naphthalenes, C4- and C3-phenanthrene/anthracene, and C2-dibenzothiophenes (Table 17). Health implications of these chemicals in foods are currently unknown.

	A	B	C	D	E	F	G	H	I	J	K
59	Table 18	Average				Average		TEF	Average	Cancer	
60		Concentration				Conc		Conversion	Conc	Slope	Cm x CSF
61	Chemical					in mg/kg		Factor	in mg/kg	Factor	↓
62											
63	Octachlorodibenzodioxin	6.3	ng/kg	÷	1,000,000	0.0000063		0.0003	0.000000002	156,000	0.000295
64	PCBs Aroclor 1260	1,421	ng/kg	÷	1,000,000				0.001421	2	0.002842
65	Chlordane	2,898	ng/kg	÷	1,000,000				0.002898	0.35	0.001014
66	DDT/DDE	7,682	ng/kg	÷	1,000,000				0.007682	0.34	0.002612
67	DDD	1,154	ng/kg	÷	1,000,000				0.001154	0.24	0.000277
68	Dieldrin	649	ng/kg	÷	1,000,000				0.000649	16	0.010384
69	Heptachlor Epoxide	150	ng/kg	÷	1,000,000				0.00015	9.1	0.001365
70	Hexachlorobenzene	1,783	ng/kg	÷	1,000,000				0.001783	1.6	0.002853
71	Lindane	123	ng/kg	÷	1,000,000				0.000123	1.3	0.00016
72											
73										sum (Cm x CSF) =	0.021802
74											
75	**CR lim = ARL x BW / sum (Cm x CSF)**										
76											
77	CR lim = 0.00001 x 70 / 0.02249										
78											
79	CR lim =	0.032108	kg fish per day								
80											
81	CR lim =	0.032108	kg fish / day x 30.4 days / month ÷ 0.227 kg in 8 oz / meal								
82											
83	CR lim =	4.3	# 8 oz meals/month that equal a 1 in 100,000 cancer risk								
84											

Aroclor 1260 and Dioxin

Aroclor 1260 was found in 3 of the seven fish species tested. Using a range of fish intakes described previously (7 oz/day, 14 oz/day, and 18 oz/day for adults and lower amounts for children), ATSDR estimated the total dose of Aroclor 1260 for village residents. The estimated cancer risks follow:

Average native food consumption	1 fish meal/day	0 to less than 1 extra case per 100,000 people,
Above average native food consumption	2 fish meals/day	0 to 1 extra cases per 100,000 people,
Highest native food consumption	2 fish meals/day	0 to 2 extra cases per 100,000 people.

Dioxin is made up of a group of similar chemicals and only one dioxin compound was detected, octachlordibenzodioxin (OCDD) in one sample in one fish species, Chinook salmon. OCDD is about 3,000 times less toxic than tetrachlorodiobenzodioxin (TCDD) (WHO 2008). The OCDD concentration was converted to a dioxin-equivalent concentration by multiplying by 0.0003. The resulting concentration as dioxin equivalents was used to estimate overall cancer risk (see Table 18). OCDD contributes very little to total cancer risk, which is consistent with it being found in only one fish sample.

Comparison of Cook Inlet Biota Data with Other Alaska Data

Alaska Department of Environmental Conservation (ADEC) Fish Monitoring Program

To determine if Alaskan seafood is safe to eat, ADEC is collecting salmon (all five species), halibut, pacific cod, sablefish, lingcod, pollock, and other species from primarily marine waters throughout the state, including locations in Cook Inlet. All fish are being analyzed for heavy metals and a subset are being analyzed for dioxins and furans, pesticides, PCB congeners, inorganic arsenic, and chromium VI (ADEC 2005b, 2005c). Since 2002, over 2,300 fish samples were collected and analyzed by the Alaska Division of Public Health (ADPH). With a few exceptions, those primarily being shark species or very large fish, the levels of contaminants in Alaska fish are low.

The State of Alaska has issued fish consumption advice for Alaskan residents, which can be found at this website: http://www.epi.hss.state.ak.us/bulletins/docs/rr2007_04.pdf.

Table 19 shows concentrations of pesticides, dioxins, and PCBs in skinless Chinook salmon fillets collected from Cook Inlet (ADEC 2005a) compared to fillets collected from marine waters and river mouths throughout Alaska (ADEC 2005b). In general, the concentrations detected in Cook Inlet fall within the range of concentrations detected from fish caught throughout Alaska. None of the maximum concentrations in Cook Inlet exceeded the maximum concentrations detected elsewhere. The average concentrations for fish collected throughout Alaska were calculated differently than for fish collected from Cook Inlet, so direct comparisons can be made only for contaminants that were detected in 100 percent of the samples[1]. For these samples, the average concentrations in fish from Cook Inlet were lower than the average concentrations in fish throughout Alaska.

Table 20 shows the average concentrations of metals in fish fillets collected from Cook Inlet (ADEC 2005a) compared to fish fillets collected from marine waters throughout Alaska (ADEC 2005c). There was no clear pattern of higher contaminant concentrations. Most average concentrations in fish from Cook Inlet were similar to the average concentrations in fish collected throughout Alaska.

Some caution is warranted when making these comparisons because the data are derived from separate sampling events.

2001 U.S. Fish and Wildlife Service (USFWS) Kuskokwim River and Yukon River Salmon Study

Between June and August 2001, USFWS collected 108 salmon from the Kuskokwim River (20 Chum and 20 Chinook) and the Yukon River (40 Chum and 28 Chinook). Muscle from 108 salmon and eggs from 43 salmon were analyzed for organochlorines, metals, and methylmercury. Metals in kidney and organochlorines in liver were also analyzed. Table 21 shows the organochlorine concentrations in Cook Inlet Chinook salmon fillets (ADEC 2005a) compared to muscle samples from fish collected in the Kuskokwim River and Yukon River (Matz and Mueller 2005). The Cook Inlet fillets contained lower average concentrations than both the Kuskokwin River and Yukon River, except for alpha-BHC and dieldrin. With the exception of alpha-BHC, muscle samples from the Yukon River contained the highest average levels of contaminants.

Because the metals data from the Kuskokwim River (Table 22) and Yukon River (Table 23) salmon are reported in dry weight concentrations (Matz and Mueller 2005), they cannot be directly compared to the wet weight concentrations from Cook Inlet (ADEC 2005a).

1992–1997 National Institute of Standards and Technology (NIST) Beluga Whale Monitoring Study

Because Cook Inlet beluga whales spend most of their lives in Cook Inlet and lie at the top of the food chain, they can serve as good indicators of bioaccumulation from local contaminant sources. As part of the Alaska Marine Mammal Tissue Archive Project, NIST analyzed the liver, blubber, kidney, and muscle from 13 beluga whales collected in Cook Inlet between 1992 and 1997. USFWS collected samples from these animals, which were either found stranded or taken from the inlet by subsistence hunters, and analyzed them for organochlorine compounds and metals. Table 24 and Table 25 list contaminant levels reported in beluga whales from Cook Inlet and present contaminant levels detected in beluga whales from Alaskan, Canadian, and Greenland Arctic marine waters (Becker et al. 2000). Beluga whale data compiled by Becker show lower average concentrations of organochlorine compounds in beluga whales collected

[1] To calculate averages for fish collected from Cook Inlet, non-detects were substituted with a value equal to half the detection limit. Non-detects were not included in the calculation of averages for fish collected throughout Alaska.

from Cook Inlet when compared with other regions in Alaska and the arctic (Table 24) (Becker 2000). Other than some of the essential nutrients (calcium, magnesium, potassium, and sodium), beluga whales collected from Cook Inlet contained higher average concentrations of cesium and copper for both male and female whales, and rubidium and zinc in male whales only (Table 25).

Assumptions and Limitations

Conservative approaches were used to evaluate non-cancer and cancer effects from exposure to individual chemicals. Exposure estimates assumed that most chemicals are 100 percent bioavailable, that is, all the chemical that is eaten crosses the gut; and, that people eat native foods every day of the year. Average chemical concentrations for each fish species were determined to help provide reasonable estimates of exposure levels. Data for whole fish and fish fillet samples were not used to assess chemical exposures from eating specific portions of fish, such as liver, kidney, or roe. In addition, the ADEC data, which focused on fillet samples, may not represent the exposure that Alaskan Natives receive who eat other parts of the fish, such as organs, skin, and heads.

