Health Consultation

Polyaromatic Hydrocarbons and Polychlorinated Biphenyls in Fish From the Suqitughneq River — St. Lawrence Island, Alaska

August 24, 2005

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Prepared by the

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation

200-1f
F10AK096903_03.11_0008_a

Statement of Issues

From the 1950s through the early 1970s, military activities at the Northeast Cape of St. Lawrence Island (NE Cape), Alaska, resulted in spills and releases that contaminated the Suqitughneq River and reduced the river's fish population. Recently, fish populations in the river have been returning, and residents of the villages on St. Lawrence Island have expressed a renewed interest in using the fish as a food source. The U.S. Army Corps of Engineers (COE) asked the Agency for Toxic Substances and Disease Registry (ATSDR) to evaluate whether fish from the river are safe to eat. This health consultation reviews data collected by a recent project conducted at the NE Cape site during the summer of 2001 [1]. ATSDR specifically evaluated levels, which were provided by COE, of polychlorinated biphenyls (PCBs) and polyaromatic hydrocarbons (PAHs) in fish from the NE Cape.

Background

The NE Cape site covers approximately 4 square miles and is located 9 miles west of the northeastern cape of St. Lawrence Island, between Kitnagak Bay to the northeast and Kangighsak point to the northwest (Figure 1). The Suqitughneq River is the primary stream drainage in the area, and it runs a north/northeast course through the site to the Bering Sea.

In 1969, diesel fuel from a punctured tank at the military site spilled into a tributary of the Suqitughneq River, eventually contaminating the river's drainage basin with PAHs. The widespread contamination caused by the spill dramatically reduced the river's fish population. Routine military activities at the NE Cape site also resulted in accidental spills of other chemicals (e.g., PCBs). PCBs and PAHs are of concern because they can be taken up by fish and can harm people who eat the contaminated fish. Fish sampling, however, was not done for many years after the 1969 fuel spill because of the scarcity of fish [2].

Although few people live in the NE Cape area, St. Lawrence Island residents frequently use a nearby fishing camp during the spring and summer (Figure 2). Since the fuel spill, members of these villages have not used the river as a food source because of the scarcity of fish. Recently, fish, including Dolly Varden and Alaska blackfish, have returned to the Suqitughneq River. As a result, community members have expressed a renewed interest in using fish from the Suqitughneq River as a food source—if the fish are safe to eat [2].

COE has conducted two sampling and analysis activities at the NE Cape. The first, conducted in 1999, was a screening project that sampled fish as part of their Tier II Ecological Assessment. The primary aim of the screening project was to conduct a broad-spectrum survey to determine whether additional data should be collected [1,3]. In a health consultation that reviewed the screening project data, ATSDR determined that the available data were insufficient to assess

whether contaminant levels could be harmful to people who eat fish from the Suqitughneq River. The health consultation also recommended that additional work be conducted to analyze more and larger fish in a manner that was representative of what the local fishermen catch and eat [2].

In response to ATSDR's recommendations, COE conducted a second sampling and analysis project. In the summer of 2001, COE conducted a project aimed at catching and analyzing fish of a size that are sought after by the local fishermen. These fish were collected in a contaminated location (the Suqitughneq River) and an uncontaminated location (the Tapisagahak River).

Using gill nets and minnow traps, COE collected three different species of fish: 12 Dolly Varden, approximately 30 Alaska blackfish, and 2 pink salmon. Portions of the Dolly Varden and the pink salmon were dissected to provide subsamples of eggs, fillets, heads, and the remains.

