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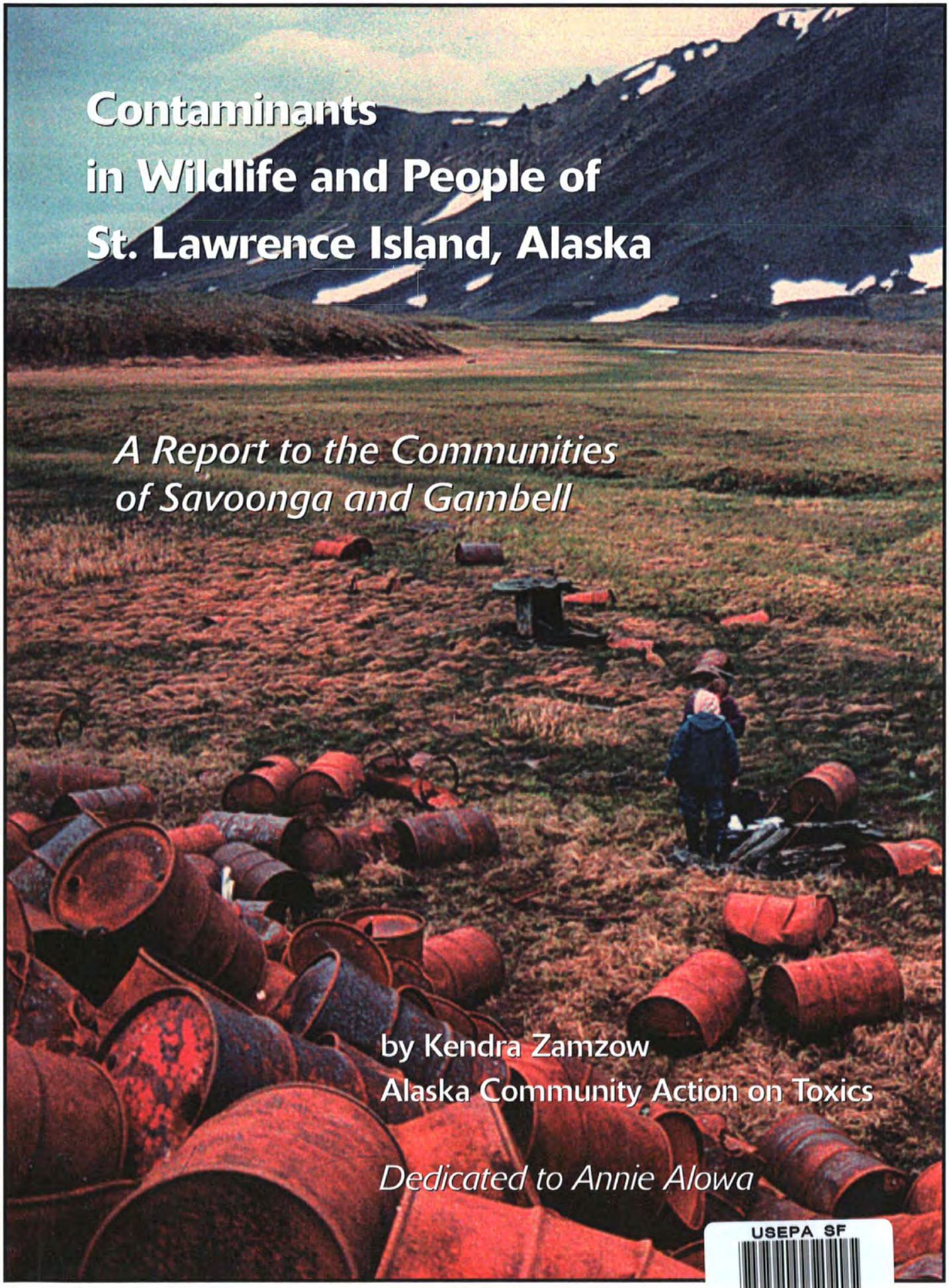