A variety of fish ingestion rates were used in this report for the different age groups as shown below:

- 7 to 18 oz per day for adults,
- 6 to 14 oz per day for teenagers,
- 3.5 to 9 oz per day for elementary school children, and
- 2 to 6 oz per day for preschool children.

The range of ingestion rates for adults encompassed the ingestion rates of traditional foods determined from the Port Graham dietary survey. The ranges selected for other age groups were estimated. Residents of the villages are encouraged to continue developing information on consumption rates and dietary habits relevant to their specific customs.

This health consultation focuses on chemical-specific exposures and evaluating potential adverse health effects of individual chemicals. While it is important to understand potential interactions of chemicals at environmentally relevant doses, relatively few studies have been conducted to assess chemical interactions at low doses. Studies by Jonker et al. (1990, 1993), Seed et al. (1995), and Wade et al. (2005) indicated no discernable responses until doses of individual chemicals approached or exceeded their individual thresholds. The authors reported that there was no evidence of interactive effects from exposures to mixtures when individual chemicals were well below individual thresholds, which is the case for native foods from Cook Inlet. Based on the data reviewed for this health consultation, the potential for adverse interactions of chemicals found in Cook Inlet biota is not likely. We recognize that limited information is currently available for evaluating chemical mixtures.

Table 19. Concentrations of Pesticides, Dioxins, and PCBs in Skinless Chinook Salmon Fillets Collected from Cook Inlet Compared to Fillets Collected From Marine Waters and River Mouths Throughout Alaska (ppb wet weight).

Chemical	Min	Max	Average[1]	Detects[2]	Min	Max	Average[3]	Detects[4]
	Cook Inlet				Throughout Alaska			
cis-Chlordane	0.448	0.86	0.741	6/6	0.45	2.42	**1.07**	17/17
trans-Chlordane	0.183	0.32	0.258	6/6	0.18	0.84	**0.37**	17/17
O,p'-DDD	0.113	0.377	0.22	6/6	0.11	0.55	**0.3**	17/17
o,p'-DDE	0.129	0.273	0.187	5/6	0.11	0.8	0.31	16/17
p,p'-DDE	1.94	5.39	3.853	6/6	2.12	10.7	**4.8**	17/17
o,p'-DDT	0.284	0.83	0.579	6/6	0.29	2.79	**1.04**	17/17
p,p'-DDT	0.255	0.693	0.567	6/6	0.29	4.03	**1.29**	17/17
Dieldrin	0.271	0.77	0.532	6/6	0.14	1.89	**0.69**	17/17
Dioxin/Furan TEQ	3.50E-05[5]	9.50E-05[5]	5.90E-05[5]	6/6	NA	NA	4.00E-04[6,7]	NA
Endrin	0.132	0.201	0.138	4/6	0.13	0.56	0.25	10/17
α-HCH	0.357	1.84	0.948	6/6	0.21	3.38	**1**	17/17
β-HCH	0.401	0.987	0.468	4/6	0.16	1.63	0.64	14/17
γ-HCH	0.341	0.341	0.121	1/6	0.14	0.88	0.32	8/17
Heptachlor epoxide	0.157	0.428	0.315	6/6	0.16	0.86	0.04[8]	17/17
Hexachlorobenzene	0.898	1.82	1.506	6/6	0.9	5.19	**2.2**	17/17
Mirex	0.081	0.098	0.067	4/6	0.04	0.15	0.09	14/17
cis-Nonachlor	0.207	0.316	0.285	6/6	0.21	0.8	**0.38**	17/17
trans-Nonachlor	0.73	1.09	0.984	6/6	0.73	3.24	**1.41**	17/17
Total PCBs	2.071[9]	3.262[9]	2.828[9]	6/6	4.11[6,10]	18.02[6,10]	8.17[6,10]	NA
Total Toxaphene	10.1	17.7	10.043	3/6	3.69	52.4	21.14	13/17

Source: ADEC 2005a, 2005b

[1]To calculate averages, non-detects were substituted with a value equal to half the detection limit.

[2]A total of six chinook salmon were collected for analysis.

[3]Pesticide averages are calculated from individual fish samples with reportable concentrations above the detection limit, non-detects are not included in the calculation.

[4]A total of 17 chinook salmon were collected for analysis.

[5]Total relative concentrations were calculated using the toxic equivalency factor (TEF) approach for dioxins. The TEF approach compares the relative potency of individual dioxin congeners with that of tetrachlorodibenzo-p-dioxin (TCDD), the best-studied member of this chemical class. The concentration or dose of each dioxin-like congener is multiplied by its TEF to arrive at a toxic equivalent (TEQ). The TEQs are added to give the total toxic equivalency (USEPA 1996b and ATSDR 2000c).

[6]PCBs and dioxins levels below the detection limit were reported as zero for the calculations.

[7]TEQ calculated using World Health Organization Toxic Equivalency Factors (Van Den Berg et al. 1998).

[8]This is the average concentration reported in ADEC 2005b, however, given the minimum concentration and that heptachlor epoxide was detected in all samples, the average concentration appears to be incorrect.

[9]Total PCBs equal the sum of congeners above detection limits from the following congener list: 18,28,37,44,49,52,66,74,77,81,87,95,99,101,105,110,115,118,123,126,128, 137,138,146, 149,151,153,156,157,167,169,170,172,177,178,180,183,187,189,194,195,196,201,206,209.

[10]Total PCBs based on the sum of 44 congeners: 18,29,28,37,44,49,52,61,66,77,74,81,83,99,86,90,93,95,101,105,110,114,118,123,126,128,129, 138,135,151,137,146,147,149,153, 156,167,169,170,172,177,178,180,183,187,189,194,195,196,201,206,209.
NA = not available
ND = not detected
Bold indicates the higher value between Cook Inlet fillet samples (ADEC 2005a) and fillet samples collected throughout Alaska (ADEC 2005b), for contaminants that were detected in 100 percent of the samples.

Table 20. Average Concentrations of Metals in Fish Fillets Collected From Cook Inlet Compared to Fish Fillets Collected From Marine Waters Throughout Alaska (ppb wet weight).

Chemical	**Chinook salmon fillet**		**Chum salmon fillet**		**Pink salmon fillet**		**Red salmon fillet**	
	Cook Inlet	**Across Alaska**	**Cook Inlet**	**Across Alaska**	**Cook Inlet**	**Across Alaska**	**Cook Inlet**	**Across Alaska**
Arsenic	**470**	450	240	**260**	210	**220**	290	**320**
Cadmium	5	5	**8**	5	2	**4**	5	**7**
Chromium	4	**7**	**20**	8	**16**	15	**8**	5
Lead	**27**	22	**30**	24	**25**	22	18	**22**
Methylmercury	**48**	34	**33**	31	**17**	16	**32**	27
Nickel	ND	**10**	ND	**10**	ND	**20**	**23**	12
Selenium	95	**145**	**202**	196	140	**150**	142	**146**
Chemical	**Silver salmon fillet**		**Cod fillet**		**Pollock fillet**		**Halibut roast**	
	Cook Inlet	**Across Alaska**	**Cook Inlet**	**Across Alaska**	**Cook Inlet**	**Across Alaska**	**Cook Inlet**	**Across Alaska**
Arsenic	**400**	340	7,100	**11,300**	3,600	**6,100**	**1,750**	1,570
Cadmium	**5**	4	3	3	**5**	3	**3**	2
Chromium	ND	**50**	**62**	17	**37**	24	3.6	**4.6**
Lead	ND	**20**	17	**22**	19	**17**	31	31
Methylmercury	**31**	27	56	**89**	38	**45**	100	**220**
Nickel	ND	**70**	**30**	18	14	**20**	ND	**10**
Selenium	**160**	130	190	**210**	139	**148**	**410**	260

Source: ADEC 2005a, 2005c
To calculate averages, non-detects were substituted with a value equal to half the detection limit.
Bold **indicates the higher value between Cook Inlet fillet samples (ADEC 2005a) and fillet samples collected throughout Alaska (ADEC 2005c).**

Table 21. Organochlorine Concentrations in Cook Inlet Chinook Salmon fillets Compared to Muscle Samples From Fish Collected in the Kuskokwim River and Yukon River (ppb wet weight).

