Health Consultation

Review of Annette Islands Seafood Study Results

METLAKATLA INDIAN COMMUNITY
(a/k/a USDOT FAA ANNETTE ISLAND)

METLAKATLA, PRINCE OF WALES-OUTER KETCHIKAN, ALASKA

EPA FACILITY ID: AK3690500167

MAY 13, 2004

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 document has previously been released for a 30 day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The health consultation has now been reissued. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared by:

Federal Facilities Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

Summary

In 1887, about 800 Tsimshian Indians founded the village of Metlakatla, which is located in Port Chester, on the west coast of Annette Island, Alaska. Currently, about 1,375 people live in Metlakatla, of whom the majority are Alaskan Native. Fishing is very important to the Metlakatla Indian Community. Subsistence foods make a substantial contribution to their nutritional well-being, as well as social, mental, physical, and spiritual well-being. Harvesting the fish and shellfish is also an important element of the community's economy. As a result of past military activities, a closed sawmill, sanitary sewer outfalls, and other activities, the Metlakatla Indian Community worries that environmental contamination exists in the seafood around the Metlakatla Peninsula. They are concerned that exposures to contaminants in fish and shellfish can potentially lead to harmful health effects, as well as affect the commercial fishing industry. Because of these concerns, the Agency for Toxic Substances and Disease Registry (ATSDR) reviewed and evaluated the community's potential exposure and concluded the following:

- *It is safe to eat fish and shellfish from the Metlakatla Peninsula.* Although polycyclic aromatic hydrocarbons, organochlorine pesticides, polychlorinated biphenyls, and metals were detected in the fish and shellfish collected around the peninsula, the levels were too low to cause harmful health effects for members of the Metlakatla Indian Community who eat up to 227 grams (one 8-ounce meal) of seafood every day for 70 years.

- ATSDR concluded it is safe for the Metlakatla Indian Community to continue to harvest the fish and shellfish from the Metlakatla Peninsula for commercial sale. All of the chemical concentrations are too low to result in harmful health effects for people who eat fish and shellfish from the peninsula. Further, the concentrations were well below levels considered to be safe by the United States Food and Drug Administration (FDA).

ATSDR's health conclusions are supported by the fact that there are no fish advisories for the state of Alaska and the Alaska Division of Public Health recommends continued unrestricted consumption of traditional subsistence foods in Alaska (EPA 2003; State of Alaska 1998).

> A study by Ridolfi compared the analytical results from the *Annette Islands Seafood Study* to three recent NOAA- and EPA-sponsored studies and found that the chemical concentrations detected in species collected from Annette Island were comparable to, or lower than, those reported in the three studies. They also observed that there were no spatial trends in the distribution of chemicals by location. Therefore, they concluded that the detected chemicals represent regional ambient levels and the inorganic arsenic, specifically, represents naturally occurring levels (Ridolfi 2004).

Despite this, there are people who might be more sensitive or susceptible to exposure to certain chemicals because of factors such as age, occupation, gender, or behaviors (e.g., cigarette smoking). Children, pregnant women, and older people, for example, are often more sensitive to environmental exposures. If community members are concerned and wish to reduce their exposure, they can follow the cleaning and cooking methods presented in *A Guide to Healthy Eating of the Fish You Catch*, provided in Appendix C.

Statement of Issue

The Metlakatla Indian Community (MIC) is concerned about eating fish and shellfish harvested from around the Annette Islands Reserve due to potential contamination from past federal agency activities, a closed sawmill, sanitary sewer outfalls, and other activities on the island (NOAA 2002). To address the community's concerns, Ridolfi, Inc., the MIC Environmental Office, and the National Oceanic and Atmospheric Administration (NOAA) conducted a screening-level[1] seafood study in 2002 and 2003 (Ridolfi 2004). ATSDR agreed to use the data generated from the study to determine whether the fish and shellfish around the island are safe for subsistence consumption by the community and for commercial sale.

ATSDR recognizes that the use of seafood, as part of a subsistence diet, has a high cultural, nutritional, and economic significance. Therefore, before decisions are made to limit consumption of traditional foods, consideration should be given to the benefits that the foods provide compared to the potential risks, if any, from low levels of chemical contaminants present in the foods. To help the community weigh this information in terms of their own personal values, ATSDR also presents information on, and considers the benefits of, eating fish within this document.

[1] The study is considered screening-level because it is biased toward areas where contaminants were most likely to be found and toward organisms likely to be contaminated (NOAA 2002; Ridolfi 2004).

Background

Site Description

Annette Island is located in southeast Alaska, south of Ketchikan. The village of Metlakatla is located on the west coast of Annette Island at the northern end of the Metlakatla Peninsula (see Figure 1). As there is currently no road to Annette Island, the only access is by ferry or air. The 86,000-acre Annette Islands Reserve is a Federal Indian Reservation that also includes the surrounding 3,000 feet of coastal water. It is the only federal reservation for indigenous people in Alaska (ADCED 2003; Ridolfi 2004). Because the Metlakatla Indian Community did not participate in the Alaska Native Claims Settlement Act, the reservation is a sovereign territory; the state of Alaska does not have legal jurisdiction. The community has full control and authority over its natural resources and regulates the commercial fishing industry (ADCED 2003).

Annette Island

In the early 1940s, the Annette Island Airfield was constructed about 6 miles south of the village of Metlakatla. The airfield included a runway, hangar, seaplane ramp, plane revetments, fuel tanks, and fuel pipelines on 12,783 acres of land (EPA 2000a; Ridolfi 2004). In 1946, the airport was turned over to the Civil Aeronautics Administration and in 1949, when the United States Navy left Annette Island, the remaining facilities were turned over to the Civil Aeronautics Administration and the United States Coast Guard. The airport was used for commercial flights until 1974, when the Ketchikan International Airport was constructed. At that time the Annette Island airport was closed and most of the former military facilities on the island were turned over to the Metlakatla Indian Community (EPA 2000a; Ridolfi 2004). The United States Coast Guard maintained a facility on the peninsula until 1977, and currently leases 5 acres on the island for a global positioning system (GPS) communication antenna. Additionally, the Federal Aviation Administration (FAA, formerly the Civil Aeronautics Administration) leases 96 acres on the island for navigational aids and the National Weather Service leases three small areas (Ridolfi 2004).

In 1996, the Metlakatla Indian Community conducted a preliminary site assessment of the Metlakatla Peninsula and identified over 80 sites associated with former federal facilities (EPA 2000a). Additionally, the Metlakatla Indian Community has also been working with the FAA, the United States Department of Defense, the United States Coast Guard, the United States Army Corps of Engineers, the Bureau of Indian Affairs, and Chevron-Texaco to identify and clean up abandoned facilities on the island (Ridolfi 2004). Leaking drums, asbestos, lead, pesticides, polychlorinated biphenyls (PCBs), chemical and oil spills, and leaking storage tanks are among the leading concerns (EPA 2000a).

Metlakatla

Metlakatla means “saltwater channel passage” (ADCED 2003).

Metlakatla is located at Port Chester, on the west coast of Annette Island. It is 15 miles south of Ketchikan, Alaska, 300 miles south of Juneau, Alaska, and about 720 miles northwest of Seattle, Washington. In 1887, led by Reverend William Duncan, Tsimshian

Indians from British Columbia, Canada, who were seeking religious freedom, founded Metlakatla, Alaska. In 1891, the United States Congress recognized the community (of about 800 residents) and founded the Annette Islands Reserve (ADCED 2003).

According to the 2000 U.S. Census, there are 530 homes with 1,375 people living in Metlakatla. The majority of the population (81.8%) is Alaskan Native, 9.5% are white, 7.9% are two or more races, and a small percentage consists of persons of other races. The median age is 31 years. There are 109 children under the age of five and 99 people over the age of 65 in Metlakatla. About 280 students attend the three community schools. The population is almost equally comprised of men (52%) and women (48%) (U.S. Census 2000).

The community is traditional Tsimshian who practice a subsistence lifestyle. Salmon, halibut, cod, clams, scallops, cockles, abalone, crab, octopus, seaweed, and waterfowl are the primary subsistence foods for the community (ADCED 2003; Ridolfi 2004). Local harvests include fish (salmon, herring, smelt, cod, flounder, halibut, rockfish, char), land mammals (deer), marine mammals (seal), birds (duck, geese, eggs), marine invertebrates (abalone, chiton, clam, crab, octopus, scallop, sea cucumber, sea urchin, shrimp), and vegetation (berries, plants/greens, seaweed/kelp, wood) (ADFG 2000).

The community also has an active economy based on fishing, fish processing, and services. They built a salmon hatchery in Tamgas Creek/Bay that raises and releases millions of fry of all five salmon species (ADCED 2003). The community also used to have an active timber industry, however, the two sawmills are no longer in operation and the cannery has also closed. Two hydroelectric plants, one on Purple Lake and one on Chester Lake, provide electricity to the community (ADCED 2003).

> "Brownfields are abandoned, idled or underused industrial and commercial properties where expansion or redevelopment is complicated by real or perceived contamination" (EPA 2003).

The Metlakatla Indian Community is a federally designated Enterprise Community as well as a Showcase Community in the U.S. Environmental Protection Agency's (EPA's) Brownfields National Partnership Program (EPA 2000a). With its federal, state, and local partners, the community has developed a plan to clean up sites for redevelopment and/or expanded use to promote sustainable economic development and protect natural resources (EPA 2000a).

Review of the Annette Islands Seafood Study

In May 2002, community members helped personnel from Ridolfi, the MIC Environmental Office, and NOAA collect about 80% of the fish and shellfish samples. The remaining samples were collected during subsequent sampling efforts through February 2003.

Based on the consumption patterns obtained from the Alaska Department of Fish and Game's Community Profile Database[2] and an informal survey of local seafood consumption patterns[3], the following species were collected:

- Butter clams (*Saxidomus giganteus*)
- Cockle (*Clinocardium nuttallii*)
- Slipper chiton, also known as gumboot chiton (*Cryptochiton stelleri*)
- Dungeness crab (*Cancer magister*)
- Giant Pacific octopus, also known as devilfish (*Octopus dofleini*)
- Pacific halibut (*Hippoglossus stenolepis*)
- Chinook "king" salmon (*Oncorhynchus tshawytscha*)
- Seaweed (*Porphyra*)

Clam, cockle, chiton, and seaweed samples were composited from multiple whole-body specimens to attain sufficient sample sizes. Composites of crab muscle (crab meat) and crab hepatopancreas (crab butter) were analyzed separately and one composite of muscle combined with hepatopancreas was analyzed. The beak and internal organs were removed from the individual octopus samples. Salmon and halibut samples were filleted, but three of the halibut samples also included the heads (Ridolfi 2004).

The Metlakatla Indian Community requested that sampling be conducted in areas where the community fishes to support their subsistence lifestyle or harvests fish and shellfish for commercial sale (Ridolfi 2004). The locations were also biased toward places where contamination was most likely to be found. As shown in Figure 2, the following areas were sampled around the Metlakatla Peninsula:

1. Tamgas Harbor Beaches
2. Hospital Beach
3. Central Tamgas Harbor
4. Moss Point
5. Point Davison
6. Smuggler Cove
7. Sand Bar
8. Sawmill Beach
9. Port Chester

Fish and shellfish were collected from Crab Bay/Cascade Inlet as a reference location.

[2] The Community Profile Database was developed by the Division of Subsistence within the Alaska Department of Fish and Game to be a central repository of information on contemporary subsistence uses within Alaskan communities (ADFG 2000).

[3] On September 24, 2001, personnel from NOAA and Ridolfi asked members of the Metlakatla Indian Community which resources they harvest, where on the island they harvest the resources, and how they prepare the fish and shellfish. The results of the survey generally agreed with the information available in the Community Profile Database (NOAA 2002).

Samples were analyzed for targeted contaminants within four major groups: polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides, PCBs, and metals. Specific chemicals were chosen based on the contamination known to be present at or around the study areas (Ridolfi 2004). A list of chemicals is provided in Table 1.