Contaminants in Wildlife and People of St. Lawrence Island, Alaska

A Report to the Communities of Savoonga and Gambell

by Kendra Zamzow
Alaska Community Action on Toxics

Dedicated to Annie Alowa

USEPA SF
1168726

Reviewed by

Dr. Ron Scrudato

Dr. David Carpenter

June Martin

Pam K. Miller

Heidi Zamzow

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Prologue

In 1998, Alaska Community Action on Toxics (ACAT) was asked by Annie Alowa and the community of Savoonga to investigate toxins at the abandoned military area at Northeast Cape (officially called a "Formerly Used Defense Site"), which is located near traditional subsistence camps, because a suspicious number of cancers seemed to be associated with people who spent time there. Was it possible that contaminants used and left by the military thirty years ago are affecting food sources today?

ACAT began an investigation that explored contaminants at Northeast Cape, in Gambell, and in foods eaten by both communities.

ACAT reviewed chemical analyses[1] of soil and water at Northeast Cape to determine

a. what contaminants are in the area
b. where they are, and
c. at what concentrations

Samples of soil and water were collected and analyzed by Corps of Engineers contractors.

ACAT reviewed contaminant levels in foods from Northeast Cape:

a. plants (nunivagseghat)[2]
b. fish[3] (iqalluget/kayut)

Samples of plants and fish were collected and analyzed by Corps of Engineers contractors.

ACAT reviewed contaminants in foods provided by residents of Savoonga:

a. reindeer[4] (quyngiq)
b. murre eggs[5] (alpa manik)
b. bearded seal (oogruk)
c. walrus (ayveq)[6]

Samples of reindeer were collected by University of Alaska and analyzed by the US federal agency "Agency for Toxic Substances and Disease Registry". Samples of murre eggs, bearded seal, and walrus were collected by ACAT and analyzed by State University of New York and Exeter University (in England).

Lastly, residents of Savoonga and Gambell offered to have their blood drawn and analyzed[7] for contaminants, and we discuss those results.

Residents who worked for the military at Northeast Cape or Gambell may have been exposed to toxins during that time, and these exposures could be very significant to their health today. ACAT is not able to tell to what extent this past exposure is affecting people, although some indication may be seen from contaminant levels in blood.

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[1] Collected and analyzed by the contractors Ecology and Environment (1993) and Montgomery Watson (1994 – 2001)
[2] Collected and analyzed by the contractor Montgomery Watson
[3] Collected and analyzed by Environment and Natural Resources Institute, a part of the University of Alaska, Anchorage (1999) and Montgomery Watson (2001)
[4] Collected during community reindeer roundup and analyzed by the Agency for Toxic Substances and Disease Registry (ATSDR), a part of the US Environmental Protection Agency
[5] Collected by Wilfred Miklahouk and Douglas Gologergen and analyzed by State University of New York for ACAT
[6] Bearded seal and ayveq samples were collected by Pamela K. Miller and analyzed by Exeter University in England for ACAT
[7] Collected by ACAT and analyzed by Dr. David Carpenter of State University of New York

Executive Summary

This summary is a short version of this report. All important results and conclusions are summed up here. For those people who are interested in more detail, the full report provides more information.

Every human has PCBs and other contaminants in them. A developing fetus and breastfeeding infant are exposed to the contaminants in their mother's body, and are more susceptible than adults, particularly while the child is still growing and forming in the mother's womb.

Every animal, plant, and person is a constant interplay of nutrients, new contaminants, and old contaminants being built up, broken down, stored, and eliminated. For humans, exposure to contaminants is a mosaic of past contamination underlying daily toxic exposures to cleaners, household pesticides, pharmaceuticals, vehicles, paints, and plastics. While contamination in wild woods are a concern, people are also exposed to small amounts in store bought foods (especially pesticides), along with preservatives, sugars, and fats which also interact and affect an individual's health. Because multiple contaminants and nutrients are overlaid on each other, there is no possible way to predict how exposure to any one contaminant will affect any one person or animal. We can provide information on what contaminants are in you (through blood testing) and health effects each may cause. Looking at communities helps us see what sources are most likely impacting each community.