Chemical	Fillets from Cook Inlet				Muscle from the Kuskokwin River				Muscle from the Yukon River			
	n	**Min**	**Max**	**Average[1]**	***n***	**Min**	**Max**	**Average[2]**	***n***	**Min**	**Max**	**Average[2]**
α-BHC	6	0.357	1.84	**0.948**	20	0.2	1.4	0.54	28	0.03	0.56	0.30
γ-BHC	1	0.341	0.341	0.121	NA	NA	NA	NA	NA	NA	NA	NA
α-Chlordane	6	0.448	0.86	0.741	20	0.28	1.7	0.92	28	0.95	4.4	**2.2**
γ-Chlordane[3]	6	0.183	0.32	0.258	20	0.10	0.56	0.30	28	0.31	1.6	**0.73**
o,p'-DDD	6	0.113	0.377	0.22	20	0.06	0.46	0.22	28	0.28	1.2	**0.57**
p,p'-DDD	NA	NA	NA	NA	20	0.23	1.6	0.89	28	0.85	3.5	**1.6**
o,p'-DDE	5	0.129	0.273	0.187	20	0.06	0.38	0.20	28	0.23	1.3	**0.61**
p,p'-DDE	6	1.94	5.39	3.853	20	1.1	6.6	3.9	28	4.0	18	**8.7**
o,p'-DDT	6	0.284	0.83	0.579	20	0.16	1.3	0.72	28	0.95	3.8	**1.9**
p,p'-DDT	6	0.255	0.693	0.567	20	0.27	2.0	1.2	28	1.3	6.0	**3.1**
Dieldrin	6	0.271	0.77	0.532	20	0.05	0.97	0.43	28	0.40	1.7	**0.95**
Endrin	4	0.132	0.201	0.138	NA	NA	NA	NA	NA	NA	NA	NA
HCB	6	0.898	1.82	1.506	20	0.81	3.5	2.0	28	1.8	7.6	**4.1**
Heptachlor epoxide	6	0.157	0.428	0.315	NA	NA	NA	NA	NA	NA	NA	NA
Mirex	4	0.081	0.098	0.067	20	0.01	0.19	0.09	27	0.08	0.20	**0.14**
trans-Nonachlor	6	0.73	1.09	0.984	20	0.48	2.3	1.3	28	1.4	5.6	**2.9**
Oxychlor	NA	NA	NA	NA	20	0.27	5.2	0.88	28	0.32	47	**4.4**
PCB total	6	2.071	3.262	2.828	48	2.93	37.8	**12.4**	48	2.93	37.8	**12.4**
Toxaphene	3	10.1	17.7	10.043	20	5.6	107	31	28	29	158	**62**

Source: ADEC 2005a; Matz and Mueller 2005

[1]To calculate averages, non-detects were substituted with a value equal to half the detection limit.

[2]To calculate averages, non-detects were substituted with a random number between zero and the highest reasonable limit of detection (indicated by the minimum for the tissue/analyte combination.

[3]Reported as trans-chlordane for fillets from Cook Inlet.

NA = not analyzed

Bold indicates the highest average values. Note that average concentrations were calculated using different methods.

Table 22. Metal Concentrations in Kuskokwim River Salmon (ppb dry weight).

Chemical	Muscle				Egg				Kidney			
	n[1]	Min	Max	Average[2]	*n*	Min	Max	Average	*n*	Min	Max	Average
***Chinook salmon*[3]**												
Arsenic	20	1,100	6,000	2,000	10	1,000	2,000	1,300	20	1,100	8,500	2,100
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	20	4,600	28,000	14,000
Mercury	20	78	560	220	NA	NA	NA	NA	20	150	770	380
Selenium	20	510	1,800	840	10	3,600	5,500	4,400	20	5,600	10,000	7,600
Chum salmon												
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	20	520	3,700	1,400
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	20	5,300	36,000	15,000
Mercury	20	49	360	210	NA	NA	NA	NA	20	210	530	350
Selenium	NA	NA	NA	NA	10	5,100	6,600	5,800	20	490	12,000	3,900

Source: Matz and Mueller 2005
[1]n = number of individuals analyzed.
[2]To calculate averages, non-detects were substituted with a random number between zero and the highest reasonable limit of detection for the tissue/analyte combination.
[3]Weight (kg), length (cm), and age (years) of individuals reported by species as an average: Chinook: 8.8 kg, 86 cm, and 5.8 years; chum: 3.7 kg, 64.5 cm, 4.5 years.
NA = not analyzed

Table 23. Metal Concentrations in Yukon River Salmon (ppb dry weight).

Chemical	Muscle				Egg				Kidney			
	n[1]	Min	Max	Average[2]	*n*	Min	Max	Average	*n*	Min	Max	Average
***Chinook salmon*[3]**												
Arsenic	28	1,300	3,800	2,400	4	1,000	1,200	1,100	28	750	4,000	1,850
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	28	2,700	35,000	17,420
Mercury	28	77	220	130	NA	NA	NA	NA	28	170	460	270
Selenium	28	510	920	480	4	3,200	4,600	4,000	28	5,300	9,000	7,350
Chum salmon												
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	40	520	2,500	670
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	40	2,700	20,000	7,800
Mercury	40	84	320	190	NA	NA	NA	NA	40	170	410	260
Selenium	NA	NA	NA	NA	19	3,900	5,800	4,700	40	490	7,300	1,800

Source: Matz and Mueller 2005
[1]n = number of individuals analyzed.
[2]To calculate averages, non-detects were substituted with a random number between zero and the highest reasonable limit of detection for the tissue/analyte combination.
[3]Weight (kg), length (cm), and age (years) of individuals reported by species as an average: Chinook: 5.7 kg, 76.8 cm, 5.1 years; chum: 3.4 kg, 64.7 cm, and 4.6 years.
NA = not analyzed

Table 24. Average[1] Concentrations of Organochlorine Compounds Found in Cook Inlet Beluga Whale Blubber Compared With Concentrations in Beluga Whales From Arctic Locations (ppb wet weight).

Location (Date)	Gender	*n*[2]	Age (yr)[3]	Dieldrin	HCB	HCH (total)[4]	Mirex	PCB's (total)[5]	DDT (total)[6]	Toxaphene	Chlordane (total)[7]
Comparison Values[8]				*0.00018(c)*	*0.0018(c)*	*NA*	*0.059(nc)*	*0.0015(c)*	*0.0086(c)*	*0.0027(c)*	*0.0084(c)*
Cook Inlet (1992–1997), Alaska	M	10	9.2	90	220	210	10	1,490	1,350	2,400	560
	F	10	9.9	60	150	170	10	790	590	2,020	300
Cumberland Sound (1983), Pangnirtung	M	6	7.3	910	960	**390**	10	4,910	6,830	5,780	2,380
	F	6	8.1	200	180	240	10	1,150	930	1,770	620
St. Lawrence (1986–1987), Estuary	M	4	17.5	**930**	**1,340**	370	**1,000**	**75,800**	**1,010**	**14,700**	**7,430**
	F	5	15.6	**560**	**600**	240	**1,110**	**37,300**	**23,000**	**6,340**	**3,550**
East Hudson Bay (1984–1985), Nastapoka	M	6	15.6	280	300	210	20	2,770	2,270	4,130	1,860
	F	6	17.0	140	140	150	10	1,230	980	1,990	870
West Hudson Bay (1986), Eskimo Point	M	4	13.0	360	610	240	360	3,120	3,130	5,100	2,330
	F	4	10.3	140	190	150	140	960	850	1,770	850
Jones Sound (1986), Grise Fjord	M	8	4.4	340	500	190	10	2,530	1,960	4,250	1,870
	F	7	4.6	330	390	160	10	2,460	2,190	3,740	1,840
Beaufort Sea (1983, 1987, 1989), Mackenzie R. & Point Hope	M	10	17.0	230	590	230	40	3,330	2,200	3,830	1,750
	F	4	10.2	160	420	**270**	20	1,800	950	2,220	990
E. Chukchi Sea (1990, 1996), Point Lay, Alaska	M	11	12.2	390	810	330	60	5,200	3,630	3,930	2,420
	F	8	16.4	120	230	250	20	1,500	930	2,620	790

Source: Becker et al. 2000

[1]Source documentation does not report methods for calculating averages.

[2]Number of tissue samples.

[3]Average age in years.

[4]Sum of α-, β-, and γ-hexachlorocyclohexane.

[5]Muir et al. 1990 calculated total PCBs in belugas from the Beaufort Sea, eastern Chukchi Sea, and Cook Inlet by multiplying the sum of the concentrations of the following congeners: 18, 28, 44, 52, 66, 101, 105, 118, 128, 138, 153, 170, 180, 187, 195, 206 and 209 by 2. Total PCBs in belugas from all other locations represent the sum of all congeners measured.