Eight of the Dolly Varden were collected from the Suqitughneq River (at the lagoon area, approximately 1½ mile from the suspected source of the contaminant spills) (Figure 2). The Alaska blackfish were collected at an upstream location on a Suqitughneq River tributary (at Site 28, approximately 3 mile from the suspected source of the contaminant spills) (Figure 2). Three Dolly Varden and two pink salmon were collected at the Tapisagahak River lagoon area. These fish from the Tapisagahak River were collected to provide "reference" information about fish from an area unaffected by the spills. The length of the fish ranged from 430–490 mm (about 16–19 inches) for the Dolly Varden, and 445–470 mm (about 17–18 inches) for the pink salmon The Alaska blackfish were analyzed as an 8–10 fish composite [1]. For the composite samples of the Alaska blackfish, the individual fish were not measured. However, Alaska blackfish seldom exceed a length of 200 mm (about 8 inches) [4].

Total PCB levels were analyzed and quantified using Aroclor 1254 or Aroclor 1260 as a basis [1]. Because health-based comparison values have been established for Aroclor 1254, data for Aroclor 1254 were used as the basis by which PCB levels in the fish were evaluated. The PAHs measured were benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h)perylene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The sum of the PAHs is considered for some of the text that follows; however, a number of the PAH assessments are based on using the level of benzo(a)pyrene as a metric for total PAHs [5].

Mean contaminant levels were used for the assessments presented in this health consultation. To generate mean contaminant levels, samples with levels below detection limits were assigned the value of one half the detection limit.

Results

PAHs

PAHs were not detected in fish from the Tapisagahak River. Approximately one third of the Dolly Varden taken from the Suqitughneq River contained low levels of various PAHs (Table 1). Low, but detectable, levels of PAHs were found in about 25% of the fillet samples from the Dolly Varden taken from the Suqitughneq River. The mean benzo(a)pyrene level in the fish fillets was 1.8 parts per billion (ppb). The benzo(a)pyrene levels were highest in the egg samples (mean: 3.7 ppb) (Table 1).

PCBs

PCBs were detected at low levels in all of the samples from fish species collected from both rivers (Table 2). Mean PCB concentrations in fish fillet samples from Dolly Varden and pink salmon ranged from 8.1 ppb to 11.6 ppb. Generally, the highest PCB levels in the Dolly Varden or the pink salmon were found in the head samples (Table 2). The three composite samples of Alaska blackfish had a mean PCB level of 100 ppb (Table 2).

Discussion

Exposure Scenario

A site-specific exposure scenario was developed for the assessment and discussion presented in this health consultation. The site-specific exposure scenario is based on available information describing a) the usage of the site and nearby area and b) the expected fish consumption patterns of persons expected to be fishing at the Suqitughneq River. To facilitate comparisons, contaminant concentrations in the fish are presented in units of parts per billion (ppb). In several cases, various contaminant concentrations or exposure doses were converted to ppb to aid comparisons and provide perspective.

Initial screening of contaminant levels was accomplished using values derived from risk-based concentrations that are generated for biota by the U.S. Environmental Protection Agency (EPA) (Region III) [6]. The risk-based concentrations were converted to site-specific reference values for fish tissues; this was consistent with the following exposure scenario (also see Appendix A).

Site-Specific Exposure Scenario for Fishermen at NE Cape

Exposure Scenario Considerations

- Adult fishermen
- One fish meal every other day
- Eating fish for 3 months per year

Exposure Scenario Parameters

- Adult body weight = 70 kilograms
- One fish meal = 216 grams (approximately 8 ounces)

Fish intake per day = 108 grams (216 grams per meal; one meal eaten every other day)
Exposure duration = 30 years
Exposure factor = 0.25 (eating fish for 3 months per year)

By using the parameters described above, the risk-based concentrations were converted to site-specific reference values for fish tissues as follows: 8.4 ppb for benzo(a)pyrene and dibenzo(a,h)pyrene, 84.0 ppb for the other PAHs, and 31.0 ppb for total PCBs (Appendix A).

Assessment of PAH Levels.

Because the mean levels of PAHs detected in the Suqitughneq River Dolly Varden were below the reference values developed for the exposure scenario described above, no adverse health effects are likely to result from ingestion of the PAHs. PAHs were not detected in Alaska blackfish. In some circumstances, individuals may eat more fish than was considered in the site-specific exposure scenario; therefore, additional information about PAH exposures is provided in the Perspectives on Site-Related Exposures section.