People come in contact with contaminants in the following ways:

- on the job (while working in the military, mining, oil production, oil cleanup, industrial jobs)
- through drinking water
- through eating plants and animals carrying global contaminants
- through eating plants and animals carrying contaminants from local spills or pollution
- by living in modern times, with contaminants in household cleaners, vehicle exhaust, cigarettes, pharmaceuticals, paints, carpets, and plastics

This report explores each of these potential sources in detail, and you can look through the Table of Contents to go to a section you want to read about in detail. Highlights of the results follow.

Concerning Contamination of Soil and Water:

Gambell

- Corps of Engineers found soil in Gambell had fuel and petroleum contamination, and some isolated incidences of high metals. No independent researchers have tested Gambell soil yet, but ACAT will do some testing in 2002.
- City of Gambell reports that lead and copper have been borderline to high in city drinking water several times in the last six years. Lead and copper come from corroding water pipes. High levels of lead can cause kidney problems and high blood pressure in adults, and mental and physical delays in kids. High copper can cause stomach problems during short term exposure and kidney and liver damage if an individual is exposed over a long period of time.
- City of Gambell reports that lead was found to be at borderline levels in Troutman Creek and at high levels in Troutman Lake when they were tested in 1991. No other contaminants were found.

Savoonga

- No soil testing has been done in Savoonga.
- City of Savoonga drinking water had elevated lead and copper in 1995 tests of city water, but tests done in 2001 showed only one home out of 40 had high levels of lead.

Northeast Cape

- Corps of Engineers reports show soil at Northeast Cape is contaminated with petroleum, PCBs, and metals (such as arsenic, lead, and zinc). The strongest contamination was near the military base and directly below it in the wetlands drainage of the Suqi River. Pesticide levels were very low, and the pesticide that showed up was DDD (which comes from DDT), which may have come from other countries.
- Corps of Engineers reports on water at Northeast Cape indicate water in the drainage and Suqi River is contaminated with petroleum and metals. Some of the metals are natural to the area, but some particularly high levels of metals are probably from military dumping of batteries and other material. PCBs were found in the water in four places directly beneath the main base housing, but none were found downstream in the Suqi River itself. ACAT will be doing further testing downstream in water and sediment for low levels of PCBs and petroleum residues.

In Gambell, remediation efforts began in 1999. Some soil remains to be removed. Potential pools of petroleum dumped by the military (reported by residents) have not been found, despite many holes being drilled to ten and twelve feet down. If petroleum is there, holes may have to be drilled deeper to find it. The Corps of Engineers is not planning on drilling deeper holes at this time. Their recent efforts are focused on finding buried ammunition. ACAT will be testing soil and water at Gambell for explosives residues, and test air inside the high school for potentially dangerous vapors. They may test stickleback fish from the Lake as well.

At Northeast Cape, a large amount of debris (wire, fuel lines, poles, buildings) and soil have been removed. A great deal of work remains to be done. The White Alice site is being added to remediation efforts this summer. Remediation is expected to continue for several more years. ACAT will be testing soil and water for PCBs, oil residues, explosives residues, and pesticides the Corps did not look for. They will be testing downstream Suqi River water for low levels of particular chemicals from petroleum that may affect fish growth and development. They will also test air.

Concerning Plants and Animals

Since food is an important way that people are exposed to contaminants, ACAT has looked in detail at foods suspected to contain contaminants that have drifted to the arctic from around the world, and at foods that may be contaminated by known local pollution at the military base at Northeast Cape. No foods have been collected at Gambell yet. Bird eggs were collected from outside Savoonga.

All northern plants and animals are exposed to contaminants that accumulate in the north. Worldwide air and water currents bring pollutants to the Arctic and Antarctic. They travel in clouds, fog, rain, and dust, and settle out on tundra, mountains, lakes, rivers, streams, ice and oceans. From soil and water, they move into plants (nunivagseghat), and from there into animals.