[6]Total DDT is the sum of the concentrations of 2,4′-DDT, 4,4′-DDT, 2,4′-DDD, 4,4′-DDD, 2,4′-DDE, and 4,4′-DDE.

[7]Total chlordane is the sum of the concentrations of heptachlor, heptachlor epoxide, cis-chlordane, trans-chlordane, trans-nonachlor, cis-nonachlor, oxychlordane, and nonachlor III.

[8]EPA risk-based consumption limits (unrestricted monthly fish consumption) (EPA 2000b); (c)=cancer health endpoint, (nc)=non-cancer endpoint.

NA = not available

Bold indicates the highest average values for males and females.

Table 25. Average[1] Metal Concentrations Found in Cook Inlet Beluga Whale Livers Compared With Concentrations Reported in Belugas From Other Locations in Alaska (ppb wet weight).

Chemical	Cook Inlet			Beaufort Sea			Chukchi Sea			CV[2]
	Average	Min	Max	Average	Min	Max	Average	Min	Max	
Males										
	n[3]=6			*n=1*			*n=7*			
Arsenic	780	<50	120	**177**	NA	NA	160	65	616	2(c)
Bromine	17,830	13,170	22,480	**25,620**	NA	NA	20,450	18,360	23,060	NA
Cadmium	<1,000	<440	<1,000	750	NA	NA	**1,884**	1,140	2,410	88
Calcium	**41,600**	34,700	50,300	30,820	NA	NA	31,640	20,500	44,000	NA
Cesium	**51**	9	75	21	NA	NA	28	24	33	NA
Chlorine	1,610,000	1,312,000	1,971,000	1,384,000	NA	NA	**1,814,000**	1,638,000	1,880,000	NA
Cobalt	9	6	12	11	NA	NA	**12**	8	15	NA
Copper	**48,930**	15,620	123,800	12,360	NA	NA	12,660	6,850	26,400	NA
Iron	316,900	228,000	494,500	587,500	NA	NA	**599,000**	474,500	726,000	NA
Magnesium	**149,800**	131,200	177,400	111,800	NA	NA	116,900	58,500	164,000	NA
Manganese	2,170	1,700	2,520	**2,506**	NA	NA	1,939	1,620	2,400	NA
Mercury	5,454	2,980	11,420	3,520	NA	NA	**36,530**	17,730	50,140	NA
Me-Mercury	1,470	800	2,110	490	NA	NA	**1,517**	860	2,010	29(nc)
Potassium	**2,898,000**	2,552,000	3,306,000	2,272,000	NA	NA	2,222,000	1,523	2,700,000	NA
Rubidium	**1,765**	1,372	2,084	ND[6]	NA	NA	1,050	90	1,493	NA
Selenium	4,347	2,907	6,088	6,243	NA	NA	**18,550**	7,010	29,360	1,500(nc)
Silver	6,778	1,513	11,610	14,580	NA	NA	**24,320**	14,380	40,690	NA
Sodium	1,331,000	1,101,000	1,567,000	960,500	NA	NA	**1,397,000**	1,136,000	1,576,000	NA
Vanadium	41	21	54	34	NA	NA	**164**	37	205	NA
Zinc	**27,260**	24,560	30,640	22,620	NA	NA	23,860	21,100	28,650	NA
Females										
	n=4			*n=3*			*n=3*			
Arsenic	**356**	<70	815	215	163	252	180	162	201	2(c)
Bromine	17,280	10,220	25,000	24,360	NA	NA	**25,300**	17,200	35,600	NA
Cadmium	630	<500	740	1,307	455	1,840	**3,330**	2,760	3,650	88
Calcium	26,700	24,000	30,950	26,300	25,300	26,920	**32,700**	28,500	40,950	NA
Cesium	**64**	56	75	38	31	38	33	30	35	NA
Chlorine	1,312,000	1,251,000	1,561,000	1,481,000	1,392,000	1,556,000	**1,684,000**	1,486,000	1,790,000	NA
Cobalt	28	5	90	**100**	10	180	15	8	21	NA
Copper	**29,260**	3,970	48,270	12,860	12,000	14,400	21,180	7,100	40,700	NA
Iron	235,000	100,000	443,000	457,300	362,500	622,500	**558,000**	332,000	781,000	NA
Magnesium	134,500	111,000	162,200	151,400	78,500	219,000	**157,600**	140,500	172,500	NA
Manganese	2,651	1,617	3,254	**3,211**	3,093	3,357	1,920	1,660	2,220	NA
Mercury	2,568	704	5,030	5,462	1,397	10,180	**52,600**	27,900	72,900	NA
Me-Mercury	520	340	700	513	370	780	**1,150**	850	1,600	29(nc)
Potassium	**2,849,000**	2,516,000	3,021,000	2,524,000	2,315,000	2,704,000	1,754,000	1,326,000	2,442,000	NA
Rubidium	1,387	1,222	1,602	1,346,000	1,174	1,518	**1,720**	NA	NA	NA
Selenium	2,620	1,078	4,215	8,472	3,961	14,250	**37,300**	18,200	75,500	1,500
Silver	4,383	637	9,787	20,830	14,360	30,510	**46,600**	10,100	107,000	NA

Chemical	Cook Inlet			Beaufort Sea			Chukchi Sea			CV[2]
	Average	Min	Max	Average	Min	Max	Average	Min	Max	
Sodium	**1,204,000**	983,000	1,449,000	1,198,000	1,049,00	1,340,000	1,141,000	1,321,000	1,494,000	NA
Vanadium	34	15	65	79	49	95	**153**	90	279	NA
Zinc	24,380	22,660	26,070	**33,670**	30,240	38,530	23,680	20,900	26,100	NA

Source: Becker et al. 2000

[1]Source documentation does not report methods for calculating averages.

[2]CV= comparison value. EPA risk-based consumption limits (unrestricted monthly fish consumption) (EPA 2000b); (c)=cancer health endpoint, (nc)=non-cancer endpoint.

[3]Number of whales sampled.

NA = not available

ND = not detected

Bold indicates the highest average values.

Children's Health Considerations

ATSDR recognizes that children can be especially sensitive to some contaminants. Two ATSDR internet sites provide additional information on children's health considerations. These web sites are www.atsdr.cdc.gov/child/ochchildhlth.html and www.atsdr.cdc.gov/child/atsdrpage2.html. ATSDR includes children when evaluating exposures to contaminants. In this health consultation, ATSDR included 3 age groups of children when estimating exposure: teenagers, elementary age school children, and preschool children. Based on our exposure scenarios for children, no adverse health effects would be expected from exposure to contaminants found in native foods from Cook Inlet, including lead.

We do not expect that children in Tyonek, Seldovia, Port Graham, and Nanwalek are being adversely exposed to lead. In 1992, the State of Alaska collected blood samples from 967 children in 33 communities (State of Alaska 1994a). They found an overall average lead level of 2.4 µg/dL and a geometric average of 2.0 µg/dL. These four villages were not part of the 1992 sampling.

In 1994, the State of Alaska collected 82 blood samples from Port Graham. Thirty of the 39 children enrolled at the school (77%) were tested. They had an average blood lead level of 1.6 µg/dL (geometric average = 1.4 µg/dL), with a maximum of 5 µg/dL (State of Alaska 1994b). These levels are well-below CDC's level of concern of 10 µg/dL.

No other data on residential or recreational child exposures to lead in these villages were found. If the village representatives consider this to be a concern, we encourage them to gather information on potential residential and recreational lead exposure in addition to information on dietary customs.

Health Considerations for Alaska Natives

Alaska Natives have many unresolved concerns about changes in the environment, including impacts to plants and animals used as traditional subsistence foods. These foods include a wide variety of plants (kelp, goose tongue, seaweed, berries), fish (salmon and other species), invertebrates (clams, mussels, snails, chiton), and mammals (caribou, moose, seals). Many of these concerns were compiled by a collaborative effort of the University of Alaska's Institute of Social and Economic Research and the Alaska Native Science Commission (Kruse et al. 2004). The project was funded, in part, by two EPA technical assistance agreements.

Traditional foods comprise from 40 percent to more than 90 percent of rural Alaskan diets. Reports of high levels of persistent contaminants in the food chain can be especially alarming; and, Alaska Natives may attribute health problems to eating traditional foods containing these contaminants (ANHB 2004).

This consultation is based on limited information from various native food samples collected in the Cook Inlet area. Alaska Natives are encouraged to identify data gaps and to develop information, such as additional sampling, which will allow exposure evaluations that reflect traditional lifestyles and cultural practices, particularly in foods or organs that were not previously sampled. We encourage village representatives to take an active role in identifying dietary customs, types of foods, and consumption patterns so that better exposure assessments can be done.