Assessment of PCB Levels

Because the mean levels of PCBs detected in the Dolly Varden and the pink salmon at NE Cape were all below the reference values used for the site-specific exposure scenario, no adverse health effects are likely to result from ingestion of the PCBs in those fish species.

PCB concentrations in the Alaska blackfish were approximately three times greater than the site-specific reference value. Because of those PCB concentrations, a recommendation for restricting consumption of the Alaska blackfish is suggested as a protective measure (the Perspectives on Site-Related Exposures section).

In some circumstances, individuals may eat more fish than was considered in the site-specific exposure scenario. For this reason, additional information is provided to help persons gain perspective on their individual exposures (see the next section).

Perspectives on Site-Related Exposures

Perspective on PAHs

Published information on PAHs in food and fish is limited. However, information describing PAHs in store-bought foods and in fish collected from two other geographic areas was located. Smoked meats and smoked fish typically contain the highest PAH levels of common grocery store products. In one recent report of PAHs in grocery store products in the United States, smoked chicken, ham, bacon, or beef samples ranged from approximately 10 ppb to about 17 ppb for total PAHs, and from "not detected" to approximately 1 ppb for benzo(a)pyrene [7]. Smoked salmon, trout, and whitefish each had total PAH values of approximately 12–87 ppb, with benzo(a)pyrene accounting for about 1–4 ppb [7]. Some cereal and grain products exceeded

benzo(a)pyrene levels of 4 ppb [7]. Most other grocery store food items have PAH levels that are approximately 10 times lower than smoked meats and fish [7]. The total PAHs in fish fillets (the sum of mean values from Table 1) from the Dolly Varden in the Suqitughneq River is approximately 6.5 ppb, and the mean benzo(a)pyrene level in these fish is 1.8 ppb (Table 1). The level of total PAHs in the Suqitughneq Dolly Varden is approximately 2–10 times lower than similar estimates for the smoked fish purchased from a grocery store. The mean level of benzo(a)pyrene in the Suqitughneq Dolly Varden is in the middle of the range of estimated levels in store-bought smoked fish.

A report documenting the PAH levels in various fish collected in waters of the Chesapeake Bay area showed that the mean total PAHs for all fish was 37.6 ppb (maximum: 205 ppb). From the same study, the mean B(a)P level for all fish was 0.9 ppb (maximum: 6.9 ppb) [8]. The levels of PAHs in the Chesapeake Bay fish are notably higher than those in fish from a popular fishing area on the coast of New York where most of the PAHs, in a variety of fish species, were at levels too low to be detected [9].

Considering similar exposure scenarios and the limited data available for comparisons, note that eating fish from the Suqitughneq River would likely result in significantly lower PAH exposures than would be expected from either eating smoked fish from a grocery store or eating fish caught from the Chesapeake Bay.

The National Institute of Public Health and the Environment for the Netherlands has published a "maximal permissible risk" value [10] that also provides perspective for the PAH exposures. The maximal permissible risk for benzo(a)pyrene, considering the site-specific scenario used in this health consultation, is reached when the fish tissue contains 32.4 ppb benzo(a)pyrene. (The maximal permissible risk value was converted to a fish concentration using the rationale presented in Appendix A.) The mean benzo(a)pyrene level in fillets of the Suqitughneq River Dolly Varden was 1.8 ppb; that concentration is approximately 15 times lower than the reference value derived from the maximal permissible risk value.

Perspective on PCBs

Levels of PCBs detected in the Dolly Varden and pink salmon samples reviewed for this health consultation are similar to levels detected in other Alaskan waters. The State of Alaska reported that mean PCB levels in marine fish collected at the mouth of Alaskan rivers during 2001–2002 ranged from 1.2 ppb in halibut to 10.0 ppb in sockeye salmon (maximum mean level: 18.8 ppb) [11]. Alaskan health officials concluded that those findings support the "...Public Health Division's recommendation that all Alaskans, including pregnant women, women of childbearing age, and young children continue unrestricted consumption of fish from Alaska waters" [11].