Nunivagseghat and animals may accumulate contaminants – that is, they take them in faster than they can get rid of them. Some of these contaminants can build up "through the food chain" as one animal eats another eats another, becoming more concentrated and dangerous at each step. This is called bio-magnification. Not all contaminants bio-magnify. For instance, metal levels may accumulate in an animal but not increase through the food chain; indeed, they tend to *decrease* in higher animals (there are some exceptions).

The contaminants that biomagnify are called *persistent organic pollutants*, or POPs. They are PCBs, pesticides, and some chemicals released in incinerators.

Toxin build up in an animal depends on "trophic level", which means where it eats on the food chain.

For instance:

Algae is eaten by a duck (qagingiiq) which is eaten by a man. (1, 2) → 2 steps

Plant is eaten by a reindeer (quyngiq) which is eaten by a man. (1, 2) → 2 steps

Phytoplankton eaten by small fish eaten by large fish eaten by seal (neghsat) eaten by man. (1, 2, 3, 4) → 4 steps

Phytoplankton eaten by small fish eaten by large fish eaten by neghsat eaten by nanuq eaten by man. (1, 2, 3, 4, 5) → 5 steps

A qagingiiq or quyngiq is considered to eat "low on the food chain". Nunivagseghat are the lowest of all on the food chain. Plants and plant-eating animals generally have low levels of global contaminants. They *may* still have high levels of contaminants if they are where local spills of oil, solvents, and other chemicals have occurred.

Polar bears (nanug) tend to have the highest levels of contaminants, because they eat highest on the food chain. ACAT did not analyze nanuq samples, but research on the North Slope and other arctic areas that verifies this.

The amount of contamination is not related to the *size* of an animal. For instance, a whale that eats mostly plants and zooplankton, like a bowhead (aghvepik), may have lower contaminants than a killer whale (mesungesak) that eats neghsat, even though the aghvepik is larger. Ayveq that eats clams (imanat) has much

lower levels of PCBs and pesticides than ayveq that eats neghsapik (ringed seal). People and animals that eat large amounts of marine mammals seem to be the most at risk for high contaminant levels.

Not all animals have their health affected by contaminants. Some animals may be having subtle health effects – like slightly lower antibody production – that we are not able to see or measure easily. Some animals are definitely being affected by contaminants. Beluga whales (puugzaq) in a polluted river in northeastern Canada, called the St. Lawrence River, are definitely having health problems related to contamination. Neghsat in polluted areas of Europe died off in large numbers from viral infections; it is suspected that their immune systems did not work well because of the polluted water they lived in. New research on nanuq shows their immune systems are definitely lowered. In these examples, we can say that nanuq are affected by global contaminants that have biomagnified to dangerous levels, while puugzaq in Canada and naghset in Europe are affected by local contamination.

It is important to keep this difference in mind. Nunivagseghat should be lowest on the trophic level and not have very high levels of contaminants, because there is no biomagnification involved at all: they receive contaminants directly from soil, water, and air. However, some nunivagseghat collected at Northeast Cape showed *very* high levels of PCBs because of local spills left by the military. These nunivagseghat were analyzed with the dust that was on them. PCBs may be in the dust, not on the plant, but if people simply picked nunivagseghat and ate them without washing them, they could have eaten PCBs. These high levels of PCBs may have only recently shown up. With the recent debris removal work that has been going on out there, soil and water have been stirred up. Stirred up PCBs and oil residues have been traveling on wind and water to areas downwind/downstream.

Results of nunivagseghat and animal testing is shown below:

	POPs						Not POPs		
	PCBs (ppb)	**DDT or DDE** (ppb)	**HCH**	**HCB**	**Chlordane**	**mirex**	**PAHs global**	**PAHs Non global**	**Metal**
	Average	Average	Average	Average	Average	Average	Max	Max	
Oogruk						NA	NA	NA	NA
Blubber	128	70	37	~35	Very low				
Oil	159	50	39	~0.5	Very low				
Dried meat	3	0.6	1						
Dried meat in oil	19	9	4						
Ayveq (1998)						NA	NA	NA	NA
Blubber	61	9	110	Very low	Very low				Cd
Oil	68	7	109	Very low	Very low				
Alpa manik	82	78		39	NA	2	NA	NA	NA
Quyngiq	ND	5	NA/ND	NA/ND	NA/ND	NA	134	174	NA
Suqi blackfish, 1999	100	NA/ND	NA	NA	NA	NA	11	103	NA
Suqi blackfish, 2001	100	NA/ND	NA	NA	NA	NA	11	37	Hg
Suqi Dollies, 1999	ND - 160	NA/ND	NA	NA	NA	NA	ND	ND	NA
Suqi Dollies,2001	30	NA/ND	NA	NA	NA	NA	21	153	No concern
Tapi and Quang Rivers	20	NA/ND	NA	NA	NA	NA	ND	ND	No concern
Plants with Dust	10-9300	NA/ND	NA	NA	NA	NA	NA	NA	Pb, Hg

Contaminants in St. Lawrence Island Plants and Animals, 1998-2001*(wet weight, ppb)*

The units used are parts per billion (ppb). This means one bit of contaminant was found in a billion bits of meat or fat. ND means not detected. This doesn't mean that none of that contaminant was in the animal, but that if it was there it was in such a low amount the test could not find it. NL means not looked for. Contaminants of Concern to humans who eat these animals are highlighted in yellow. This does not mean the animal itself necessarily has health problems.

This chart shows that global contamination is affecting all animals to some degree. The extra *local* contamination at Northeast Cape is affecting some fish and plants in the area. Reindeer, who spend only part of their time at the Cape, do not appear to be affected by contamination on plants.

None of the contaminants are likely to have significant affects on animal populations, but animals may be feeling subtle health effects.

The important things we learned about animals are:

- Some nunivagseghat (with dust on them) and some fish have high levels of PCB from the military. Stirred up PCBs are probably increasing levels at this time.
- Fish eggs at the Cape were probably subjected to oil residues at high enough levels to affect the growth and development of fish.
- All ayveq, oogruk, and alpa manik are affected by global contamination. Alpa manik, which eat small fish and ayveq, which eat a lot of clams have generally less PCBs than oogruk.
- Fatty foods, such as blubber, have more contaminants than lean meat or lean blubber.
- The pesticide DDE is not a big concern. The pesticide HCB may be having subtle health effects on alpa and oogruk. HCB affects reproduction, the thyroid (which regulates growth), and the immune system
- The pesticide HCH was high in walrus, and walrus may be feeling health effects. HCH depresses the immune system and affects hormones and kidneys. There may be no obvious signs of health problems.

Because of biomagnification, contaminants that are not high enough to affect the health of an animal *may* affect the health of a person eating the animal. The yellow highlights in the chart refer to levels of contamination that are high enough to be of concern *to people eating animals*, not to the animals themselves.

Recall the main ways that arctic people come in contact with contaminants:

1. On the job (military, mining, oil work)
2. From eating foods contaminated by local spills (this includes non POPs like metal as well as POPs).
3. From eating foods contaminated by global pollutants (POPs only).
4. Every day toxins in consumer products and vehicle exhaust.

Elders from both Gambell and Savoonga could have been exposed on the job while working for the military. This could have been direct exposure (actually touching and breathing PCB fluids). Direct exposure can create drastic health effects, like cancer, many years later.

Subsistence users at Northeast Cape over the last 40 years could have eaten locally contaminated foods. All ages of people could have been exposed in this way.

All ages of people from all communities have been exposed through eating marine mammals.

Human Blood Results

Blood results are listed below, and compared to averages of the US population, women from the Aleutians and Pribilof islands, Canadian Dene Indians (who eat a diet similar to Athabascans, with no marine mammals), and to people exposed directly to PCBs through their jobs.

	US	ACAT staff	Gambell		Savoonga		Northeast Cape		Pribilofs	Dene	US
	avg	Female	female	male	female	male	female	male	women	women	job
PCB average	1.5	3.20	4.53	7.23	6.96	7.60	9.34	8.71	2.0	1.6	30-44
HCB average	0.1	0.13	0.47	0.55	0.68	0.75	0.87	0.63		0.2	
DDE average	2.0	3.84	3.33	3.19	2.88	2.51	1.36	0.69		1.3	
Mirex average	?	0.08	0.10	0.22	0.18	0.28	0.30	0.28	0-0.8		

Contaminant Levels in Human Blood, 2001 *(ppb)*

For PCBs, a pattern emerges. The average US population has the lowest levels, followed by ACAT, then Gambell residents, Savoonga, and Northeast Cape people had the highest levels.