Benefits of Fish and Other Traditional Foods

Several studies have reported that subsistence foods contribute substantially to the nutritional well-being of the Alaska Native population (Mozaffarian 2007, Willett 2005, Hibbeln 2007, Kuhnlein 1995). Over half of the protein, iron, vitamin B-12, and omega-fatty acids are found in the Alaska Native traditional foods. Therefore, subsistence foods have nutritional benefits that make them preferable to many purchased foods. Beside being rich in many nutrients and being low in fat, they contain more heart-healthy fats and less harmful fats than many non-Native foods. Alaska Natives eating traditional foods have fewer signs of diabetes, heart disease, and certain kinds of cancer. In addition, eating and gathering traditional foods contributes to social, mental, and spiritual well being (Nobmann 1996).

The benefits of eating fish are especially important for subsistence consumers. Removing fish from these diets can result in serious health, social, and economic consequences (Nobmann 1996). Fish are an excellent protein source, and are associated with reduced risk of coronary heart disease. The benefits of eating fish have been associated with high levels of unsaturated fats (e.g., omega-3 polyunsaturated fatty acids) which are essential nutrients. Saturated fats are linked with increased cholesterol levels and risks of heart disease. Fish can be a source of essential trace elements, which are required by the body in small amounts to function normally. Fish also provide a good source of some vitamins and minerals (AHA 2000; USEPA and TERA 1999).

The health benefits of eating fish deserve particular consideration when dealing with subsistence consumer populations. Providing accurate, balanced information is very important to help people make informed decisions about the risks and benefits of personal fish consumption. Benefits of traditional foods in healthy diets are receiving more attention as tribes focus more attention on contaminant impacts to their trust resources (ADPH 1998). In its report, Fish Consumption Advice for Alaskans, the State of Alaska provides much information about the health benefits of eating native foods. More information is available at this website: www.epi.hss.state.ak.us/bulletins/docs/rr2007_04.pdf . In addition, the Government of the Northwest Territories (GNWT) Health and Human Services Department (http://www.gov.nt.ca) published a food guide in March 2005, which is available at the website: http://www.hlthss.gov.nt.ca/pdf/brochures_and_fact_sheets/healthy_eating_and_active_living/2005/english/nwt_food_guide.pdf.

The GNWT also compiled a booklet of traditional foods fact sheets, which discusses the nutritional, economic, and other benefits of a wide variety of traditional foods. The booklet consists of 49 fact sheets in three series: Dene/Metis, Inuit and Pictorial Nutritional Fact Sheets. Eleven fact sheets in the Dene/Metis series focus on traditional food sources and seven on nutrients found in these foods. The Inuit Series consists of 20 fact sheets on traditional foods and six on nutrients in those foods. Five Pictorial Nutritional Fact Sheets outline nutrients significant for growth and development of healthy babies. This booklet is available from the internet site: http://www.hlthss.gov.nt.ca/pdf/reports/healthy_eating_and_active_living/2002/english/nwt_traditional_food_fact_sheets/nwt_traditional_food_fact_sheet_series.pdf.

Conclusions

1. ATSDR concludes that preschool and elementary-age children should limit their consumption of chiton or badarki to less than 3 ounces a week as a precaution to prevent excessive exposure to lead. Adults are not at risk of excessive exposure to lead from eating chiton because adults absorb less lead from food than children do. The small amount of lead found in other native foods will not cause excessive lead exposure in children or adults. It should be noted that a blood lead survey of children from the Village of Port Graham in 1994 did not find any children with blood lead levels above 10 µg/dL, the CDC's level of concern for case management. The State of Alaska has a blood lead surveillance program and information about this program can be found at http://www.epi.hss.state.ak.us/eh/lead/default.htm.

2. The other chemicals detected in native foods from Cook Inlet and evaluated in this health consultation are not expected to harm people's health. Metals, pesticides, PCBs, one dioxin compound, and PAHs were detected in native foods from Cook Inlet in small amounts, often at levels that are found in fish from other parts of Alaska and from grocery stores in the U.S. This conclusion was reached because either: (a) the estimated exposure from each chemical was below levels of health concern or (b) in some cases, the chemicals were found occasionally in just a few samples.

3. Several chemicals that are known to cause cancer in humans or animals, such as arsenic, pesticides, PAHs, and polychlorinated biphenyls were detected occasionally at low levels in some native foods. A range of theoretical excess cancer risk was calculated for these chemicals depending upon how much native food was eaten. Most village residents eat about one fish meal a day along with small amounts of other native foods, such as mussels, clams, chiton, snail, octopus, and plants. The calculated cancer risk for every 100,000 residents who eat one fish meal daily and other native foods is increased above background by 0 to 3 cases. The cancer risk is slightly higher for village residents who eat 2 fish meals daily. This cancer risk is similar to the risk that can be calculated for consuming the same amount of fish from other parts of Alaska or purchased from grocery stores in the U.S. The risk of cancer from these chemicals in native foods is very low and could be zero.

4. ATSDR cannot currently conclude whether eating eggs and organs from Cook Inlet fish could harm people's health. Data were insufficient to adequately assess chemicals in liver, kidney, and eggs of fish.

5. Several polycyclic aromatic hydrocarbons that were detected in some seafood samples have little information about their harmful effects. Until more research is conducted, ATSDR cannot determine whether these chemicals could harm people's health.

6. The Environmental Monitoring Program (EMP) conducted by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) targeted contaminants originating from oil and gas facilities. The EMP performed analyses on a small, unspecified number of bivalves. In most of these bivalve samples, polycyclic aromatic hydrocarbons were either not detected or were found at very low levels. Because of the limited information available, ATSDR could not determine whether eating bivalves could harm people's health.

Recommendations

1. Preschool and elementary-age children should eat 3 ounces or less of chiton (badarki) a week to help prevent high blood lead levels.

2. Future sampling of fish in Cook Inlet for human health-related purposes should target specific parts of native fish, such as eggs and liver that are relevant to traditional dietary customs of Alaskan Natives**.**

Public Health Action Plan

1. ATSDR will provide the findings of this health consultation to Alaskan Natives, the State of Alaska and the EPA.

2. Parents concerned about blood lead levels in their children should have them tested at their local health clinic. Health prevention information about how to avoid lead exposures in children can be obtained from local clinics, or from Alaska's lead surveillance program. More information about Alaska's lead surveillance program is available at this website: http://www.epi.hss.state.ak.us/eh/default.stm. You also may contact a staff person at the state's lead surveillance program at 907-269-8000.

3. Villages are encouraged to develop information on consumption rates and dietary uses of native foods that are relevant to their traditional subsistence customs.

4. The State of Alaska provides much information about the health benefits and risk of consuming native foods. Comprehensive reviews of chemicals in Alaska subsistence foods are available in the following reports:

   - The Use of Traditional Foods in a Healthy Diet in Alaska: Risks in Perspective,

   - The Use of Traditional Foods in a Healthy Diet in Alaska: risk in Perspective. Second Edition: Volume 1. Polychlorinated Biphenyls (PCBs) and Related Compounds.

   - The Use of Traditional Foods in a Healthy Diet in Alaska: Risks in Perspective, Second Edition: Volume 2. Mercury, and

   - Fish Consumption Advice for Alaskans: A Risk Management Strategy to Optimize the Public's Health – Full Report.

   These reports and more information about the benefits and risk of consuming native foods can be found at this State of Alaska website: http://www.epi.hss.state.ak.us/eh/subsistence.htm.

5. The Government of the Northwest Territories (GNWT) Health and Human Services Department (http://www.gov.nt.ca) published a food guide in March 2005, which might be useful to Native Alaskans. The guide is available at this website: http://www.hlthss.gov.nt.ca/pdf/brochures_and_fact_sheets/healthy_eating_and_active_living/2005/english/nwt_food_guide.pdf.

6. As villages build their capacity to assess public health issues, we encourage them to gather information about (1) residential/recreational lead exposures in children, and (2) levels of inorganic arsenic in drinking water sources. Additional information on State and Federal resources is included in Appendix D.