Because one form of arsenic (inorganic) is more harmful than the other form (organic arsenic), butter clams were also analyzed for the form of arsenic to determine the amount of inorganic arsenic present in seafood collected from the Metlakatla Peninsula. Butter clams were chosen as the representative species because they were sampled at most locations and had higher concentrations of total arsenic in the initial sampling. The results showed that inorganic arsenic represents less than 1% of the total arsenic found in the samples (Ridolfi 2004).

Scientists with Ridolfi and NOAA evaluated and interpreted the analytical results from the *Annette Islands Seafood Study* for trends among species, sampling locations, and chemical groups. Some of their more notable findings include:

- PAHs were detected at low concentrations in every species of fish and shellfish sampled. The clams collected from Sawmill Beach and the clams, cockles, and chitons collected from Tamgas Harbor Beaches contained higher PAH concentrations in their tissues.

- PCBs were only detected at concentrations above detection limits in the crab butter and halibut whole head samples.

- Pesticides were detected at trace amounts in every species sampled, however, there were no clear spatial trends or patterns among species, except that the more lipid-rich tissues contained higher concentrations of pesticides.

- The crab butter samples tended to have high metal concentrations. With the exception of lead, metal concentrations collected from around the Metlakatla Peninsula were found in trace amounts, and were similar to those collected from Crab Bay/Cascade Inlet (the reference location). Lead concentrations were higher in clams from Sawmill Beach and Tamgas Harbor Beaches. Two outlier results were identified: an octopus from Crab Bay with a cadmium concentration of 1.7 milligrams per kilogram (mg/kg) and a halibut from Tamgas Harbor with a chromium concentration of 9.5 mg/kg.

Ridolfi compared the analytical results from the *Annette Islands Seafood Study* to three recent NOAA- and EPA-sponsored studies: *National Status and Trends Program for Marine Environmental Quality: Alaska* (Cantillo et al. 1999 as cited in Ridolfi 2004), *Human Exposure Evaluation of Chemical Contaminants in Seafood Collected in the Vicinity of Tyonek, Seldovia, Port Graham, and Nanwalek in Cook Inlet, Alaska* (USEPA et al. 2001 as cited in Ridolfi 2004), and *Columbia River Basin Fish Contaminant Survey 1996–1998* (USEPA 2002 as cited in Ridolfi 2004). They found that the chemical concentrations detected in species collected from Annette Island were lower than, or comparable to, those reported in the three studies. Taken with their observation that there were no spatial trends in the distribution of chemicals by location, they concluded that the detected chemicals represent “regional ‘ambient’ levels.” The inorganic arsenic evaluation in butter clams further supported the conclusion that concentrations found in seafood samples from the Annette Islands Reserve represent naturally occurring levels (Ridolfi 2004).

Ridolfi performed a preliminary risk assessment following standard EPA guidance on evaluating potential human health risks. They assumed that an individual could consume up to 227 grams (an 8-ounce serving) of a specific fish or shellfish from Annette Island every day for a lifetime (70 years). These assumptions are intended to be conservative, however, individual risks may vary considerably. Their evaluation showed that all estimated risks fell within the "safe range" identified by EPA. They noted that more precise information is needed about community-specific consumption rates for each species before more realistic estimates of health risks can be determined (Ridolfi 2004).

Discussion

Nutritional Benefits of Eating Seafood and Other Traditional Subsistence Foods

ATSDR realizes that a subsistence lifestyle is very important to the Metlakatla Indian Community, as well as other Alaskan Natives. Not only do subsistence foods provide nutritional and health benefits, but they also promote cultural, spiritual, medicinal, and economic well being in the community (State of Alaska 1998).

Traditional foods provide inexpensive and readily available nutrients (such as iron, zinc, and copper), omega-3 fatty acids, antioxidants, vitamins, calories, and protein (Nobmann 1997; State of Alaska 1998). In addition, they are lower in carbohydrates and salt than store-bought foods. Traditional foods, which are low in saturated fat and high in monounsaturated fat and omega-3 fatty acids, are considered to be healthier than and nutritionally superior to "typical American foods" (State of Alaska 1998). It has been shown that people who gather and eat traditional foods have lower incidences of cardiovascular disease and obesity, as well as improved maternal nutrition and neonatal and infant brain development (Nobmann 1997; State of Alaska 1998).

Economically, subsistence foods are very important to Alaskan communities because store-bought foods are expensive and many typical American foods are not readily available. In addition, a subsistence lifestyle provides meaningful, productive work where paying jobs are scarce (State of Alaska 1998).

Many Alaskans worry that exposures to contaminants resulting from a subsistence lifestyle can potentially lead to cancer, worsen existing conditions such as diabetes and asthma, and increase the incidence of other health problems. To enable informed choices about foods, Alaskans have requested more information about the risk from these exposures and the nutritional benefits of traditional foods. To assist in this effort, ATSDR awarded a grant to the Alaska Native Health Board to support surveys of the dietary habits of Alaskans who regularly eat traditional foods. This grant formed the cornerstone for ATSDR's Alaska Traditional Diet Project, which was developed to assist consumers of Alaskan traditional foods in making informed dietary decisions to prevent adverse health outcomes.

Community members who would like additional information about the ATSDR Alaska Traditional Diet Project may call Leslie Campbell or Bill Cibulas, toll free, at 888-477-8737 or call Richard Kauffman in the ATSDR Region 10 office (Seattle) at 206-553-2632. ATSDR has published information about the project on the following Web site: http://www.atsdr.cdc.gov/alaska.

Public Health Implications of Eating Seafood from the Metlakatla Peninsula

To evaluate exposures from eating fish and shellfish caught around the Metlakatla Peninsula, ATSDR derived exposure doses (see text box for definition) specific for the Metlakatla Indian Community and compared them against health-based guidelines. ATSDR also reviewed relevant toxicologic data to obtain information about the toxicity of the chemicals of interest.

> An exposure dose is the amount of chemical a person is exposed to over time.

Because it is highly unlikely that anyone would ingest fish or shellfish with the maximum concentration on a daily basis and for an extended period of time, ATSDR calculated average[4] chemical concentrations for each species. This approach is taken because not every fish or shellfish contains the maximum detected concentration of any given chemical. Therefore, it is more likely that fish or shellfish containing a range of concentrations would be ingested over time. Additionally, several chemicals (e.g., aldrin and hexachlorobenzene) were not detected in all samples collected. Therefore, fish or shellfish without any chemical contamination could also be consumed.

Comparing Estimated Doses to Health Guidelines

As a first step in evaluating noncancer effects, ATSDR calculated exposure doses for the detected chemicals and compared them to conservative health guideline values, including ATSDR's minimal risk levels (MRLs) and EPA's reference doses (RfDs). ATSDR evaluated exposure from eating 227 grams (8 oz) of fish and shellfish per day for 70 years. *Estimated exposure doses that are less than health guideline values are not considered to be of health concern.* Through this process, ATSDR determined that health effect levels and exposure potential should be further evaluated for the following chemicals:

- Aldrin
- Arsenic
- Benzo(e)pyrene
- Cadmium
- Chromium
- Dieldrin
- Heptachlor epoxide
- Hexachlorobenzene
- Mercury

Exposure to 1-methylphenanthrene in fish and shellfish was also evaluated further because this chemical does not have a health guideline value. All other chemicals were not detected, detected infrequently, or detected at concentrations that resulted in exposure doses below health guidelines; therefore, not at levels of health concern in fish and shellfish from the Metlakatla Peninsula.

As a second step, ATSDR examined the chemical-specific health effect levels discussed in the scientific literature and more fully reviewed exposure potential for the chemicals listed above. This information was used to describe the disease-causing potential of a particular chemical and to compare site-specific dose estimates with doses shown in applicable studies to result in illness. For cancer effects, ATSDR compared an estimated lifetime exposure dose to available cancer

[4] Averages were calculated using the detection limit for non-detected chemicals.

effect levels (CELs) and reviewed genotoxicity studies to further understand the extent to which a chemical might be associated with cancer outcomes. Please see Appendix B for more details on the methods and assumptions ATSDR used to estimate human exposure doses and determine health effects.

Public Health Evaluation

Is it safe to eat fish and shellfish collected around the Metlakatla Peninsula?

Yes, it is safe for the Metlakatla Indian Community to continue to collect and eat the fish and shellfish from the Metlakatla Peninsula to support their subsistence lifestyle. Even though PAHs, pesticides, PCBs, and metals were detected in the fish and shellfish, the concentrations that were present were too low to be of health concern for anyone eating a variety of seafood every day. Please see Appendix B for more details concerning ATSDR's evaluation.

It should be noted that marine shellfish, such as mussels, cockles, clams, scallops, oysters, crabs, snails, and lobsters (not shrimp and finfish) feed on tiny microorganisms called dinoflagellates, which may contain a very poisonous, naturally-occurring toxin that causes Paralytic Shellfish Poisoning (PSP). Because of this threat, the State of Alaska only recommends consumption of shellfish from certified beaches (personal communication with Alaska Division of Public Health Environmental Toxicologist, April 2004).

Is it safe to harvest and sell fish and shellfish from around the Metlakatla Peninsula?

Yes, it is safe for the Metlakatla Indian Community to continue to harvest the fish and shellfish from the Metlakatla Peninsula for commercial sale. As discussed above, ATSDR evaluated whether eating one meal of fish and shellfish per day for 70 years from the peninsula would result in harmful health effects and determined that eating a variety of seafood every day would not result in noncancer health effects or an increase in the risk of developing cancer. Further, the fish and shellfish that are harvested for commercial sale are canned or frozen locally and then globally distributed; making it highly unlikely that any consumer could eat fish and shellfish exclusively from the Metlakatla Peninsula every day.

Where available, ATSDR compared the levels of chemicals detected in the fish and shellfish from the Metlakatla Peninsula to guidelines established by the United States Food and Drug Administration (FDA), the federal agency responsible for ensuring the safety of the United States' food supply. All of the concentrations were well below levels considered to be safe by FDA. The majority of the chemicals were detected below EPA's risk-based concentrations for fish, which are health-based comparison values used to screen chemicals during a baseline risk assessment. A few chemicals were detected above EPA's risk-based concentrations. These chemicals were evaluated further by ATSDR and determined to not be at levels of health concern. Therefore, the concentrations detected in the Metlakatla Peninsula seafood are safe for commercial sale.

Child Health Considerations

A child's exposure may differ from an adult's exposure in many ways. ATSDR recognizes that infants and children can be more sensitive to contamination of their food than adults because children are smaller; therefore, childhood exposure results in higher doses of chemical exposure per body weight. A child's behavior and lifestyle also influence exposure. Because children can sustain permanent damage if these factors lead to toxic exposure during critical growth stages, ATSDR, as part of its public health assessment process, is committed to evaluating their special interests at sites such as Metlakatla. ATSDR paid special attention to child exposures during the health evaluation. *Children are not expected to experience adverse health effects from consuming fish or shellfish from around the Metlakatla Peninsula.*

That said, the estimated doses for children eating both Dungeness crab meat and crab butter every day approach, *but do not exceed*, the health effects level for arsenic. Although there are uncertainties associated with this level (specifically, effects may actually be associated with doses higher than those reported), there is also some indication that children may be more susceptible to health effects from exposure to inorganic arsenic because children may be less efficient at converting inorganic arsenic to the less harmful organic forms (ATSDR 2000a). To estimate doses, ATSDR assumed that 10% of the total arsenic was in the more harmful inorganic form (FDA 1997). However, this may overestimate childhood exposure by as much as a factor of 10 (butter clams from the Metlakatla Peninsula were shown to have less than 1% inorganic arsenic; Ridolfi 2004). Therefore, ATDR does not expect that eating Dungeness crab with the level of arsenic detected would result in adverse health effects for children. Please see Appendix B for more details about the arsenic evaluation.