A recent report showed that fish obtained from Canadian grocery stores had PCB levels ranging from 1.8 ppb in farmed tilapia to 17.5 ppb in farmed salmon [12]. General comparisons between the PCB levels in the Dolly Varden and pink salmon from the NE Cape versus levels in fish from other Alaskan waters or Canadian grocery stores indicate that the Dolly Varden and pink salmon from the NE Cape contain PCB levels similar to a "background range." Furthermore, a person probably would not significantly reduce PCB exposures associated with eating fish by substituting the fish from Canadian grocery stores [12] for the Dolly Varden from the Suqitughneq River.

The Alaska blackfish samples had the highest levels of PCBs found in fish at the NE Cape. Although the composite samples with PCB levels of 100 ppb are greater than levels considered "area background" (see information describing fish from Alaskan waters below), limiting consumption of these fish to one or fewer meals per week and adopting food preparation methods that reduce contaminants in the edible portion (see Appendix B) would be protective of the health of persons eating fish caught at the NE Cape.

Various governmental organizations provide advice on eating fish taken from waters where known contamination exists. Much of this advice is in the form of recommendations, and the advice is usually specific for various groups, including sensitive populations. Sensitive populations include young children and women who are pregnant, or who may become pregnant, and the recommendations are generally more restrictive for these persons.

A search of various state Internet sites for guidance on eating PCB-contaminated fish identified a range of advice. None of that advice suggested that the Suqitughneq River Dolly Varden and pink salmon would be considered for consumption restrictions for any group. The Internet search of states showed that the State of Montana provides some of the most restrictive advice. Montana recommends unlimited consumption for men, women, and children if PCB levels in fish are <25 ppb. Montana also recommends eating a) only one meal per week if the fish have a PCB concentration of 25–100 ppb and b) only one meal per month if the fish have a PCB concentration of 110–470 ppb [13].

Using the consumption advice from Montana, only the head samples (from the pink salmon from the Tapisagahak River and from the Dolly Varden in the Suqitughneq River) would have any consumption restriction. Those head samples (mean values) slightly exceed the recommended 25 ppb limit for unlimited consumption, but they would be suitable for one meal per week. With respect to the PCB concentrations in the Alaska blackfish, and considering the advice of the State of Montana, no more than one meal per month is recommended.

The state of Michigan has produced a maximal protective value for PCBs in fish that is reached when edible portions of the fish are at approximately 32 ppb [14; see Appendix A for the rationale for conversions to fit the site-specific exposure scenario]. Mean PCB levels in Dolly

Varden taken from the Suqitughneq River are approximately three times lower than Michigan's maximal protective level.

Fish as a Food Source, and Preparation Methods to Reduce Contaminant Levels

Fish is a nutritious source of protein, antioxidants, and vitamins; and a diet containing fish can help reduce the risk for heart disease [11–13]. Although the Dolly Varden and pink salmon from the NE Cape contain low levels of contaminants, similar levels, or higher levels, are found in fish taken from other Alaskan waters and in grocery store foods. If individuals are concerned about the low level of contaminants described in this report, it should be remembered that specific methods of choosing the fish that are eaten and specific preparation methods can reduce an individual's exposures to contaminants.

For example, it is better to eat a variety of different fish species that are collected at different locations. Eating smaller fish also can reduce exposures, because larger fish tend to accumulate higher levels of contaminants such as PCBs and PAHs. Advisable preparation methods include trimming fat and skin from the fish. When the fish is cooked, the juices and drippings from the fish should not be eaten. In addition, this health consultation found higher contaminant levels in the head and egg samples; therefore, reducing consumption of those portions of the fish will help reduce exposures. (Additional advice on how to reduce exposures to contaminants in fish is provided in Appendix B.)