Response to Comments

Following the public release of this health consultation in January 2006, ATSDR received technical comments from a scientist who reviewed ATSDR's health consultation for the villages. This scientist and representatives of the Village of Port Graham requested that ATSDR use EPA's guidance for assessing chemicals in fish to evaluate the risk from pesticides. In addition, representatives of the Village of Port Graham requested that ATSDR use the average concentration in each fish species rather than the average concentration for all fish to evaluate pesticide risk. ATSDR modified its approach for evaluating the risk from pesticide in fish (1) by calculating the average concentration of pesticide in each fish species to estimate dose and to make comparison to health guidelines, and (2) by using EPA's mathematical approach for estimating the number of acceptable meals that equate to a risk of 1 in 100,000. For more details on EPA's approach, the reader is referred to EPA's Guidance for Assessing Chemical Contaminant Data for Use In Fish Advisories, which is available at this website: http://www.epa.gov/waterscience/fish/guidance.html.

In addition to these requests, ATSDR included children of different age groups and where appropriate estimated a lifetime dose to ensure that all aspects of exposure were evaluated. Looking at all age groups and estimating lifetime doses for non-cancer and cancer endpoints is important because native Alaskans are likely to have a lifetime of exposure to the chemicals found in their native foods. In addition to fish, ATSDR included other seafood (e.g., mussels, clams, chiton, snails, and octopus) as well as plants in estimating the total dose.

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Appendix A

Overview of How to Estimate Exposure Doses

Assessing exposure to contaminants in the environment requires identifying pathways (air, water, food, and soil) by which people can be exposed. This consultation evaluates native foods as an exposure pathway. Exposure assessment also requires estimating the amounts of chemicals to which people can be exposed (ATSDR 2005a). For non-cancer health concerns, this is done by using the following calculation:

$$\text{Estimated Exposure Dose (EED)} = \frac{\text{Contaminant Concentration (CC)} \times \text{Ingestion Rate (IR)} \times \text{Annual Exposure Factor (AEF)} \times \text{Absorption Factor (AF)}}{\text{Body Weight (BW)}}$$

The estimated exposure dose (EED) is also referred to as the annual exposure dose, and is calculated from available site specific information. In this health consultation, contaminant concentration (CC) refers to the chemical concentrations reported for native food samples from Cook Inlet.

The amount of food people eat is described by an ingestion rate (IR) or consumption rate. The frequency and duration of exposure on a yearly basis is expressed as an annual exposure factor (AEF) to ease calculations. The amount of a chemical absorbed by people eating biota is estimated by an absorption factor (AF). Some formulas may also contain bioavailability factors (BFs) that estimate how much of a chemical is actually available to be absorbed. In practice, AFs or BFs are used only when reduced absorption or bioavailability are assumed. Estimated body weight (BW) for people in an exposed group is the denominator of the equation. This can vary by age, sex, or geographic region.

The previous formula is used to estimate exposure doses for non-carcinogenic health effects. For cancer, lifetime excess cancer risks are calculated for a 70 year exposure period as follows:

$$\text{Estimated Annual Exposure Dose (mg/kg/day)} \times \text{Cancer Slope Factor (mg/kg/day}^{-1}\text{)}$$

Excess cancer risks for exposures less than an entire lifetime are calculated as follows:

$$\text{(Estimated Annual Exposure Dose} \times \text{Cancer Slope Factor)} \times \frac{\text{No. of Years Exposed}}{\text{70 year lifetime}}$$

A typical less-than-lifetime exposure period is the residence time in the community where the exposure occurred. Two such residence times often used are 30 years for the maximum time at one residence and 9 years for the median time at one residence (USEPA 1997). In this consultation, we took a conservative approach by considering only lifetime exposures because most village residents are likely to eat native foods their entire lives.

Chemical Concentrations in Native Foods

Average chemical levels in biota samples from Cook Inlet are shown in Table 1 (USEPA 2003), Table 2 (ADEC 2005a), and Table 3 (ADEC 2005a). Table 1 compares the average chemical concentrations. The contaminants reported were usually lowest in plant samples and highest in the whole fish samples. For our evaluations, we used average concentrations in all fish or the average concentration in each fish species to address reasonable exposure conditions.

Ingestion Rates for Native Foods

Accurate estimates of how much fish or native foods that people eat can be difficult to obtain. It can vary by age, sex, lifestyle, tribal custom, or health status. Consumption rates used in this consultation varied with the type of food that was eaten. For fish, three ingestion rates were used: 7 oz/day, 14 oz/day, and 18 oz/day. ATSDR chose these ingestion rates because the survey conducted by the Village of Port Graham reported that the average fish consumption rate for adults was 7 oz/day or about one fish meal daily. To ensure that residents with higher fish intakes were protected, ATSDR assumed daily intakes of 14 oz/day and 18 oz/day after discussing this issue with representatives of the Village of Port Graham. ATSDR used the following lower intake rates for children.

Elementary-age children	9 oz/day, 7 oz/day, 3.5 oz/day,
Preschool children	6 oz/day, 4 oz/day, 2 oz/day
1-yr-old children	4 oz/day, 2 oz/day, 1 oz/day

For other seafood, such as mussels/clams, other invertebrates (snails, chiton, octopus), and plants, ATSDR used the following daily intake rates for various age groups:

		oz/day	
Adults			
Mussels/clams	1	0.5	0.1
Snails, chiton, octopus	3	2	1
Plants	0.2	0.1	0.05
Elementary-age children			
Mussels/clams	0.5	0.25	0.05
Snails, chiton, octopus	1	0.5	0.3
Plants	0.1	0.05	0.025
Preschool children			
Mussels/clams	0.25	0.125	0.025
Snails, chiton, octopus	1	0.5	0.3
Plants	0.05	0.03	0.01
1-yr-old children			
Mussels/clams	0.2	0.06	0.01
Snails, chiton, octopus	0.5	0.25	0.15
Plants	0.025	0.01	0.005

The average intake rates were determined using information from the survey conducted by the Village of Port Graham and then professional judgment was used to select native food intake that reflected above average intake and the highest intake rates.

Bioavailability and Absorption

Most chemicals detected in native foods were assumed to be completely (100%) available and totally absorbed. This is a conservative approach. Many chemicals in native foods are neither 100 percent bioavailable nor 100 percent absorbed based on their physical and chemical properties, storage in specific tissues, the chemical form present, and other factors. In our exposure calculations, this is reflected by using an absorption factor (AF) of 1 for most chemicals. In practice, absorption factors less than one are used only when we assume reduced bioavailability or absorption (e.g., cadmium).

Only methylmercury values were used to estimate mercury exposures. This form is highly bioavailable and more toxic to humans (ATSDR 1999a). To estimate arsenic exposures, we used the levels of inorganic arsenic reported by EPA (USEPA 2003) and levels of total arsenic reported by ADEC (ADEC 2005a). Inorganic arsenic in fish, mussels/clams, and other invertebrates was less than 1 percent of total arsenic. Inorganic arsenic was not measured in plants. Fish, shellfish, and other native foods can absorb inorganic arsenic from water or sediment. They rapidly convert most of it to organic forms. Fish/shellfish can have high levels of organic arsenic. The organic form of arsenic found in fish is not harmful to people because people easily and quickly eliminate organic arsenic through the urine (ATSDR 2000a).

Body Weight

We used a body weight of 70 kg (154 lbs) for adult men and women (ATSDR 2005a). For children, ATSDR uses body weights from 10 kg (22 lbs) to 35 kg (77 lbs) depending on age group (Table A-1).

Table A-1. ATSDR Body Weight Assumptions for Children and Adults

Children	**Body Weight Assumption**
1 yr old child	10 kg (22 lbs)
2-6 yr old children	16 kg (35 lbs)
7-14 yr old	35 kg (77 lbs)
Adults	**Body Weight Assumption**
General Population	70 kg (154 lbs)
Pregnant Women	70 kg (154 lbs)

Now that all the individual components of the exposure dose calculation have been presented, the equation shown earlier in this section is given below with abbreviations and units:

$$\underset{(mg/kg/day)}{EED} = \frac{CC\ (mg/kg) \times IR\ (kg/day) \times AEF\ (1) \times AF\ (usually\ 1)}{BW\ (kg)}$$

Ingestion rate is shown here as *kg/day* to eliminate converting between grams (g) and milligrams (mg). Inverting the denominator (1/BW) and multiplying solves the equation. The result is an estimated exposure dose (EED) expressed as *mg* of contaminant per *kg* of body weight per *day*. This is how estimated exposure doses were calculated for this consultation.

Health Guideline Values

Minimal risk levels (MRLs) and reference doses (RfDs) are daily exposure estimates with no appreciable risks of adverse non-cancer health effects over a specified length of exposure. The conservative approaches used to develop MRLs and RfDs often result in them being 100 to 1000 times below levels shown to be harmful. Such effect levels are often referred to as lowest-observable-adverse-effect levels (LOAELs).