Conclusions

- PAHs, pesticides, PCBs, and metals were detected in the fish and shellfish collected around the Metlakatla Peninsula. However, the levels were too low to cause harmful health effects for the Metlakatla Indian Community, who subsist on seafood from the area. ATSDR has categorized exposure to fish and shellfish from the Metlakatla Peninsula as "***no apparent public health hazard***." This means that people are being exposed to environmental contamination in the seafood, but that the exposures are not at levels expected to cause harmful health effects. *ATSDR concluded that it is safe to eat fish and shellfish from the Metlakatla Peninsula.*

- ATSDR concluded that it is safe for the Metlakatla Indian Community to continue to harvest fish and shellfish from the Metlakatla Peninsula for commercial sale. All of the chemical concentrations are too low to result in harmful health effects for people who eat fish and shellfish from the peninsula. Further, the concentrations were well below levels considered to be safe by the FDA.

Recommendations/Public Health Action Plan

- ATSDR recommends that the level of inorganic arsenic be analytically determined in Dungeness crab. Inorganic arsenic is the more harmful form of the chemical and the estimated doses for children eating both crab meat and crab butter every day approach, *but do not exceed*, the health effects level in the scientific literature. ATSDR based the arsenic evaluation on a conversion factor recommended by FDA (i.e., ATSDR assumed that 10% of the total arsenic was in the inorganic form; FDA 1993). Although, according to the arsenic speciation conducted for butter clams collected from the Metlakatla Peninsula, less than 1% of the total arsenic is in the inorganic form (Ridolfi 2004). If Dungeness crab also contain less than 1% inorganic arsenic (or up to 10%), then it is safe for children to eat them. However, if Dungeness crab contain more than 10% inorganic arsenic, ATSDR would caution children to avoid eating crab every day. Because the percent of inorganic arsenic can vary between species, it is important to determine the amount in the Dungeness crab.

- Ridolfi and the MIC are designing a program to collect and analyze fresh Dungeness crab samples from locations near Metlakatla where community members usually catch crab (personal communication with Ridolfi personnel, April 2004). When the data are available, ATSDR will evaluate the results and adjust this public health evaluation, if needed.

Preparer of Report

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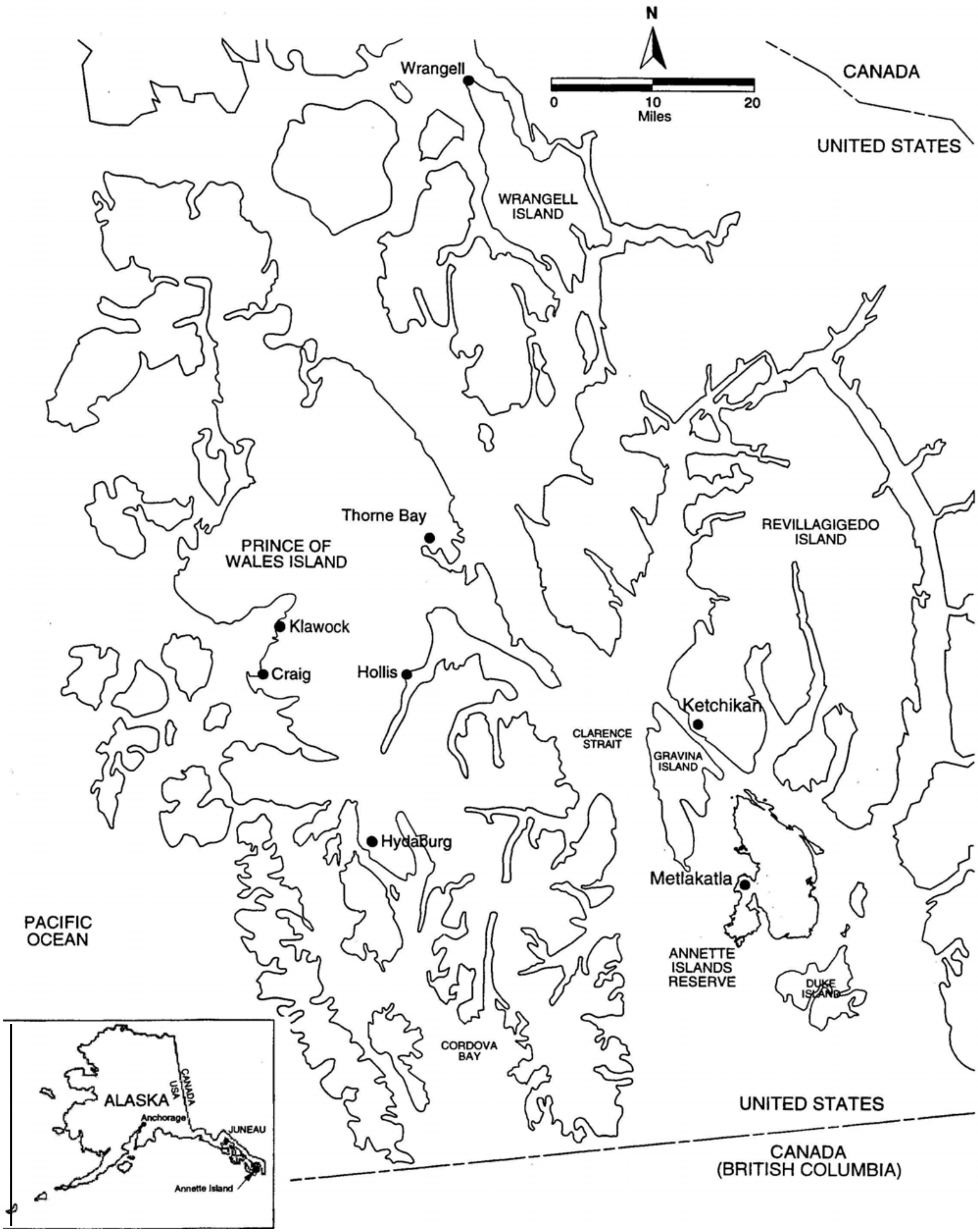
Table 1. Chemicals Analyzed

Physical Characteristics	***Organochlorine Pesticides***
Percent solids	Aldrin
Percent lipids	alpha-Chlordane
	gamma-Chlordane
Polycyclic Aromatic Hydrocarbons (PAHs)	4,4'-DDD
Acenaphthene	4,4'-DDE
Acenaphthylene	4,4'-DDT
Anthracene	Dieldrin
Benz(a)anthracene	Endosulfan I
Benzo(a)pyrene	Endosulfan II
Benzo(b)fluoranthene	Endosulfan sulfate
Benzo(e)pyrene	Endrin
Benzo(g,h,i)perylene	Endrin Aldehyde
Benzo(k)fluoranthene	alpha-Hexachlorocyclohexane (HCH)
Biphenyl	beta-HCH
Chrysene	delta-HCH
Dibenz(a,h)anthracene	gamma-HCH (Lindane)
Dibenzofuran	Heptachlor
2,6-Dimethylnaphthalene	Heptachlor epoxide
Fluoranthene	Hexachlorobenzene
Fluorene	Methoxychlor
Indeno(1,2,3-cd)pyrene	Mirex
1-Methylnaphthalene	Oxychlordane
2-Methylnaphthalene	Toxaphene
1-Methylphenanthrene	
Naphthalene	***Total Metals***
Phenanthrene	Arsenic
Pyrene	Barium
2,3,5-Trimethylnaphthalene	Cadmium
	Chromium
Polychlorinated Biphenyls (PCBs)	Copper
Aroclor 1016	Lead
Aroclor 1221	Mercury
Aroclor 1232	Selenium
Aroclor 1242	Zinc
Aroclor 1248	
Aroclor 1254	
Aroclor 1260	

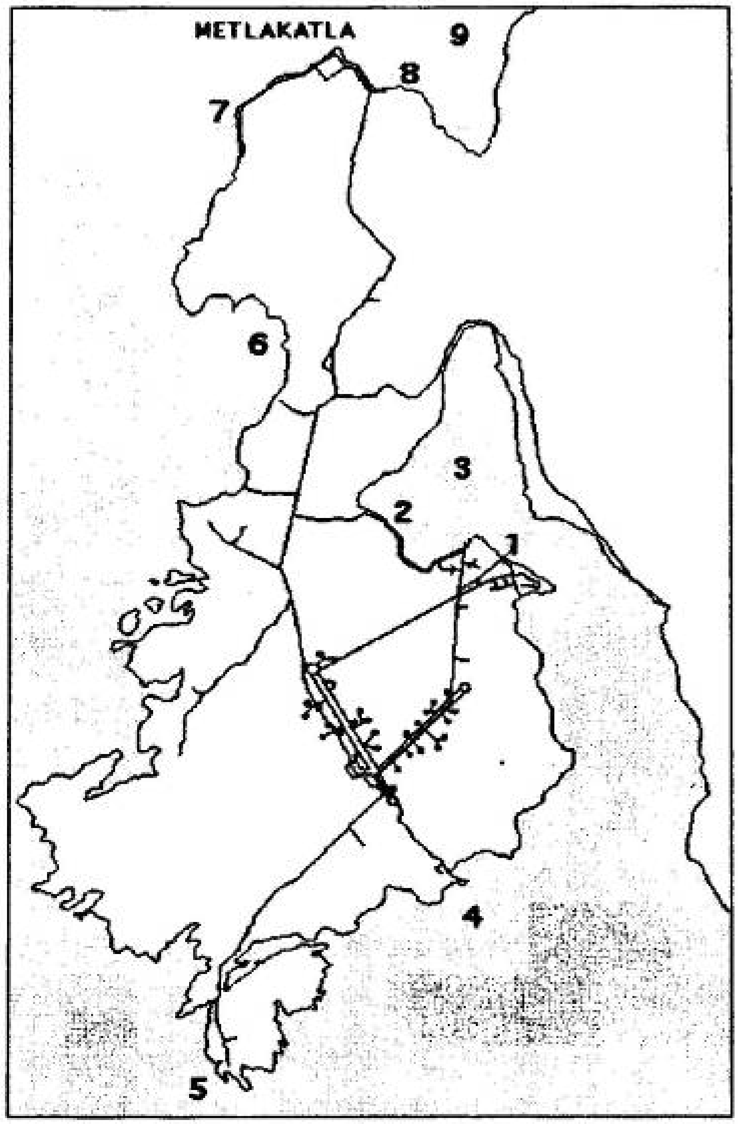
Source: Ridolfi 2004

Figure 1. Location of the Annette Islands Reserve



Source: Ridolfi 2004

Figure 2. Metlakatla Peninsula Sample Locations



Metlakatla Peninsula

1 - Tamgas Harbor Beaches
2 - Hospital Beach
3 - Central Tamgas Harbor
4 - Moss Point
5 - Point Davison
6 - Smuggler Cove
7 - Sand Bar
8 - Sawmill Beach
9 - Port Chester

Source: Ridolfi 2004

Appendix A
ATSDR Glossary of Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health. This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

Absorption
The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems

Ambient
Surrounding (for example, ambient air).

Cancer
Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

Cancer Effect Level (CEL)
The lowest dose of chemical in a study, or group of studies, that produces significant increases in the incidence of cancer (or tumors) between the exposed population and its appropriate control.

Cancer risk
A theoretical risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Chronic
Occurring over a long time.

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year).

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

Dose
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose-response relationship
The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and

transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Hazard
A source of potential harm from past, current, or future exposures.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way.

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Receptor population
People who could come into contact with hazardous substances [see exposure pathway].

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Risk
The probability that something will cause injury or harm.

Safety factor [see uncertainty factor]

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size
The number of units chosen from a population or an environment.

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Substance
A chemical.

Survey
A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Tumor
An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

Other glossaries and dictionaries
Environmental Protection Agency (http://www.epa.gov/OCEPAterms/)
National Center for Environmental Health (CDC) (http://www.cdc.gov/nceh/dls/report/glossary.htm)
National Library of Medicine (NIH) (http://www.nlm.nih.gov/medlineplus/mplusdictionary.html)

For more information on the work of ATSDR, please contact
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Agency for Toxic Substances and Disease Registry
1600 Clifton Road, N.E. (MS E-60)
Atlanta, GA 30333
Telephone: (404) 498-0080

Appendix B
Overview of ATSDR's Methodology for Evaluating Potential Public Health Effects

A. Introduction

What is meant by exposure?