The same pattern was seen for HCB and mirex levels *in women*, but men on the island had similar levels.

For DDE, the *opposite* trend was seen, with ACAT staff having the highest levels, followed by Gambell, Savoonga, and Northeast Cape with the lowest levels. Savoonga had levels similar to the US population, and Northeast Cape had levels similar to people in the Pribilofs. The "parent" compound of DDE is DDT. DDT breaks down into two compounds, DDE and DDD. Possibly if the sum of DDT + DDE + DDD levels were measured, we would see a different result. Only DDE was measured because most Alaskans are not exposed to DDT; it has normally broken down into DDE by the time it reaches Alaska from Asia and Africa.

The overall impression is that PCBs left by the military at Northeast Cape have impacted food and people who eat Northeast Cape plants and animals. If contaminated food was brought from Northeast Cape to Savoonga to share with relatives, this would explain why Savoonga blood was higher in PCBs than Gambell. It appears that military in Gambell did not contaminate local Gambell foods with PCBs; Gambell has levels only slightly higher than ACAT, which is probably due to eating marine mammals.

What the blood levels mean

While there may be some health effects from the pesticides, they are much less concerning than the PCB levels seen. In addition, one effect pesticides have is that they become more dangerous to health when they are mixed with PCBs. New research, using human embryo cells in petri dishes, exposed cells to DDE by itself (in amounts commonly seen in people from Barrow) and to DDE mixed with PCBs (both in amounts seen in Barrow women). DDE by itself had very little effect on the cells, but the mixture caused cells to stop dividing for a while. Cells did not die, but they did interrupt their normal growth (division, reproduction). This can be extremely important if the cells that are exposed are in a developing fetus.

Levels for PCBs were much lower than in people exposed on the job (average 44 ppb on the job, and 30 ppb thirty years later), and lower than "concern" or "action" levels set by Canada for men and for women past reproductive age. Concern levels are set at 20 ppb; action levels at 100 ppb. No one had levels over 20 ppb, so PCBs in men and older women may not be having drastic health effects.

This does not mean there is no reason for concern. Women from St. Lawrence Island had significantly higher PCB levels (7 – 9 ppb) than women from the Aleutians and Pribilof Islands (2 ppb). Levels over 5 ppb are considered high enough to potentially increase risk of problems with the reproduction, the immune system, nerves, and endocrine system (hormones that regulate growth, metabolism, sexual cycles and development). **This is a serious concern**. Once a child is born, there is little that can be done except minimize exposure to contaminants and give them as healthy a diet and lifestyle as possible. Having contaminants in your blood does not *necessarily* mean you will have health problems, but it is an added burden to the body.

It is important also to realize that PCBs *are* broken down in the body over time if exposure is minimized. An infant born with PCBs will only have half the amount of PCBs by the time she is ten years old (if she has no new exposure to them), and only one-quarter of her original PCBs by the time she is twenty (if there is no expossure). It is critical that all women minimize PCB exposure until they are past reproductive age.

Most traditional foods have PCBs in them. Some on St. Lawrence Island, however, are very low – like reindeer, oogruk meat, and fish from unpolluted rivers. ACAT would like to continue to study traditional foods to see if there are more foods with low levels of PCBs. Nunivagseghat from most areas should be very safe because they do no biomagnify global contaminants; they are only affected by local pollution. ACAT would like to know how far the contamination of nunivagseghat extends at Northeast Cape, whether contaminants drop off when remediation is finished, and whether nunivagseghat from the Gambell area show contamination.

ACAT will continue its work with the people of St. Lawrence Island for the next two years, on a grant from the National Institute of Environmental Health Sciences. They will pursue further grants to focus on traditional foods and remediation efforts.