MRLs are used by ATSDR health assessors to identify contaminants of concern (http://www.atsdr.cdc.gov/mrls.html) for further evaluation. Reference doses (RfDs) are developed by U.S. Environmental Protection Agency (EPA) (http://www.epa.gov/iris/) to evaluate chronic (lifetime) exposures. Oral cancer slope factors developed by EPA (http://www.epa.gov/iris/) were used estimate excess lifetime cancer risks.

Hazard Quotient

Because so many calculations were done, it is easier to determine if a health guideline (MRL, RfD) is exceeded by calculating an hazard quotient. When a hazard quotient is greater than 1, then the estimated dose is greater than the MRL or RfD and further toxicological evaluation is needed to determine if harmful effects might be possible. If the hazard quotient is less than 1, then the estimated dose is less than the MRL or Rfd and non-cancerous harmful effects are not likely. The hazard is calculated using the following formula:

HQ = estimated dose ÷ health guideline.

For example, if the estimated dose 0.05 mg/kg/day and the MRL is 0.5 mg/kg/day, then:

HQ = 0.01 ÷ 0.1 = 0.1.

Because the HQ of 0.1 is less than 1, the estimated dose is less than the health guideline and non-cancerous harmful effects are not likely. Using the HQ makes reading a column of information with much easier to quickly focus on any HQ that is greater than 1. As shown in Figures 2 and 3, graphically displaying the HQ also makes it easy to see that the numerous dose estimates for the various age groups are below the health guidelines for the chemicals evaluated.

Appendix B

Tables Showing Calculations for Non-Cancer Endpoints Using Arsenic and Cadmium as Examples

The computations for estimating exposed dose for different age groups from preschool children to adults is shown for arsenic as an example of how doses, hazard quotient, and cancer risks were estimated. The hazard quotient (HQ) is the estimated dose divided by the health guideline. When the HQ is less then 1 then the estimated dose is less than the health guideline and non-cancerous effects are not likely. In the case of arsenic, the HQ was less than 1 for each food group and for all food groups combined (see total dose lines in Table B-1a and Table B-1b). When a lifetime dose was calculated by adding the doses for each age group, the lifetime HQ was also below 1, indicating that non-cancerous effects are not likely. Similar calculations were made for other age groups, including elementary-age children, preschool children, and 1-year-old children since they could have different doses because of their lower body weight and fish intake. Table B-1a shows the doses and HQs for preschool children. None of the HQs for these age groups exceeded 1; therefore, non-cancerous effects are unlikely.

Table B-1a Arsenic	Metal Concentration (mg/kg)	Ingestion Rate Adults oz/day	Ingestion Rate (kg/day)	Adult (70kg) Exposure Dose	Hazard Quotient	Above MRL/RfD
Native Foods	*Inorganic Arsenic MRL mg/kg/day ------->*			*0.0003*		
Whole fish	0.001	18	0.5103	0.00000729	0.024	no
Whole fish	0.001	14	0.3969	0.00000567	0.019	no
Whole fish	0.001	7	0.19845	0.00000284	0.009	no
Mussels/Clams	0.008	1	0.02835	0.00000324	0.011	no
Mussels/Clams	0.008	0.5	0.014175	0.00000162	0.005	no
Mussels/Clams	0.008	0.1	0.002835	0.00000032	0.001	no
Other Invertebrates	0.017	3	0.08505	0.00002066	0.069	no
Other Invertebrates	0.017	2	0.0567	0.00001377	0.046	no
Other Invertebrates	0.017	1	0.02835	0.00000689	0.023	no
Goose tongue	0.0037	0.02	0.000567	0.00000003	0.000	no
Goose tongue	0.0037	0.01	0.000284	0.000000015	0.00005	no
Goose tongue	0.0037	0.005	0.000142	0.000000007	0.00002	no
Total dose for highest native food consumption--------------------->				0.000031	0.10	no
Total dose for above average native food consumption ---------->				0.000021	0.07	no
Total dose for average native food consumption------------------->				0.000010	0.03	no
						Lifetime HQ
Lifetime dose for highest native food consumption				0.000031	mg/kg/day	0.10
Lifetime dose for above average native food consumption				0.000019	mg/kg/day	0.06
Lifetime dose for average native food consumption				0.000010	mg/kg/day	0.03
Cancer Slope Factor				1.5	per mg/kg/day	
Cancer risk for highest native food consumption				5.E-05		
Cancer risk for above average native food consumption				3.E-05		
Cancer risk for average native food consumption				1.E-05		

Table B-1b	Metal	Ingestion Rate	Ingestion Rate	Child (16kg)		
Arsenic	Concentration	Preschool Child	Preschool Child	Exposure	Hazard	Above
	(mg/kg)	oz/day	kg/day	Dose	Quotient	MRL/RfD
Native Foods	*Inorganic Arsenic MRL mg/kg/day ------------------->*			*0.0003*		
Whole fish	0.001	6	0.1701	0.0000106	0.035	no
Whole fish	0.001	4	0.1134	0.0000071	0.024	no
Whole fish	0.001	2	0.0567	0.0000035	0.012	no
Mussels/Clams	0.008	0.25	0.0070875	0.0000035	0.012	no
Mussels/Clams	0.008	0.125	0.00354375	0.0000018	0.006	no
Mussels/Clams	0.008	0.025	0.00070875	0.0000004	0.001	no
Other Invertebrate	0.017	1	0.02835	0.0000301	0.100	no
Other Invertebrate	0.017	0.5	0.014175	0.0000151	0.050	no
Other Invertebrate	0.017	0.3	0.008505	0.0000090	0.030	no
Goose tongue	0.0037	0.01	0.0002835	0.0000001	0.0002	no
Goose tongue	0.0037	0.005	0.00014175	0.00000003	0.0001	no
Goose tongue	0.0037	0.003	0.00008505	0.00000002	0.0001	no
Total dose for highest native food consumption				0.000044	0.15	
Total dose, above av. native food consumption				0.000024	0.08	
Total dose, average native food consumption				0.000013	0.04	

Tables B-2a and B-2b show the cadmium doses and corresponding HQs for adults and preschool children. See text under cadmium for explanation.

Table B-2a	Metal	Ingestion Rate	Ingestion	Adult (70kg)		
Cadmium	Concentration	Adults	Rate	Exposure	Hazard	Above
	(mg/kg)	oz/day	(kg/day)	Dose	Quotient	MRL/RfD
Native Foods	Cadmium	MRL in mg/kg/day --->		0.0002		
Whole fish	0.059	18	0.5103	0.0000215	0.11	no
Whole fish	0.059	14	0.3969	0.0000167	0.08	no
Whole fish	0.059	7	0.1985	0.0000084	0.04	no
Mussels/Clams	0.236	1	0.0284	0.0000048	0.02	no
Mussels/Clams	0.236	0.5	0.0142	0.0000024	0.01	no
Mussels/Clams	0.236	0.1	0.0028	0.0000005	0.002	no
Other Invertebrates	2.128	3	0.0851	0.0001293	0.65	no
Other Invertebrates	2.128	2	0.0567	0.0000862	0.43	no
Other Invertebrates	2.128	1	0.0284	0.0000431	0.22	no
Plants	0.406	0.2	0.0057	0.0000016	0.01	no
Plants	0.406	0.1	0.0028	0.0000008	0.004	no
Plants	0.406	0.05	0.0014	0.0000004	0.002	no
Total dose for highest native food consumption-------------------->				0.000157	0.8	no
Total dose for above average native food consumption ---------->				0.000106	0.5	no
Total dose for average native food consumption------------------->				0.000052	0.3	no
						Lifetime HQ
Lifetime dose for highest native food consumption				0.000192	mg/kg/day	0.96
Lifetime dose for above average native food consumption				0.000115	mg/kg/day	0.57
Lifetime dose for average native food consumption				0.000061	mg/kg/day	0.31