The Agency for Toxic Substances and Disease Registry's (ATSDR's) public health evaluations are driven by exposure or contact. Chemicals released into the environment have the potential to cause harmful health effects. *Nevertheless, a release does not always result in exposure*. People can only be exposed to a chemical if they come in contact with that chemical. If no one comes into contact with a chemical, then no exposure occurs, thus no health effects can occur.

How a chemical moves through the environment, and how people contact the chemical, defines an exposure pathway. ATSDR identifies and evaluates exposure pathways by considering how people might come into contact with a chemical. In this report, ATSDR is evaluating exposures from eating potentially contaminated fish and shellfish from the Metlakatla Peninsula, Annette Island, Alaska.

If someone is exposed, will they get sick?

Exposure does not always result in harmful health effects. The type and severity of health effects that occur in an individual as the result of contact with a chemical depend on the exposure concentration (how much), frequency (how often), duration (how long), and the route by which the chemical gets into the body (drinking water, eating seafood, etc.). Once exposure occurs, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status of the exposed individual influence how that individual absorbs, distributes, metabolizes, and excretes the chemical. Taken together, these factors and characteristics determine the health effects that can occur as a result of exposure to a chemical in the environment.

B. Methodology

Deriving Exposure Doses

When estimating exposure doses[5], health assessors evaluate chemical concentrations to which people could be exposed, together with the length of time and the frequency of exposure. Collectively, these factors influence an individual's physiological response to chemical exposure and potential outcomes. ATSDR used site-specific information regarding the frequency and duration of exposures. In addition, ATSDR employed several protective exposure assumptions to estimate exposures.

[5] Exposure doses are expressed in milligrams per kilogram per day (mg/kg/day).

The following equation was used to estimate ingestion of chemicals by eating fish and shellfish:

$$\text{Estimated exposure dose} = \frac{\text{Conc.} \times \text{IR} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

where:

Conc.: Concentration of chemical in fish and shellfish tissue in milligrams per kilogram (mg/kg)
IR: Ingestion rate: adult = 0.227 kilograms (kg)* of fish or shellfish per day; child = 0.1135 kg of fish or shellfish per day
EF: Exposure frequency, or number of exposure events per year of exposure: 365 days/year
ED: Exposure duration: adult = 70 years; child = 6 years
BW: Body weight: adult = 70 kg; child = 16 kg**
AT: Averaging time, or the period over which cumulative exposures are averaged (6 years or 70 years x 365 days/year)

* 0.227 kg/day is equal to an 8-ounce meal. This ingestion rate is consistent with the approach used by Ridolfi (2004) and, by all accounts, is an acceptable ingestion rate for the Metlakatla Indian Community (personal communication with a Metlakatla Indian Community representative and Ridolfi personnel, December 2003). A child's ingestion rate was assumed to be half the adult ingestion rate.

**According to the U.S. Environmental Protection Agency's (EPA's) Exposure Factors Handbook, the approximate average adult body weight is 70 kg (154 pounds) and the 50th percentile body weight for children 1 through 6 years old is 16 kg (35 pounds) (EPA 1997).

ATSDR used average chemical concentrations to calculate exposure doses to estimate a more probable exposure. This approach is taken because it is highly unlikely that anyone would ingest fish or shellfish with the maximum concentration on a daily basis and for an extended period of time because not every fish or shellfish contains the maximum detected concentration of any given chemical. Therefore, it is more likely that fish or shellfish containing a range of concentrations would be ingested over time. In addition, several chemicals (e.g., aldrin, hexachlorobenzene) were not detected in all samples collected. Therefore, fish or shellfish without any chemical contamination could also be consumed.

Using exposure doses to evaluate potential health hazards

ATSDR evaluates available toxicologic, medical, and epidemiologic data to determine whether exposures might be associated with harmful health effects (noncancer and cancer). As part of this process, ATSDR examines relevant health effects data to determine whether estimated doses are likely to result in harmful health effects. As a first step in evaluating noncancer effects, ATSDR compares estimated exposure doses to conservative health guideline values, including ATSDR's minimal risk levels (MRLs) and EPA's reference doses (RfDs). The MRLs and RfDs are estimates of daily human exposure to a substance that are unlikely to result in noncancer effects over a specified duration. Estimated exposure doses that are less than these values are not considered to be of health concern. To maximize human health protection, MRLs and RfDs have built-in uncertainty or safety factors, making these values considerably lower than levels at which health effects have been observed. The result is that even if an exposure dose is higher than the MRL or RfD, it does not necessarily follow that harmful health effects will occur.

If health guideline values are exceeded, ATSDR examines the health effect levels discussed in the scientific literature and more fully reviews exposure potential. ATSDR reviews available human studies as well as experimental animal studies. This information is used to describe the disease-causing potential of a particular chemical and to compare site-specific dose estimates with doses shown in applicable studies to result in illness (known as the margin of exposure). For cancer effects, ATSDR compares an estimated lifetime exposure dose to available cancer effect levels (CELs), which are doses that produce significant increases in the incidence of cancer or tumors, and reviews genotoxicity studies to understand further the extent to which a chemical might be associated with cancer outcomes. This process enables ATSDR to weigh the available evidence in light of uncertainties and offer perspective on the plausibility of harmful health outcomes under site-specific conditions.

Sources for health-based guidelines

By Congressional mandate, ATSDR prepares toxicological profiles for hazardous substances found at contaminated sites. These toxicological profiles were used to evaluate potential health effects from ingestion of fish and shellfish from the Metlakatla Peninsula. ATSDR's toxicological profiles are available on the Internet at http://www.atsdr.cdc.gov/toxpro2.html or by contacting the National Technical Information Service (NTIS) at 1-800-553-6847. EPA also develops health effects guidelines, and in some cases, ATSDR relied on EPA's guidelines to evaluate potential health effects. These guidelines are found in EPA's Integrated Risk Information System (IRIS)—a database of human health effects that could result from exposure to various substances found in the environment. IRIS is available on the Internet at http://www.epa.gov/iris. For more information about IRIS, please call EPA's IRIS hotline at 1-301-345-2870 or e-mail at Hotline.IRIS@epamail.epa.gov.

C. Evaluation of Health Hazards Associated with Eating Fish and Shellfish from the Metlakatla Peninsula

Chemicals not detected

Aroclor 1016, aroclor 1221, aroclor 1232, aroclor 1242, aroclor 1248, endosulfan sulfate, and toxaphene were analyzed for but not detected in any fish or shellfish sample. ATSDR reviewed the analytical detection limits for these chemicals and found them to be protective of public health. As discussed above, people can only be exposed to a chemical if they come in contact with that chemical. If no one comes into contact with a chemical (because it is not present in the seafood they eat), then no exposure occurs, thus no health effects can occur. Therefore, none of these chemicals are of health concern for people consuming fish and shellfish around the Metlakatla Peninsula and will not be discussed further.

Chemicals detected infrequently

Aroclor 1254, aroclor 1260, biphenyl, gamma-chlordane, 4,4'-DDD, dibenz(a,h)anthracene, endosulfan I, endosulfan II, endrin, endrin aldehyde, alpha-HCH, beta-HCH, gamma-HCH, delta-HCH, heptachlor, methoxychlor, mirex, and oxychlordan were detected in less than 10% of the samples. People eating fish and shellfish from the Metlakatla Peninsula have less than a one in ten chance of eating seafood containing these chemicals. As discussed above, people can only be exposed to a chemical if they come in contact with that chemical. If no one comes into contact with a chemical (because it is not present in the seafood they eat), then no exposure occurs, thus no health effects could occur.

Additionally, the exposure doses that were calculated using the maximum concentrations for more than half of these chemicals were below the health guidelines. This indicates that the vast majority of the chemicals were detected at levels too low to be of health concern. For those chemicals in which exposure doses were above the health guidelines (in less than 10% of the samples), ATSDR evaluated the health effect levels in the scientific literature and determined that none of these chemicals were found at levels of health concern for either noncancer or cancer health effects. Therefore, these chemicals will not be discussed further.

Chemicals in which using the maximum concentrations resulted in exposure doses below health guidelines

The maximum concentrations were used to calculate exposure doses. The exposure doses for the following chemicals were below the protective health guidelines: acenaphthene, acenaphthylene, alpha-chlordane, anthracene, barium, benz(a)anthracene, benzo(g,h,i)perylene, benzo(k)fluoranthene, biphenyl, chrysene, 4,4'-DDD, 4,4'-DDT, dibenzofuran, 2,6-dimethylnaphthalene, endosulfan I, endosulfan II, endrin, endrin aldehyde, fluoranthene, fluorene, gamma-BHC (lindane), gamma-chlordane, indeno(1,2,3-cd)pyrene, lead, methoxychlor, 1-methylnaphthalene, 2-methylnaphthalene, mirex, naphthalene, oxychlordane, phenanthrene, pyrene, and 2,3,5-trimethylnaphthalene. As discussed above, the MRLs and RfDs are estimates of daily human exposure to a substance that are unlikely to result in health effects over a specified duration. Estimated exposure doses that are less than these values are not considered to be of health concern. Therefore, none of these chemicals are of health concern for people consuming fish and shellfish around the Metlakatla Peninsula and will not be discussed further.

Chemicals in which using the average concentrations resulted in exposure doses below health guidelines for every species

As an additional screen, ATSDR calculated average[6] concentrations for each species sampled and derived exposure doses using the average concentrations. This approach was taken because it is highly unlikely that anyone would ingest fish or shellfish with the maximum concentration on a daily basis and for an extended period of time because not every fish or shellfish contains the maximum detected concentration of any given chemical. The exposure doses for benzo(a)pyrene, benzo(b)fluoranthene, copper, 4,4'-DDE, selenium, and zinc were below the health guidelines for

[6] Averages were calculated using the detection limit for non-detected chemicals.

every species. Therefore, these chemicals also are not considered to be at levels of health concern and will not be discussed further.

Chemicals in which using the average concentrations resulted in exposure doses above health guidelines for one or more species

ATSDR determined that the following chemicals warrant further evaluation because the exposure doses that were derived using the average concentrations for one or more species exceeded the health guidelines:

- Aldrin
- Arsenic
- Benzo(e)pyrene
- Cadmium
- Chromium
- Dieldrin
- Heptachlor epoxide
- Hexachlorobenzene
- Mercury

However, MRLs and RfDs have built-in uncertainty or safety factors, making these values considerably lower than levels at which health effects have been observed. It does not automatically mean harmful health effects will occur from eating the fish and shellfish. Rather, this is an indication that ATSDR should further examine the health effect levels reported in the scientific literature and more fully review exposure potential for these chemicals. The remainder of this appendix further evaluates these chemicals and their exposure potential. 1-Methylphenanthrene is also included in this analysis because a health guideline is not available for this chemical. The chemical-specific evaluations follow.

Aldrin

Aldrin is a man-made chemical that was used as an insecticide until 1970, when the U.S. Department of Agriculture canceled all uses. Although EPA approved the use of aldrin for killing termites in 1972, in 1987 the manufacturer voluntarily canceled the registration (ATSDR 2002a). Aldrin readily changes into dieldrin once it enters the environment or a person's body. Aldrin and dieldrin are structurally similar chemicals.

Studies in animals show that aldrin enters the body quickly after exposure. Once aldrin is inside the body, it quickly changes to dieldrin. Dieldrin then stays in fat tissue for a long time and can change to other products. It can take many weeks or years for dieldrin and its breakdown products to leave a person's body (ATSDR 2002a).