Notes Concerning PCB Levels in Plants

Evaluating the PCB concentrations of plants at the NE Cape was not the focus of this health consultation. However, the data available for review showed that PCBs were measured in several plant samples. PCB concentrations in the plants were at a median level of approximately 60 ppb, at mean levels that exceeded 500 ppb, with the highest level measured at approximately 9,000 ppb. These data indicate that PCB levels in the plants sampled are elevated. If the specific plants are eaten or are used in herbal drinks or medicines, the PCB concentrations are at a level that represents a health concern. Furthermore, consideration should be given to the possibility that these plants could serve as a food source for local game birds or animals that are eaten by humans. These issues and questions warrant further investigation.

Conclusions

NOTE: The following conclusions are provided for the site-specific exposure scenario developed for the NE Cape fishermen (see details in the text).

1. The available data indicate that the low PCB levels in the Dolly Varden and pink salmon in waters at the NE Cape are similar to, or less than, PCB levels in fish from other Alaska waters.

2. Consumption of PCBs in the Dolly Varden and pink salmon from the waters at the NE Cape is not likely to result in adverse health effects.

3. PCB levels in Alaska blackfish collected at the site are slightly elevated. As a preventive measure, consumption of the blackfish at the NE Cape should be restricted to one meal per month.

4. The levels of PAHs in the Dolly Varden in the Suqitughneq River are similar to those found in commercially available smoked fish and are similar to, or less than, PAH levels in fish from the Chesapeake Bay fishery.

5. Consumption of the PAHs in the fish from the Suqitughneq River is not likely to result in adverse health effects.

Recommendations

NOTE: The following recommendations are provided for the site-specific exposure scenario developed for the NE Cape fishermen (see details in the text).

1. No advisories are needed regarding the Dolly Varden and pink salmon in water at the NE Cape.

2. As a preventive measure, restrict consumption of the Alaska blackfish collected at the site to less than one meal per week.

Prepared by:

Clement J Welsh, PhD, MPH
Senior Environmental Health Scientist
Exposure Investigations and Consultation Branch
Division of Health Assessment and Consultation

Reviewed by:

Peter Kowalski
Senior Environmental Health Officer
Team Leader
Exposure Investigations and Consultation Branch
Division of Health Assessment and Consultation

Susan Moore
Branch Chief
Exposure Investigations and Consultation Branch
Division of Health Assessment and Consultation

Kenneth Orloff, PhD
Associate Director for Science
Division of Health Assessment and Consultation

References

1. US Department of Defense, Department of the Army, US Army Engineer District, Alaska. Memorandum for record. Subject: Northeast Cape, Lawrence Island fish data collection report, August 18 through August 22, 2001, and contaminant concentration data submitted by the US Army Engineer District, Alaska, to the Agency for Toxic Substances and Disease Registry.
2. Agency for Toxic Substances and Disease Registry. Review of fish samples (screening data) from the Suqitughneq River, St. Lawrence Island, Alaska. Atlanta: US Department of Health and Human Services; 2001.
3. Army Corps of Engineers. Tier II ecological assessment for Northeast Cape, St. Lawrence Island, Alaska—revised draft report. Anchorage (AK): Environmental and Natural Resources Institute, University of Alaska; 1999 Nov.
4. Alaska Department of Fish and Game. Alaska blackfish. Available from: http://www.adfg.state.ak.us/pubs/notebook/fish/blackfsh.php. Last accessed; March, 2005.
5. European Commission, Health and Consumer Protection Directorate. Opinion of the Scientific Committee on Food on the risks to human health of polycyclic hydrocarbons in food. December 2002.
6. US Environmental Protection Agency, Region III. Risk-based comparison values. Available at: (http://www.epa.gov/reg3hwmd/risk/human/index.htm). Last accessed: March, 2005.
7. Jakszyn P, et al. Food content of potential carcinogens. European Prospective Investigation on Cancer; 2004. Catalan Institute of Oncology, Barcelona .
8. State of Virginia Department of Environmental Quality. Fish sampling results for the Chesapeake Bay Area. 2002.
9. U.S. National Oceanic and Atmospheric Administration. Technical memorandum NMFS-NE-157: contaminant levels in muscle of four species of recreational fish form the New York Bight Apex. June 2000.
10. National Institute of Public Health and the Environment. Re-evaluation of human-toxicological maximal risk levels. Bilthoven, Netherlands. March, 2001. RIVM report no.: 711701 025.
11. State of Alaska Division of Environmental Health. Alaska Department of Environmental Conservation Fish Monitoring Program: analysis of organic contaminants. 2004 Aug. Available at: http://www.state.ak.us/dec/eh/docs/vet/FMP%20Organic%20data%20release3.pdf and http://www.state.ak.us/dec/eh/vet/FMP2.htm. Last accessed: March, 2005