Table B-2a	Metal	Ingestion Rate	Ingestion Rate	Child (16kg)		
Cadmium	Concentration	Preschool Child	Preschool Child	Exposure	Hazard	Above
	(mg/kg)	oz/day	kg/day	Dose	Index	MRL/RfD
Native Foods	Inorganic Arsenic MRL in mg/kg/day --------------->			*0.0002*		
Whole fish	0.059	6	0.1701	0.0000627	0.31	no
Whole fish	0.059	4	0.1134	0.0000418	0.21	no
Whole fish	0.059	2	0.0567	0.0000209	0.10	no
Mussels/Clams	0.236	0.25	0.0071	0.0000105	0.05	no
Mussels/Clams	0.236	0.125	0.0035	0.0000052	0.03	no
Mussels/Clams	0.236	0.025	0.0007	0.0000010	0.01	no
Other Invertebrate	2.128	1	0.0284	0.0003771	1.89	yes
Other Invertebrate	2.128	0.5	0.0142	0.0001885	0.94	no
Other Invertebrate	2.128	0.3	0.0085	0.0001131	0.57	no
Plants	0.406	0.05	0.0014	0.0000036	0.02	no
Plants	0.406	0.03	0.0009	0.0000022	0.01	no
Plants	0.406	0.01	0.0003	0.0000007	0.004	no
Total dose for highest native food consumption--------------------->				0.00045383	2.3	yes
Total dose for above average native food consumption ---------->				0.00023773	1.2	yes
Total dose for average native food consumption-------------------->				0.00013579	0.7	no

Appendix C

Tables Showing Calculations for Cancer Using Dieldrin as an Example

Table C-1a shows the estimated cancer risk for adults and children and the total cancer risk should someone live in the village their entire life and eat fish. Cancer risk were estimated for three groups: (1) villagers with average fish intake of about 1 meal per day and (2) villagers with above average fish, and (3) villagers with the highest fish intake, which equates to about 2 fish meals per day. Table C-1b and C-1c show the calculations and incremental cancer risk for various age groups. These incremental cancer risk by age group were summed to obtain the total cancer risk shown in Table C-1a.

Table C-1a	Average fish Intake	Above Average Fish Intake	Highest Fish Intake
Cancer risk for adults	1.4E-05	2.8E-05	3.7E-05
Cancer risk for children through 18 years	5.6E-06	1.1E-05	1.9E-05
Total Cancer Risk	2.0E-05	4.0E-05	5.6E-05

Table C-1b	Average		%	Dose of Chemical in Adults, 70 kg			Dose of Chemical in Teenagers, 55 kg		
	Chem. Concentration		of fish	in mg/kg/day			in mg/kg/day		
	ppt	mg/kg	eaten	7 oz/day	14 oz/day	18 oz/day	6 oz/day	12 oz/day	14 oz/day
				0.51 kg/day	0.397 kg/day	0.198 kg/d	0.17 kg/d	0.34 kg/d	0.397 kg/d
Dieldrin									
Chinook (King)	649.38	0.0006494	0.294	5.4E-07	1.1E-06	1.4E-06	5.9E-07	1.2E-06	1.4E-06
Chum salmon	189.5	0.0001895	0.059	3.2E-08	6.3E-08	8.2E-08	3.5E-08	6.9E-08	8.1E-08
Cod	174.43	0.0001744	0.007	3.5E-09	6.9E-09	8.9E-09	3.8E-09	7.5E-09	8.8E-09
Flounder	49	0	0.005	0	0	0	0	0	0
Halibut	292.77	0.0002928	0.131	1.1E-07	2.2E-07	2.8E-07	1.2E-07	2.4E-07	2.8E-07
Sea bass	156.25	0.0001563	0.0001	4.4E-11	8.9E-11	1.1E-10	4.8E-11	9.7E-11	1.1E-10
Sockeye (Red)	345.14	0.0003451	0.141	1.4E-07	2.8E-07	3.5E-07	1.5E-07	3.0E-07	3.5E-07
Salmon -- generic (Pink)	394.673	0.0003947	0.184	2.1E-07	4.1E-07	5.3E-07	2.2E-07	4.5E-07	5.2E-07
Salmon -- generic (Silver)	394.673	0.0003947	0.171	1.9E-07	3.8E-07	4.9E-07	2.1E-07	4.2E-07	4.9E-07
Total Dose for Dieldrin				1.2E-06	2.4E-06	3.1E-06	1.3E-06	2.7E-06	3.1E-06
CSF				16	16	16	16	16	16
Cancer risk by age group				1.423E-05	2.8451E-05	3.658E-05	1.825E-06	3.649E-06	4.26E-06

Table C-1c	Average		%	Dose of Chemical in Elementary, 35 kg			Dose Chemical in Preschool Children, 16 kg		
	Chem. Concentration		of fish	in mg/kg/day			in mg/kg/day		
	ppt	mg/kg	eaten	3.5 oz	7 oz/day	9 oz/day	2 oz/day	4 oz/day	6 oz/day
				0.099 kg/d	0.198 kg/d	0.51 kg/d	0.057 kg/d	0.113 kg/d	0.17 kg/d
Dieldrin									
Chinook (King)	649.38	0.00064938	0.294	5.4E-07	1.1E-06	2.8E-06	6.8E-07	1.3E-06	2.0E-06
Chum salmon	189.5	0.0001895	0.059	3.2E-08	6.3E-08	1.6E-07	4.0E-08	7.9E-08	1.2E-07
Cod	174.43	0.00017443	0.007	3.5E-09	6.9E-09	1.8E-08	4.3E-09	8.6E-09	1.3E-08
Flounder	49	0	0.005	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Halibut	292.77	0.00029277	0.131	1.1E-07	2.2E-07	5.6E-07	1.4E-07	2.7E-07	4.1E-07
Sea bass	156.25	0.00015625	0.0001	4.4E-11	8.8E-11	2.3E-10	5.6E-11	1.1E-10	1.7E-10
Sockeye (Red)	345.14	0.00034514	0.141	1.4E-07	2.8E-07	7.1E-07	1.7E-07	3.4E-07	5.2E-07
Salmon -- generic (Pink)	394.673	0.00039467	0.184	2.1E-07	4.1E-07	1.1E-06	2.6E-07	5.1E-07	7.7E-07
Salmon -- generic (Silver)	394.673	0.00039467	0.171	1.9E-07	3.8E-07	9.8E-07	2.4E-07	4.8E-07	7.2E-07
Total dose of dieldrin				1.2E-06	2.4E-06	6.3E-06	1.5E-06	3.0E-06	4.6E-06
CSF				16	16	16	16	16	16
Cancer risk by age group				1.7E-06	3.3E-06	8.6E-06	2.1E-06	4.2E-06	6.3E-06

Appendix D

Additional Information Resources for Public Health and the Environment

Alaska Cancer Registry
http://www.epi.hss.state.ak.us/cd/cancer.stm
A population-based, statewide cancer registry funded by the CDC-National Program of Cancer Registries to track incidence trends for cancer; started in 1996.

Alaska Dept. of Conservation
http://www.state.ak.us/dec

Alaska Dept. of Health and Social Services
Cancer-related bulletins (smoking, breast cancer, cervical cancer) published by the Division of Public Health can be found at these website:

    http://www.epi.hss.state.ak.us/bulletins/catlist.jsp?cattype=Cancer, and
    http://www.epi.hss.state.ak.us/eh/default.stm.

Alaska Native Health Board
http://www.anhb.org/

Alaska Native Tribal Health Consortium
http://www.anthc.org/

Alaska Native Science Commission
http://www.nativescience.org

Indian Health Service, Alaska Area Office
http://www.ihs.gov/FacilitiesServices/AreaOffices/Alaska/index.asp

University of Alaska
http://www.uaf.edu/coop-ext/water/index.html
http://www.uaf.edu/coop-ext/water/alaskan_focus_areas.html
http://www.ankn.uaf.edu

American Cancer Society
http://www.cancer.org/docroot/home/index.asp
http://www.cancer.org/docroot/HOME/skr/skr_0.asp?level=0
http://www.cancer.org/docroot/STT/stt_0.asp

American Indian Science & Engineering Society
http://www.aises.org

Administration for Children and Families
http://www.acf.hhs.gov/

Administration for Native Americans
http://www.acf.hhs.gov/programs/ana
http://www.acf.hhs.gov/grants/grants_ana.html

National Cancer Institute
http://www.cancer.org
Information on cancer types; treatment; prevention, genetics, and causes; screening and testing; coping with cancer; support and resources. Provides a link to a glossary of cancer related terms including incidence, prevalence, and lifetime risk (http://cancer.gov/statistics/glossary.)

The Centers for Disease Control and Prevention (CDC)
http://www.cdc.gov/

US Environmental Protection Agency (EPA)
http://www.epa.gov/

US Fish and Wildlife Service
http://www.fws.gov/

U.S. Geological Survey
http://www.usgs.gov/