Table B-1. Aldrin Exposure Doses According to Species

Species	Average Concentration (mg/kg)	Estimated Exposure Dose (mg/kg/day)	
		Adult	Child
Butter Clams	0.0016	5.2×10^{-6}	1.1×10^{-5}
Slipper Chiton	*Not Detected*		
Cockle	0.0005	1.6×10^{-6}	3.5×10^{-6}
Dungeness Crab Meat	*Not Detected*		
Dungeness Crab Butter	0.0008	2.6×10^{-6}	5.7×10^{-6}
Giant Pacific Octopus	0.0005	1.6×10^{-6}	3.5×10^{-6}
Pacific Halibut	0.0006	1.9×10^{-6}	4.3×10^{-6}
Chinook Salmon	*Not Detected*		
Seaweed	*Not Detected*		

Noncancer health effects

ATSDR's MRL and EPA's RfD is 3.0×10^{-5} mg/kg/day for chronic exposure to aldrin. All of the estimated exposure doses for both adults and children are below this protective level (see Table B-1). Remember that health guidelines (MRLs and RfDs) are estimates of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects. They have built-in uncertainty or safety factors, making them considerably lower than levels at which health effects have been observed. Estimated doses that are less than these values are not considered to be of health concern. Therefore, ATSDR does not expect that eating fish or shellfish from the Metlakatla Peninsula with the detected levels of aldrin would cause harmful noncancer health effects. Furthermore, aldrin was only detected in about 25% of the samples collected and analyzed, and was not detected in chiton, crab meat, salmon, or seaweed.

> The US Food and Drug Administration (FDA) regulates the level of aldrin in food. To limit the intake of aldrin to a level considered to be safe, FDA set an action level of 0.3 mg/kg for the edible portion of fin fish and shellfish (FDA 2001). All of the fish and shellfish collected from the Metlakatla Peninsula contained aldrin concentrations well below this level

Cancer health effects

The United States Department of Health and Human Services (DHHS) and the International Agency for Research on Cancer (IARC) have determined that aldrin is not classifiable as to its carcinogenicity to humans (ATSDR 2002a). EPA has determined that aldrin is a probable human carcinogen because orally administered aldrin produced significant increases in tumor responses in three different strains of mice (EPA 2004). However, lifetime exposure to the average concentration of aldrin in fish and shellfish from the Metlakatla Peninsula is not expected to result in an increase in cancer because the expected lifetime doses (see adult exposure in Table B-1) are a hundred thousand times lower than the CELs reported in the scientific literature (CELs ranged from 0.52–1.5 mg/kg/day; ATSDR 2002a). Therefore, aldrin concentrations are also below levels of health concern for cancer effects.

Arsenic

Although elemental arsenic sometimes occurs naturally, arsenic is usually found in the environment in two forms—inorganic (arsenic combined with oxygen, chlorine, and sulfur) and organic (arsenic combined with carbon and hydrogen). The organic forms of arsenic are usually less toxic than the inorganic forms (ATSDR 2000a). Arsenic can be found in most foods, with seafood, particularly shellfish, containing the highest concentrations (FDA 1993). Therefore, ingesting fish and shellfish containing arsenic is one way arsenic can enter the body. However, most of the arsenic in fish and shellfish is the less harmful organic form (Cullen 1998, Dabeka et al. 1993, Eisler 1994, Gebel et al. 1998b as cited in ATSDR 2000a; FDA 1993).

> Research has shown that marine organisms tend to accumulate arsenic naturally present in seawater and food, rather than only accumulating arsenic due to local pollution (Eisler 1994 as cited in ATSDR 2000a). Arsenic levels in fish and shellfish are usually about 4B5 mg/kg, but may be as high as 170 mg/kg (Bennett 1986, NAS 1977b, Schroeder and Balassa 1966 as cited in ATSDR 2000a).

Once in the body, the liver changes some of the inorganic arsenic into the less harmful organic form (i.e., by methylation). This process is effective as long as the dose of inorganic arsenic remains below 0.05 mg/kg/day (ATSDR 2000a). Both inorganic and organic forms of arsenic leave the body in urine. Studies have shown that 45–85% of the arsenic is eliminated within one to three days (Buchet et al. 1981a, Crecelius 1977, Mappes 1977, Tam et al. 1979b as cited in ATSDR 2000a); however, some will remain for several months or longer.

Because inorganic arsenic is much more harmful than organic arsenic, ATSDR based its health assessment on the levels of inorganic arsenic that are present. In fish and shellfish, generally about 1–20% of the total arsenic is in the more harmful inorganic form (ATSDR 2000a; Francesconi and Edmonds 1997; NAS 2001; FDA 1993). The United States Food and Drug Administration (FDA) proposes that 10% of the total arsenic be estimated as inorganic arsenic (FDA 1993). Butter clams from the *Annette Island Seafood Study* (Ridolfi 2004) were analyzed for the individual forms of arsenic. The results showed that inorganic arsenic represents less than 1% of the total arsenic found in the samples (Ridolfi 2004). To be protective of the other fish and shellfish that were not tested for their inorganic arsenic content, ATSDR used FDA's default conversion factor of 10% to calculate the estimated doses from exposure to inorganic arsenic in fish and shellfish from the Metlakatla Peninsula (i.e., ATSDR assumed that 10% of the total arsenic detected was inorganic arsenic).

Table B-2. Arsenic Exposure Doses According to Species

Species	Average Concentration (mg/kg)	Estimated Exposure Dose (mg/kg/day)	
		Adult	Child
Butter Clams	6.4	2.1×10^{-3}	4.5×10^{-3}
Slipper Chiton	0.65	2.1×10^{-4}	4.6×10^{-4}
Cockle	1.3	4.2×10^{-4}	9.2×10^{-4}
Dungeness Crab Meat	11.5	3.7×10^{-3}	8.2×10^{-3}
Dungeness Crab Butter	9.0	2.9×10^{-3}	6.4×10^{-3}
Giant Pacific Octopus	4.2	1.4×10^{-3}	3.0×10^{-3}
Pacific Halibut	2.0	6.5×10^{-4}	1.4×10^{-3}
Chinook Salmon	0.84	2.7×10^{-4}	6.0×10^{-4}
Seaweed	2.5	8.1×10^{-4}	1.8×10^{-3}

Noncancer health effects

Daily exposure to the average concentrations of arsenic in fish and shellfish from the Metlakatla Peninsula would result in exposure doses ranging from 2.1×10^{-4} to 3.7×10^{-3} mg/kg/day for adults and 4.6×10^{-4} to 8.2×10^{-3} mg/kg/day for children (see Table B-2). As noted above, the metabolism (i.e., how it is broken down in the body) of inorganic arsenic has been extensively studied in humans and animals. ATSDR's estimated doses are below those that inhibit the body's ability to detoxify or change arsenic to non-harmful forms (doses greater than 0.05 mg/kg/day inhibit detoxification). Therefore, the amount of arsenic that a person consumes in fish and shellfish from the Metlakatla Peninsula should be controlled by normal metabolic processes in the body.

There is some indication in the scientific literature, however, that some dermal health effects could result from ingesting a lower dose of arsenic—hyperkeratosis and hyperpigmentation were reported in humans exposed to 1.4×10^{-2} mg/kg/day of arsenic in their drinking water for more than 45 years (Tseng et al. 1968 as cited in ATSDR 2000a). However, there is much uncertainty surrounding the reported dose. Because estimates of water intake and dietary arsenic are highly uncertain in this and similar studies, some scientists argue that reported effects may actually be associated with doses higher than 1.4×10^{-2} mg/kg/day. Specifically, the full extent of arsenic intake from dietary sources and the health status of the study population are not well documented.

Given the fact that the metabolism of arsenic has been well-studied in people and the estimated exposure doses for eating fish and shellfish from the Metlakatla Peninsula are within the body's capability to metabolize arsenic, ATSDR does not expect that people who eat the fish and shellfish would experience adverse noncancer health effects.

> The FDA regulates the level of arsenic in food. To limit the intake of arsenic to a level considered to be safe, FDA set an action level of 76 mg/kg for crustaceans and 86 mg/kg for molluscan bivalves (FDA 1993). All of the fish and shellfish collected from the Metlakatla Peninsula contained arsenic concentrations well below these levels.

Children, however, may be more susceptible to health effects from exposure to inorganic arsenic than adults because children may be less efficient at converting inorganic arsenic to the less harmful organic forms (ATSDR 2000a). The estimated doses for children eating both crab meat and crab butter *every day* (see child exposure in Table B-2) approach, *but do not exceed*, the health effects level mentioned above. ATSDR assumed that 10% of the total arsenic was in the more harmful inorganic form. As shown by the arsenic speciation in butter clams collected from the Metlakatla Peninsula, this may overestimate childhood exposure by as much as a factor of 10 (clams were shown to have less than 1% inorganic arsenic; Ridolfi 2004). Therefore, ATSDR does not expect that eating crab would cause harmful health effects for children.

<u>Cancer health effects</u>

DHHS, IARC, and EPA have all independently determined that inorganic arsenic is carcinogenic to humans (ATSDR 2000a). Skin cancer was reported for people exposed to 1.4×10^{-2} mg/kg/day of arsenic in their water for more than 45 years (Tseng et al. 1968 as cited in ATSDR 2000a). As explained above, scientists argue that this CEL may be underestimated (i.e., doses associated with cancer may actually be higher). Additional CELs in the literature generally ranged from 0.01–0.05 mg/kg/day (ATSDR 2000a). The estimated lifetime doses are about an order of magnitude below these levels (see adult exposure in Table B-2). While the estimated doses for eating crab every day approach levels of concern for arsenic exposure, they *are* lower than levels known to cause cancer in several human studies. Additionally, ATSDR conservatively assumed that people ate one meal of crab every day for 70 years and that 10% of the total arsenic is in the inorganic form. Even with these protective assumptions, the estimated doses are below levels of health concern for cancer effects.

Benzo(e)pyrene

Benzo(e)pyrene is one of a 100 different polycyclic aromatic hydrocarbons (PAHs) that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances, such as tobacco and charbroiled meat (ATSDR 1995). PAHs usually occur naturally, but they can be manufactured as individual compounds for research purposes. A few PAHs are used in medicines and to make dyes, plastics, and pesticides. Others are contained in asphalt used in road construction.

PAHs break down to longer-lasting products by reacting with sunlight and other chemicals in the air, generally over a period of days to weeks. Breakdown in soil and water generally takes weeks to months and is caused primarily by the actions of microorganisms (ATSDR 1995).

Eating fish or shellfish is one route for PAHs to enter a person's body, but absorption is generally slow when PAHs are swallowed (ATSDR 1995). They can enter all the tissues of the body that contain fat, however, they tend to be stored mostly in the kidneys, liver, and fat. PAHs are changed by all tissues in the body into many different substances. Results from animal studies show that PAHs do not tend to be stored in a person's body for a long time. Most PAHs that enter the body leave within a few days (ATSDR 1995).

Table B-3. Benzo(e)pyrene Exposure Doses According to Species

Species	Average Concentration (mg/kg)	Estimated Exposure Dose (mg/kg/day)	
		Adult	Child
Butter Clams	0.0006	1.9×10^{-6}	4.3×10^{-6}
Slipper Chiton	0.0002	6.5×10^{-7}	1.4×10^{-6}
Cockle	0.0002	6.5×10^{-7}	1.4×10^{-6}
Dungeness Crab Meat	0.0005	1.6×10^{-6}	3.5×10^{-6}
Dungeness Crab Butter	*Not Detected*		
Giant Pacific Octopus	*Not Detected*		
Pacific Halibut	*Not Detected*		
Chinook Salmon	0.0002	6.5×10^{-7}	1.4×10^{-6}
Seaweed	0.0002	6.5×10^{-7}	1.4×10^{-6}

Noncancer health effects

An oral health guideline for benzo(e)pyrene has not been derived because there are no adequate human or animal dose-response data available that identify threshold levels for appropriate noncancer health effects (ATSDR 1995). Thus, ATSDR consulted the available scientific literature. The health effect levels for oral exposure to PAHs reported in the literature are all much higher than the estimated exposure doses for both adults and children. No adverse health effects were observed at doses ranging from 1.3 mg/kg/day to 1,000 mg/kg/day, varying by animal and PAH tested (ATSDR 1995). Therefore, ATSDR does not expect that eating fish and shellfish containing the detected levels of benzo(e)pyrene would cause harmful noncancer health effects, as the calculated exposure doses are hundreds of thousands of times lower than the lowest NOAEL (see Table B-3). Furthermore, benzo(e)pyrene was only detected in about 25% of the samples collected and analyzed, and was not detected in crab butter, octopus, and halibut.