12. Health Canada. Fish and seafood survey—2002. Available at: http://www.hc-sc.gc.ca/food-aliment/cs-ipc/fr-ra/e_seafood_survey.html. Last accessed: March, 2005. Also see http://www.hc-sc.gc.ca/food-aliment/cs-ipc/fr-ra/e_pcb_conc_vancouver2002.html for Vancouver 2002 results. Last accessed: March, 2005.

13. Montana Department of Public Health and Human Services. 2005 Montana sport fish consumption guidelines. 2005. Available at: http://www.dphhs.mt.gov/newsevents/newsreleases/april/fish2005.pdf. Last accessed: March, 2005.

14. Fisher LJ, et al. Evaluation of Michigan's proposed 1998 Fish Advisory Program. Lansing: Michigan Environmental Science Board; 1998 Jan.

Appendices

Appendix A. Exposure parameters used to convert risk-based concentrations into reference values for site-specific exposure scenarios for fishermen who eat fish taken from the Suqitughneq River

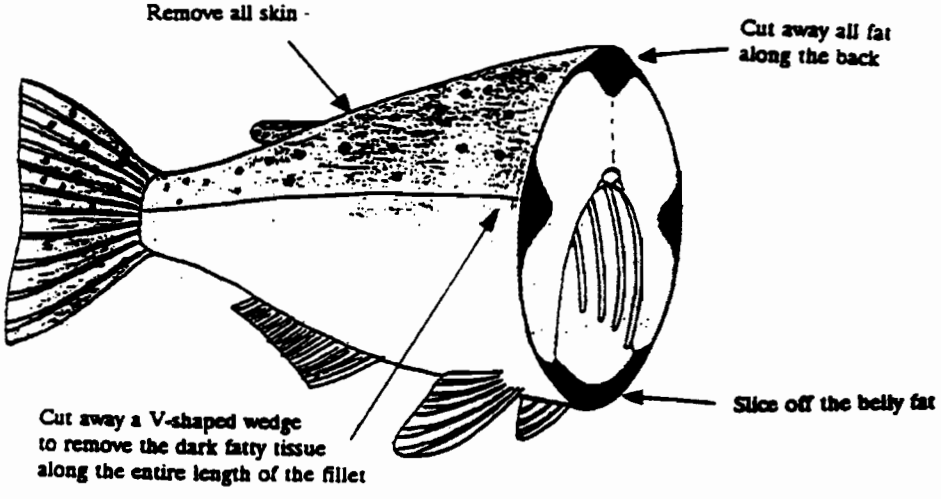
Exposure parameters	Risk-based concentration*	Conversion factor	Site-specific reference values
Target risk	10^{-6}	x 10	10^{-5}
Exposure frequency	350 day/yr	x 3.9	90 day/yr
Exposure duration	30 yr	x 1.0	30 yr
Fish ingestion	54 g/day	x 0.5	108 g/day
Reference value for contaminant			
Polyaromatic hydrocarbon			
Benzo(a)anthracene	4.30 ppb	x 19.5	**84.0 ppb**
Benzo(a)pyrene	0.43 ppb	x 19.5	**8.40 ppb**
Benzo(b)fluoranthene	4.30 ppb	x 19.5	**84.0 ppb**
Dibenzo(a,h)anthracene	0.43 ppb	x 19.5	**8.40 ppb**
Indeno(1,2,3-cd)pyrene	4.30 ppb	x 19.5	**84.0 ppb**
Polychlorinated biphenyl			
Arochlor 1254	1.60 ppb	x 19.5	**31.0 ppb**

*Parameters used in U.S. Environmental Protection Agency's Region III risk-based concentrations that were employed in the conversion to site-specific reference values.