Cancer health effects

IARC has determined that benzo(e)pyrene is not classifiable as to its carcinogenicity to humans. There are no CELs in the scientific literature for exposure to benzo(e)pyrene. For comparison, ATSDR examined the literature available for benzo(a)pyrene, a known animal carcinogen, and the relative carcinogenic potency between the two PAHs. ATSDR does not expect that lifetime exposure to the average concentration of benzo(e)pyrene in fish and shellfish from the Metlakatla Peninsula would result in an increase in cancer because the expected lifetime doses (see adult exposure in Table B-3) are a over a million times lower than the CELs reported in the scientific literature for benzo(a)pyrene (CELs are 2.6 and 33.3 mg/kg/day; ATSDR 1995). Additionally, one study concluded that based on their enzyme activity, benzo(a)pyrene was markedly more potent than benzo(e)pyrene (Ayrton et al. 1990 as cited in ATSDR 1995). Another study concluded that the effects were different for the noncarcinogenic PAHs (such as benzo(e)pyrene), as compared to the carcinogenic PAH (benzo(a)pyrene); the former induced changes that were short-lived while the latter produced more severe, long-lasting changes (Topping et al. 1978 as cited in ATSDR 1995). Therefore, benzo(e)pyrene concentrations are also below levels of health concern for cancer effects.

Cadmium

Cadmium is an element that occurs naturally in the earth's crust. It is not usually present in the environment as a pure metal, but as a mineral combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate, cadmium sulfide) (ATSDR 1999b).

Generally, the main sources of cadmium exposure are through smoking cigarettes and, to a lesser extent, eating foods contaminated with cadmium. However, only about 5 to 10% of ingested cadmium is actually absorbed by the body; the majority is passed out of the body in feces (McLellan et al. 1978, Rahola et al. 1973 as cited in ATSDR 1999b). Cadmium that is absorbed goes to the kidneys and liver. Once absorbed, cadmium tends to remain in the body for years. The body changes most of the cadmium into a form that is not harmful, but if too much cadmium is absorbed, the liver and kidneys cannot convert all of it into the harmless form (Goyer et al. 1989, Kotsonis and Klaassen 1978, Sendelbach and Klaassen 1988 as cited in ATSDR 1999b).

Table B-4. Cadmium Exposure Doses According to Species

Species	Average Concentration (mg/kg)	Estimated Exposure Dose (mg/kg/day)	
		Adult	Child
Butter Clams	0.3	9.7×10^{-4}	2.1×10^{-3}
Slipper Chiton	0.46	1.5×10^{-3}	3.3×10^{-3}
Cockle	0.06	1.9×10^{-4}	4.3×10^{-4}
Dungeness Crab Meat	0.006	1.9×10^{-5}	4.3×10^{-5}
Dungeness Crab Butter	0.62	2.0×10^{-3}	4.4×10^{-3}
Giant Pacific Octopus	0.17	5.5×10^{-4}	1.2×10^{-3}
Pacific Halibut	0.005	1.6×10^{-5}	3.5×10^{-5}
Chinook Salmon	*Not Detected*		
Seaweed	0.55	1.8×10^{-3}	3.9×10^{-3}

<u>Noncancer health effects</u>

ATSDR and EPA based the derivation of their health guidelines for cadmium on different studies involving people chronically exposed. ATSDR's MRL is based on a study of people who ate contaminated rice for up to 70 years and experienced no adverse health effects at doses of 2.1×10^{-3} mg/kg/day (Nogawa et al. 1989 as cited in ATSDR 1999b). EPA's RfD is based on a toxicokinetic model (using data from several studies), which predicts that no adverse health effects would result in people chronically exposed to 1.0×10^{-2} mg/kg/day of cadmium in their food (USEPA 1985 as cited in EPA 2004). Although the estimated doses for children who eat chitons, crabs, or seaweed everyday are slightly above the no-observed-adverse-effect level (NOAEL) cited by ATSDR, all of the estimated doses for both adults and children are below the NOAEL cited by EPA. Estimated doses that slightly exceed the NOAEL do not indicate that an adverse health effect will occur because NOAELs indicate a level in which **no** adverse health effects were observed. Additionally, the NOAELs are based on slight increases in urinary proteins and there is some discussion among the scientists about whether this endpoint should be considered an adverse effect (ATSDR 1999b). Given that the doses for children only slightly exceed one of the NOAELs and is below the other, ATSDR does not expect that eating fish and shellfish from the Metlakatla Peninsula containing the detected levels of cadmium would cause harmful noncancer health effects. Further, the health benefits of eating fish and shellfish may far outweigh any *potential* health effects.

> The FDA regulates the level of cadmium in food. To limit the intake of cadmium to a level considered to be safe, FDA set an action level of 3 mg/kg for crustaceans and 4 mg/kg for molluscan bivalves (FDA 1993). All of the fish and shellfish collected from the Metlakatla Peninsula contained cadmium concentrations well below these levels

Cancer health effects

Studies of cadmium in humans and animals have not found an increase in cancer, however, more research is needed before a definitive conclusion can be reached regarding whether cadmium does or does not cause cancer. As a conservative approach, IARC has determined that cadmium is carcinogenic to humans. DHHS reasonably anticipates that cadmium is a carcinogen. EPA has determined that cadmium, when inhaled, is a probable human carcinogen (ATSDR 1999b). However, lifetime exposure to the average concentration of cadmium in fish and shellfish from the Metlakatla Peninsula is not expected to result in an increase in cancer because the expected lifetime doses (see adult exposure in Table B-4) are hundreds of times lower than the CEL reported in the scientific literature (increased rates of prostatic adenomas resulted in rats from exposure to 3.5 mg/kg/day of cadmium in food; Waalkes and Rehm 1992 as cited in ATSDR 1999b). Therefore, cadmium concentrations are also below levels of health concern for cancer effects.

Chromium

Chromium can be found in three main forms—chromium 0, chromium III (also known as trivalent chromium), and chromium VI (also known as hexavalent chromium). Chromium VI is more harmful than chromium III, an essential nutrient required by the body. Although some or all of the chromium detected in fish and shellfish from the Metlakatla Peninsula could be chromium III; as a conservative approach to the health evaluation, ATSDR assumed that all of the chromium was the more harmful chromium VI.

> The National Research Council recommends that adults take 50–200 mg of chromium III every day and has established safe and adequate daily dietary intakes of 10–80 mg for children (NRC 1989 as cited in ATSDR 2000b).

Chromium VI is more easily absorbed than chromium III; therefore, ingesting fish and shellfish containing chromium can lead to harmful forms of chromium entering the body. However, once inside the body, the more harmful chromium VI is converted into the essential nutrient, chromium III. In addition, most of the chromium ingested will exit the body in feces within a few days and never enter the bloodstream. Only a very small amount (0.4 to 2.1%) of chromium can pass through the walls of the intestine and enter the bloodstream (Anderson et al. 1983, Anderson 1986, Donaldson and Barreras 1966 as cited in ATSDR 2000b).

Table B-5. Chromium Exposure Doses According to Species

Species	Average Concentration (mg/kg)	Estimated Exposure Dose (mg/kg/day)	
		Adult	Child
Butter Clams	0.5	1.6×10^{-3}	3.5×10^{-3}
Slipper Chiton	0.39	1.3×10^{-3}	2.8×10^{-3}
Cockle	0.14	4.5×10^{-4}	9.9×10^{-4}
Dungeness Crab Meat	*Not Detected*		
Dungeness Crab Butter	*Not Detected*		
Giant Pacific Octopus	0.24	7.8×10^{-4}	1.7×10^{-3}
Pacific Halibut	1.1	3.6×10^{-3}	7.8×10^{-3}
Chinook Salmon	0.19	6.2×10^{-4}	1.3×10^{-3}
Seaweed	0.04	1.3×10^{-4}	2.8×10^{-4}

Noncancer health effects

The oral health guideline for chromium VI is based on a study in which no adverse health effects were reported in animals exposed to 2.5 mg/kg/day of chromium VI in their drinking water (MacKenzie et al. 1958 as cited in EPA 2004). In comparison, rats were fed 1,468 mg/kg/day of chromium III and experienced no adverse health effects (Ivankovic and Preussman 1975 as cited in EPA 2004). All of the estimated exposure doses for both adults and children are hundreds of times lower than the chromium VI levels and a hundred thousand times lower than the chromium III levels (see Table B-5). Therefore, ATSDR does not expect that eating fish and shellfish from the Metlakatla Peninsula containing the detected levels of chromium would cause harmful noncancer health effects.

> The FDA regulates the level of chromium in food. To limit the intake of chromium to a level considered to be safe, FDA set an action level of 12 mg/kg for crustaceans and 13 mg/kg for molluscan bivalves (FDA 1993). All of the fish and shellfish collected from the Metlakatla Peninsula contained chromium concentrations well below these levels.

Cancer health effects

DHHS has determined that certain chromium VI compounds are known human carcinogens when inhaled. IARC has determined that chromium VI is carcinogenic to humans and chromium 0 and chromium III are not classifiable as to their carcinogenicity. EPA has determined that chromium VI in air is a human carcinogen, but insufficient evidence exists to determine whether chromium VI and chromium III in food and water are human carcinogens (ATSDR 2000b). Therefore, despite its carcinogenicity classification, consuming fish and shellfish with chromium is not expected to result in an increase in cancer because the available scientific evidence suggests that oral exposure to chromium would not result in cancer. Animal studies involving chromium ingestion have found no evidence of carcinogenicity (Ivankovic and Preussmann 1975 as cited in ATSDR 2000b). Therefore, chromium concentrations are also below levels of health concern for cancer effects.

Dieldrin

Dieldrin is a man-made chemical that was used as an insecticide until 1970, when the U.S. Department of Agriculture canceled all uses. Although EPA approved the use of dieldrin for killing termites in 1972, in 1987 the manufacturer voluntarily canceled the registration (ATSDR 2002a). Aldrin and dieldrin are structurally similar chemicals. Sunlight and bacteria in the environment can change aldrin to dieldrin. Therefore, you can find dieldrin in places where aldrin was originally released (ATSDR 2002a).

Studies in animals show that dieldrin enters the body quickly after exposure and is stored in their fat. It stays in fat tissue for a long time and can change to other products. It can take many weeks or years for dieldrin and its breakdown products to leave a person's body. Animals or fish that eat other animals have levels of dieldrin in their fat many times higher than animals or fish that eat plants (ATSDR 2002a).

Table B-6. Dieldrin Exposure Doses According to Species

Species	Average Concentration (mg/kg)	Estimated Exposure Dose (mg/kg/day)	
		Adult	Child
Butter Clams	*Not Detected*		
Slipper Chiton	0.0004	1.3×10^{-6}	2.8×10^{-6}
Cockle	0.0003	9.7×10^{-7}	2.1×10^{-6}
Dungeness Crab Meat	0.0006	1.9×10^{-6}	4.3×10^{-6}
Dungeness Crab Butter	0.0016	5.2×10^{-6}	1.1×10^{-5}
Giant Pacific Octopus	0.0002	6.5×10^{-7}	1.4×10^{-6}
Pacific Halibut	0.0011	3.6×10^{-6}	7.8×10^{-6}
Chinook Salmon	0.0027	8.8×10^{-6}	1.9×10^{-5}
Seaweed	*Not Detected*		

<u>Noncancer health effects</u>

ATSDR's MRL and EPA's RfD is 5.0×10^{-5} mg/kg/day for chronic exposure to dieldrin. All of the estimated exposure doses for both adults and children are below this protective level (see Table B-6). Remember that health guidelines (MRLs and RfDs) are estimates of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects. They have built-in uncertainty or safety factors, making them considerably lower than levels at which health effects have been observed. Estimated doses that are less than these values are not considered to be of health concern. Therefore, ATSDR does not expect that eating fish or shellfish from the Metlakatla Peninsula with the detected levels of dieldrin would cause harmful noncancer health effects. Furthermore, dieldrin was only detected in about 20% of the samples collected and analyzed, and was not detected in clams or seaweed.

The FDA regulates the level of dieldrin in food. To limit the intake of dieldrin to a level considered to be safe, FDA set an action level of 0.3 mg/kg for the edible portion of fin fish and shellfish (FDA 2001). All of the fish and shellfish collected from the Metlakatla Peninsula contained dieldrin concentrations well below this level.

Cancer health effects

DHHS and IARC have determined that dieldrin is not classifiable as to its carcinogenicity to humans (ATSDR 2002a). EPA has determined that dieldrin is a probable human carcinogen because orally administered dieldrin produced significant increases in tumor responses in seven different strains of mice (EPA 2004). However, lifetime exposure to the average concentration of dieldrin in fish and shellfish from the Metlakatla Peninsula is not expected to result in an increase in cancer because the expected lifetime doses (see adult exposure in Table B-6) are over ten thousand times lower than the CELs reported in the scientific literature (CELs ranged from 0.33–1.3 mg/kg/day; ATSDR 2002a). Therefore, dieldrin concentrations are also below levels of health concern for cancer effects.

Heptachlor epoxide

Heptachlor epoxide is a breakdown product of heptachlor. It was not manufactured and was not used as an insecticide like heptachlor[7]. Heptachlor epoxide is made by bacteria in the environment and by animals and people when heptachlor enters an organism's body. About 20% of heptachlor is changed within hours into heptachlor epoxide both in the environment and in the body (ATSDR 1993). Most of the heptachlor epoxide leaves the body in the feces within a few days after exposure. However, some is stored in body fat for long periods after exposure has occurred and leaves the body much more slowly.

Table B-7. Heptachlor Epoxide Exposure Doses According to Species

Species	Average Concentration (mg/kg)	Estimated Exposure Dose (mg/kg/day)	
		Adult	Child
Butter Clams	0.0065	2.1×10^{-5}	4.6×10^{-5}
Slipper Chiton	0.0014	4.5×10^{-6}	9.9×10^{-6}
Cockle	0.0024	7.8×10^{-6}	1.7×10^{-5}
Dungeness Crab Meat	*Not Detected*		
Dungeness Crab Butter	0.0007	2.3×10^{-6}	5.0×10^{-6}
Giant Pacific Octopus	0.0005	1.6×10^{-6}	3.5×10^{-6}
Pacific Halibut	0.0011	3.6×10^{-6}	7.8×10^{-6}
Chinook Salmon	0.0064	2.1×10^{-5}	4.5×10^{-5}
Seaweed	0.0002	6.5×10^{-7}	1.4×10^{-6}

[7] Heptachlor is a synthetic chemical that was used in the past for killing insects in homes, buildings, and on food crops. It has not been used for these purposes since 1988 (ATSDR 1993).

Noncancer health effects

The oral health guideline for heptachlor epoxide is based on a study in which adverse health effects were reported in dogs fed 1.3×10^{-2} mg/kg/day of heptachlor epoxide for 60 weeks (Dow Chemical Co. 1958 as cited in EPA 2004). All of the estimated exposure doses for both adults and children are hundreds of times lower than this health effects level (see Table B-7). Therefore, ATSDR does not expect that eating fish and shellfish from the Metlakatla Peninsula containing the detected levels of heptachlor epoxide would cause harmful noncancer health effects. Furthermore, heptachlor epoxide was only detected in about one-third of the samples collected and analyzed.

Cancer health effects

IARC and DHHS have determined that heptachlor epoxide is not classifiable as to its carcinogenicity to humans. However, EPA has determined that heptachlor epoxide is a probable human carcinogen based on sufficient evidence from rodent studies in which liver carcinomas were induced (Davis 1965, Velsicol 1973 as cited in EPA 2004). The human equivalent dose from these studies is 0.01 to 0.11 mg/kg/day (EPA 2004). Lifetime exposure to the average concentration of heptachlor epoxide in fish and shellfish from the Metlakatla Peninsula is not expected to result in an increase in cancer because the expected lifetime doses (see adult exposure in Table B-7) are hundreds of times lower than these levels. Therefore, heptachlor epoxide concentrations are also below levels of health concern for cancer effects.

> The FDA regulates the level of heptachlor epoxide in food. To limit the intake of heptachlor epoxide to a level considered to be safe, FDA set an action level of 0.3 mg/kg for the edible portion of all fish (FDA 2001). All of the fish and shellfish collected from the Metlakatla Peninsula contained heptachlor epoxide concentrations well below this level.

Hexachlorobenzene

Hexachlorobenzene does not occur naturally. It is formed as a by-product during the manufacture of chemicals used as solvents, other chlorine-containing compounds, and pesticides. Small amounts of hexachlorobenzene can also be produced during combustion processes such as burning of wastes and as a by-product in waste streams of chlor-alkali and woodpreserving plants. Until 1965, hexachlorobenzene was widely used as a pesticide. It was also used to make fireworks, ammunition, and synthetic rubber. Currently it is not used in the United States (ATSDR 2002b).

Hexachlorobenzene can enter a person's body by eating contaminated food. Within a few hours of entering the body, it spreads through the blood to many tissues in the body, but especially to fat. Hexachlorobenzene can remain in a person's body, especially in fat, for years (ATSDR 2002b).

Table B-8. Hexachlorobenzene Exposure Doses According to Species

Species	Average Concentration (mg/kg)	Estimated Exposure Dose (mg/kg/day)	
		Adult	Child
Butter Clams	*Not Detected*		
Slipper Chiton	*Not Detected*		
Cockle	*Not Detected*		
Dungeness Crab Meat	*Not Detected*		
Dungeness Crab Butter	0.0011	3.6×10^{-6}	7.8×10^{-6}
Giant Pacific Octopus	*Not Detected*		
Pacific Halibut	0.0011	3.6×10^{-6}	7.8×10^{-6}
Chinook Salmon	0.0023	7.5×10^{-6}	1.6×10^{-5}
Seaweed	*Not Detected*		

Noncancer health effects

ATSDR's MRL for chronic exposure to hexachlorobenzene is 5.0×10^{-5} mg/kg/day. All of the estimated exposure doses for both adults and children are below this protective level (see Table B-8). Remember that health guidelines (MRLs) are estimates of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects. They have built-in uncertainty or safety factors, making them considerably lower than levels at which health effects have been observed. Estimated doses that are less than these values are not considered to be of health concern. Therefore, ATSDR does not expect that eating fish or shellfish from the Metlakatla Peninsula with the detected levels of hexachlorobenzene would cause harmful noncancer health effects. Furthermore, hexachlorobenzene was only detected in 10% of the samples collected and analyzed, and was not detected in clams, chitons, cockles, crab meat, octopus, and seaweed.

Cancer health effects

DHHS has determined that hexachlorobenzene may reasonably be anticipated to be a human carcinogen. IARC has determined that hexachlorobenzene is possibly carcinogenic to humans. EPA has determined that hexachlorobenzene is a probable human carcinogen (ATSDR 2002b). However, lifetime exposure to the average concentrations of hexachlorobenzene in crab butter, halibut, and salmon from the Metlakatla Peninsula is not expected to result in an increase in cancer because the expected lifetime doses (see adult exposure in Table B-8) are hundreds of thousands of times lower than the CELs reported in the scientific literature (CELs ranged from 4–12 mg/kg/day; ATSDR 2002b). Therefore, hexachlorobenzene concentrations are also below levels of health concern for cancer effects.

Mercury

Mercury exists naturally in the environment in several different forms: metallic mercury (also known as elemental mercury), inorganic mercury, and organic mercury. Metallic mercury is the pure form of mercury. Inorganic mercury is formed when metallic mercury combines with elements such as chlorine, sulfur, or oxygen. Organic mercury is formed when mercury combines with carbon. Microorganisms (bacteria and fungi) and natural processes can change mercury from one form to another. The most common organic mercury compound generated through these processes is methylmercury (ATSDR 1999a).

The different forms of mercury are absorbed and distributed differently in the body.

- When small amounts of metallic mercury are ingested, only about 0.01% of the mercury will enter the body through the stomach or intestines (Sue 1994, Wright et al. 1980 as cited in ATSDR 1999a). More metallic mercury can be absorbed if one suffers from a gastrointestinal tract disease. The small amount of metallic mercury that enters the body will accumulate in the kidneys and the brain, where it is readily turned into inorganic mercury. It can stay in the body for weeks or months, but most mercury is eventually excreted through urine, feces, and exhaled breath.

- Typically, less than 10% of inorganic mercury is absorbed through the stomach and intestines. But it has been reported that up to 40% can be absorbed in the intestinal tract (Clarkson 1971, Morcillo and Santamaria 1995, Nielson and Anderson 1990 & 1992, Piotrowski et al. 1992 as cited in ATSDR 1999a). Once in the body, a small amount of the inorganic mercury can be converted into metallic mercury, which will be excreted or stored as described above. Inorganic mercury enters the bloodstream and moves to many different tissues, but will mostly accumulate in the kidneys. Inorganic mercury does not easily enter the brain. It can remain in the body for several weeks or months and is excreted through urine, feces, and exhaled breath.

- Methylmercury is the most studied organic mercury compound. It is readily absorbed in the gastrointestinal tract (about 95% absorbed) and can easily enter the bloodstream (Aberg et al 1969, Al-Shahristani et al. 1976, Miettinen 1973 as cited in ATSDR 1999a). It moves rapidly to various tissues and the brain, where methylmercury can be turned into inorganic mercury, which can remain in the brain for long periods. Slowly, over months, methylmercury will leave the body, mostly as inorganic mercury in the feces.

The organic form of mercury is much more harmful than the metallic and inorganic forms. In fish tissue, mercury is present predominantly as methylmercury (about 85%), the more toxic form (Jones and Slotten 1996). Therefore, to be conservative, ATSDR assumed that all the mercury detected in fish and shellfish was methylmercury.

Table B-9. Mercury Exposure Doses According to Species

Species	Average Concentration (mg/kg)	Estimated Exposure Dose (mg/kg/day)	
		Adult	Child
Butter Clams	0.008	2.6×10^{-5}	5.7×10^{-5}
Slipper Chiton	0.004	1.3×10^{-5}	2.8×10^{-5}
Cockle	0.007	2.3×10^{-5}	5.0×10^{-5}
Dungeness Crab Meat	0.036	1.2×10^{-4}	2.6×10^{-4}
Dungeness Crab Butter	0.025	8.1×10^{-5}	1.8×10^{-4}
Giant Pacific Octopus	0.008	2.6×10^{-5}	5.7×10^{-5}
Pacific Halibut	0.136	4.4×10^{-4}	9.6×10^{-4}
Chinook Salmon	0.024	7.8×10^{-5}	1.7×10^{-4}
Seaweed	0.002	6.5×10^{-6}	1.4×10^{-5}

Noncancer health effects

The oral health guideline for methylmercury is based on the Seychelles Child Development Study (SCDS) in which people who were exposed to 1.3×10^{-3} mg/kg/day of methylmercury in their food did not experience any adverse health effects (Davidson et al. 1998 as cited in ATSDR 1999a). Over 700 mother-infant pairs were followed and tested from parturition through 66 months of age. The Seychellois regularly consume a large quantity and variety of ocean fish, with 12 fish meals per week representing a typical exposure. The results revealed no evidence of adverse effects attributable to chronic ingestion of low levels of methylmercury in fish (median total mercury concentration was <1 mg/kg with a range of 0.004 to 0.75 mg/kg; Davidson et al. 1998 as cited in ATSDR 1999a). All of the estimated exposure doses for both adults and children are lower than this NOAEL (see Table B-9). Therefore, ATSDR does not expect that eating fish and shellfish from the Metlakatla Peninsula containing the detected levels of mercury would cause harmful noncancer health effects.

> The FDA regulates the level of methylmercury in food. To limit the intake of methylmercury to a level considered to be safe, FDA set an action level of 1 mg/kg for all fish (FDA 2001). All of the fish and shellfish collected from the Metlakatla Peninsula contained *total* mercury concentrations well below this level.