APPENDIX B. Cleaning and Cooking Your Fish

Many contaminants, such as polychlorinated biphenyls (PCBs) and polyaromatic hydrocarbons (PAHs), are found at high levels in the fat of fish. You can reduce the amount of these contaminants in a fish meal by properly trimming, skinning, and cooking your catch. Remove the skin and trim all the fat from the areas shown on the diagram below: the belly flap, the line along the sides of the fish, the fat along the back, and under the skin.

Cooking does not destroy contaminants in fish, but heat from cooking meals removes some of the fat in fish and allows some of the contaminated fat to drip away. Broil, grill, or bake the trimmed skinned fish on a rack so the fat drips away. Do not use the drippings to prepare sauces or gravies.



Source: Great Lakes Sport Fish Advisory Task Force. Protocol for a uniform great lakes sport fish consumption advisory. September 1993.

Figures and Tables

Table 1. Polyaromatic Hydrocarbons in Fish Samples Collected From the Suqitughneq River Lagoon.*

Polyaromatic Hydrocarbons	Statistic	Samples			
		Eggs	Heads	Fillets	Remains
Benzo(a)anthracene					
	Mean	5.2	1.5	1.7	1.3
	Maximum	12.0	2.3	8.2	2.0
	Detects/samples	2 of 3	1 of 2	2 of 8	1 of 2
Benzo(a)pyrene					
	Mean	3.7	1.6	1.8	ND
	Maximum	9.0	2.1	5.9	ND
	Detects/samples	1 of 3	1 of 2	2 of 8	0 of 2
Benzo(b)fluoranthene					
	Mean	3.1	1.3	1.1	1.2
	Maximum	7.3	2.0	4.0	1.8
	Detects/samples	2 of 3	1 of 2	2 of 8	1 of 2
Dibenzo(a,h)anthracene					
	Mean	2.8	1.2	1.2	ND
	Maximum	6.8	1.6	4.1	ND
	Detects/samples	1 of 3	1 of 2	1 of 8	0 of 2
Indeno(1,2,3-cd)pyrene					
	Mean	1.8	0.63	0.73	0.78
	Maximum	6.8	1.0	2.7	1.3
	Detects/samples	2 of 3	1 of 2	3 of 8	1 of 2

*Mean and maximum PAH levels are shown in parts per billion.

Table 2. Polychlorinated Biphenyls in Fish From the Northeast Cape*

Fish	Location	Statistic	Sample eggs	Sample head	Sample fillet	Sample remains	Sample composite
Dolly Varden	Suqitughneq River	Maximum	13.0	30.0	16.0	18.0	—
		Mean	9.9	27.0	11.6	16.5	—
		Detects/samples	3 of 3	2 of 2	8 of 8	2 of 2	—
Dolly Varden	Tapisagahak River	Maximum	9.1	10.0	11.0	6.8	—
		Mean	—	—	10.0	10.0	—
		Detects/samples	1 of 1	1 of 1	3 of 3	1 of 1	—
Pink salmon	Tapisagahak River	Maximum	17.0	28.0	10.0	9.0	—
		Mean	—	—	8.1	7.23	—
		Detects/samples	1 of 1	1 of 1	2 of 2	2 of 2	—
Alaska blackfish	Site 28	Maximum	—	—	—	—	140
		Mean	—	—	—	—	100
		Detects/samples	—	—	—	—	3 of 3

*All data are parts per billion.

Figure 1

Figure 2. Fish Sampling Locations

[insert map here – lbw]

Source: Montgomery Watson