Cancer health effects

DHHS and IARC have not classified mercury as to its human carcinogenicity. EPA has determined that mercury chloride and methylmercury are possible human carcinogens (ATSDR 1999a). However, lifetime exposure to the average concentrations of mercury in fish and shellfish from the Metlakatla Peninsula is not expected to result in an increase in cancer because the expected lifetime doses (see adult exposure in Table B-9) are over a thousand times lower than the CELs reported in the scientific literature for exposure to organic mercury (CELs ranged from 0.69–4.2 mg/kg/day; ATSDR 1999a). Therefore, mercury concentrations are also below levels of health concern for cancer effects.

1-Methylphenanthrene

1-Methylphenanthrene is one of a 100 different PAHs that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances, such as tobacco and charbroiled meat (ATSDR 1995). PAHs usually occur naturally, but they can be manufactured as individual compounds for research purposes. A few PAHs are used in medicines and to make dyes, plastics, and pesticides. Others are contained in asphalt used in road construction.

PAHs break down to longer-lasting products by reacting with sunlight and other chemicals in the air, generally over a period of days to weeks. Breakdown in soil and water generally takes weeks to months and is caused primarily by the actions of microorganisms (ATSDR 1995).

Eating fish or shellfish is one route for PAHs to enter a person's body, but absorption is generally slow when PAHs are swallowed (ATSDR 1995). They can enter all the tissues of the body that contain fat, however, they tend to be stored mostly in the kidneys, liver, and fat. PAHs are changed by all tissues in the body into many different substances. Results from animal studies show that PAHs do not tend to be stored in a person's body for a long time. Most PAHs that enter the body leave within a few days (ATSDR 1995).

Table B-10. 1-Methylphenanthrene Exposure Doses According to Species

Species	Average Concentration (mg/kg)	Estimated Exposure Dose (mg/kg/day)	
		Adult	Child
Butter Clams	0.0003	9.7×10^{-7}	2.1×10^{-6}
Slipper Chiton	0.0002	6.5×10^{-7}	1.4×10^{-6}
Cockle	0.0002	6.5×10^{-7}	1.4×10^{-6}
Dungeness Crab Meat	0.0001	3.2×10^{-7}	7.1×10^{-7}
Dungeness Crab Butter	1.94*	6.3×10^{-3}	1.4×10^{-2}
Giant Pacific Octopus	0.0006	1.9×10^{-6}	4.3×10^{-6}
Pacific Halibut	0.0001	3.2×10^{-7}	7.1×10^{-7}
Chinook Salmon	0.0001	3.2×10^{-7}	7.1×10^{-7}
Seaweed	0.0001	3.2×10^{-7}	7.1×10^{-7}

* The average was calculated using the detection limits for nondetected chemicals. In this case, the estimated detection limits for the nondetected chemicals were much higher than the actual concentration found in the one sample in which 1-methylphenanthrene was detected (0.00041 mg/kg).

<u>Noncancer health effects</u>

An oral health guideline for 1-methylphenanthrene has not been derived because there are no adequate human or animal dose-response data available that identify threshold levels for appropriate noncancer health effects (ATSDR 1995). Thus, ATSDR consulted the available scientific literature. 1-Methylphenanthrene appears to be at least as toxic as its parent compounds (Irwin 1997). The health effect levels for oral exposure to PAHs reported in the literature are all much higher than the estimated exposure doses for both adults and children. No adverse health effects were observed at doses ranging from 1.3 mg/kg/day to 1,000 mg/kg/day, varying by animal and PAH tested (ATSDR 1995). Therefore, ATSDR does not expect that eating fish and shellfish containing the detected levels of 1-methylphenanthrene would cause harmful noncancer health effects, as most of the calculated exposure doses are hundreds of thousands of times lower than the NOAELs (see Table B-10). Even the doses for adults and children eating crab butter every day are about 100 times lower than the lowest NOAEL; despite the fact that the average concentration for crab butter is much higher than actual detected concentration due to the higher detection limits for some of the samples.

Cancer health effects

IARC has determined that 1-methylphenanthrene is not classifiable as to its carcinogenicity to humans due to inadequate data. There are no CELs in the scientific literature for exposure to 1-methylphenanthrene. For comparison, ATSDR examined the literature available for another PAH, benzo(a)pyrene, a known animal carcinogen. ATSDR does not expect that lifetime exposure to the average concentration of 1-methylphenanthrene in fish and shellfish from the Metlakatla Peninsula would result in an increase in cancer because the expected lifetime doses (see adult exposure in Table B-10) are hundreds of times lower than the CELs reported in the scientific literature for benzo(a)pyrene (CELs are 2.6 and 33.3 mg/kg/day; ATSDR 1995). Therefore, 1-methylphenanthrene concentrations are also below levels of health concern for cancer effects.

Crab Bay/Cascade Inlet

Clams, chitons, cockles, crab, and octopus were collected from Crab Bay/Cascade Inlet as a reference location. These data were evaluated separately from the samples taken around the Metlakatla Peninsula. ATSDR screened the detected chemicals using the methods described previously and evaluated the health effect levels in the scientific literature for those chemicals that exceeded the health guideline values. Using the same conservative evaluation as above, ATSDR determined that none of the chemicals were found at levels of health concern for either noncancer or cancer health effects at the reference location.

Appendix C

A Guide to Healthy Eating of the Fish You Catch

Introduction

Fish are an important part of a healthy diet. They are a lean, low-calorie source of protein. Some sport fish caught in the nation's lakes, rivers, oceans, and estuaries, however, may contain chemicals that could pose health risks if these fish are eaten in large amounts.

The purpose of this brochure is not to discourage you from eating fish. It is intended as a guide to help you select and prepare fish that are low in chemical pollutants. By following these recommendations, you and your family can continue to enjoy the benefits of eating fish.

Fish taken from polluted waters might be hazardous to your health. Eating fish containing chemical pollutants may cause birth defects, liver damage, cancer, and other serious health problems.

Chemical pollutants in water come from many sources. They come from factories and sewage treatment plants that you can easily see. They also come from sources that you can't easily see, like chemical spills or runoff from city streets and farm fields. Pollutants are also carried long distances in the air.

Fish may be exposed to chemical pollutants in the water, and the food they eat. They may take up some of the pollutants into their bodies. The pollutants are found in the skin, fat, internal organs, and sometimes muscle tissue of the fish.

What can I do to reduce my health risks from eating fish containing chemical pollutants ?

Following these steps can reduce your health risks from eating fish containing chemical pollutants. The rest of the brochure explains these recommendations in more detail.

1. ***Call your local or state environmental health department.*** Contact them before you fish to see if any advisories are posted in areas where you want to fish.
2. ***Select certain kinds and sizes of fish for eating.*** Younger fish contain fewer pollutants than older, larger fish. Panfish feed on insects and are less likely to build up pollutants.
3. ***Clean and cook your fish properly.*** Proper cleaning and cooking techniques may reduce the levels of some chemical pollutants in the fish.

Health Note

Advisories are different from fishing restrictions or bans or limits. Advisories are issued to provide ***recommendations*** for limiting the amount of fish to be eaten due to levels of pollutants in the fish.

A Message from the Administrator

Christine Todd Whitman

I believe water is the biggest environmental issue we face in the 21st Century in terms of both quality and quantity. In the 30 years since its passage, the Clean Water Act has dramatically increased the number of waterways that are once again safe for fishing and swimming. Despite this great progress in reducing water pollution, many of the nation's waters still do not meet water quality goals. I challenge you to join with me to finish the business of restoring and protecting our nation's waters for present and future generations.

For More Information

For more information about reducing your health risks from eating fish that contain chemical pollutants, contact your local or state health or environmental protection department. You can find the telephone number in the blue section of your local telephone directory.

You may also contact:

U.S. Environmental Protection Agency
Office of Water
Fish and Wildlife Contamination Program (4305T)
1200 Pennsylvania Avenue, NW
Washington, DC 20460

web address: www.epa.gov/ost/fish

United States Environmental Protection Agency
Office of Water (4101M)
EPA 823-F-02-005 • April 2002

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

In celebration of the 30th anniversary of the Clean Water Act, EPA presents

A Guide to Healthy Eating of the Fish You Catch

Celebration & Recommitment

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Catching Fish

How can I find out if the waters that I fish in are polluted?

It's almost impossible to tell if a water body is polluted simply by looking at it. However, there are ways to find out.

First, look to see if warning signs are posted along the water's edge. If there are signs, follow the advice printed on them.

Second, even if you don't see warning signs, call your local or state health or environmental protection department and ask for their advice. Ask them if there are any advisories on the kinds or sizes of fish that may be eaten from the waters where you plan to fish. You can also ask about fishing advisories at local sporting goods or bait shops where fishing licenses are sold.

If the water body has not been tested, follow these guidelines to reduce your health risks from eating fish that might contain small amounts of chemical pollutants.

Health Note

Some chemical pollutants, such as mercury and PCBs, can pose greater risks to women of childbearing age, pregnant women, nursing mothers, and young children. This group should be especially careful to greatly reduce or avoid eating fish caught from polluted waters.

Do some fish contain more pollutants than others?

Yes. You can't look at fish and tell if they contain chemical pollutants. The only way to tell if fish contain harmful levels of chemical pollutants is to have them tested in a laboratory. Follow these simple guidelines to lower the risk to your family:

- If you eat gamefish, such as lake trout, salmon, walleye, and bass, eat the smaller, younger fish (within legal limits). They are less likely to contain harmful levels of pollutants than larger, older fish.
- Eat panfish, such as bluegill, perch, stream trout, and smelt. They feed on insects and other aquatic life and are less likely to contain high levels of harmful pollutants.
- Eat fewer fatty fish, such as lake trout, or fish that feed on the bottoms of lakes and streams such as catfish and carp. These fish are more likely to contain higher levels of chemical pollutants.

Cleaning Fish

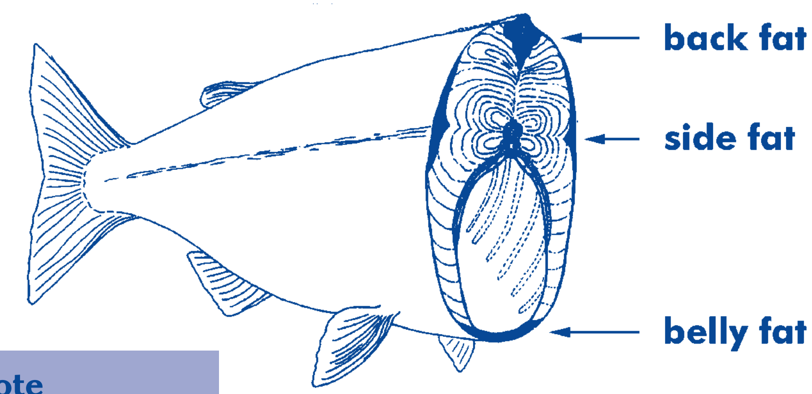
Can I clean my fish to reduce the amount of chemical pollutants that might be present?

Yes. It's always a good idea to remove the skin, fat, and internal organs (where harmful pollutants are most likely to accumulate) before you cook the fish.

As an added precaution:

- Remove and throw away the head, guts, kidneys, and the liver.

Trim away the skin and fatty tissue before cooking to reduce the level of some pollutants in the fish you eat.



Health Note

Mercury is found throughout the tissue in fish, so these cleaning and cooking techniques will not reduce the amount of mercury in a meal of fish.

- Fillet fish and cut away the fat and skin before you cook it.
- Clean and dress fish as soon as possible.

Remember that with any fresh meat, always follow proper food handling and storage techniques. To prevent the growth of bacteria or viruses, keep freshly caught fish on ice and out of direct sunlight.

Cooking Fish

Can I cook my fish to reduce my health risk from eating fish containing chemical pollutants?

Yes. The way you cook fish can make a difference in the kinds and amounts of chemical pollutants remaining in the fish. Fish should be properly prepared and grilled, baked, or broiled. By letting the fat drain away, you can remove pollutants stored in the fatty parts of the fish. Added precautions include:

- Avoid or reduce the amount of fish drippings or broth that you use to flavor the meal. These drippings may contain higher levels of pollutants.
- Eat less fried or deep fat-fried fish because frying seals any chemical pollutants that might be in the fish's fat into the portion that you will eat.
- If you like smoked fish, it is best to fillet the fish and remove the skin before the fish is smoked.