What Will Stop Contamination of People?

Limiting the traditional food is not a solution. What can be done to stop contamination?

1. There is nothing that can stop the contamination a person received if exposed directly to PCBs or pesticides while in the military in the past.

2. Local contamination will be removed by the military. Residents and ACAT need to ensure that local contamination is *completely* removed. When no sources remain, contamination in plants and animals will decrease over time.

3. The production and use of harmful chemicals needs to stop all over the world. This requires international work. An international treaty, called the Stockholm Convention, or the Global POPs treaty, has been signed by several nations, including the US. Now the congresses of the countries that signed need to agree to the treaty, that is, ratify it. The US Congress has not yet ratified the treaty. Once fifty nations ratify it, it will become international law. The treaty will ban the twelve worst chemicals (including PCBs), and make it possible to ban more when we show that others are harmful. It is *extremely* important that communities and individuals write letters to Senators Stevens and Murkowski to urge ratification.

In addition, people can become involved in the Arctic Council and other international organizations to make their voices heard. The voices of arctic people have been drowned out by the huge chemical corporations, and we need them to be heard.

A summary of the treaty is found on the final page of the report.

Only elimination of harmful chemicals and incinerator byproducts will stop the problem of arctic food contamination. Elimination *does* work. We are already seeing dramatic decreases in levels of DDT and DDE in the arctic because most nations quit using it thirty years ago. While we may not see dramatic decreases in our lifetime, if chemicals are stopped today, our children will benefit.

Introduction: Local and Global Pollution

In the world we now live in, we are all affected by pollution from sources close to us and from sources far away. Items as common as paint, gasoline, and kitchen cleaners contain toxins; as do pesticides sprayed on cotton, corn, rice, and other crops around the world. In the last 60 years, man-made chemicals have found their way into every part of our world, and have become part of our everyday life.

Our bodies are able to break toxins down and move them out of our bodies without any change in our health. But if toxins come in faster than we can remove them, they build up, overwhelming our body, and health problems occur. There is considerable debate over how much our bodies can deal with before our health or the health of our children is affected; no one knows exactly how much of a toxin is "safe" for each individual person. A level of one contaminant that causes no harm in you may cause harm in your neighbor. Each person is unique in the amount of contaminants they have, in the nutrients they have and the health of their organs and immune system, in the ability their individual body has to remove or detoxify mixtures of contaminants. It is easy to know that a very large dose of some chemical will be harmful; it is much more difficult to say what the lowest dose of chemical or chemical mixtures will affect you, your neighbor, or your child.

Why Can't We Tell if a Toxin is Causing Cancer?

"....observations of people who have been inadvertently exposed to substances gives us a clue (about) which cause cancer. But often these people have been exposed to unknown quantities over unknown periods of time.
Observations of lab animals ...supplies a second set of clues. But different animals can vary in their vulnerability to certain cancers. Which species has lymph nodes (like ours), bone marrow, brain tissue, prostate glands, bladders, breasts, livers, and spinal cords that behave most like those in humans? (Should we test).. Rats? Fish? Dogs?
Another reason for .... uncertainty is...that there (is) no control population to compare exposed populations to. Exposures are uncontrolled and multiple... Such combinations (can do) great harm (to our health) while yielding meaningless data. The tools of science do not work well when everything is changing all at once."

Living Downstream, p 29

Air, water, and soil may have contaminants. Plants depend on air, water, and soil, and animals depend on plants. This means that virtually all food has the potential to be contaminated. Grains (macaroni, flour, cereal), fruits, and vegetables in the store were sprayed with pesticides, herbicides, and fungicides at the place where they were grown. In pristine areas, marine mammals are affected by industrial pollution that travels the globe to end up in Arctic waters. Greens and fish gathered at Northeast Cape may be affected by petroleum and PCBs flowing out of a military complex that has not been used for 30 years.

If virtually all food has some contamination, how contaminated are foods that the people of St. Lawrence Island eat? This report tries to find that out by describing

1. Contaminants in soil and water at Northeast Cape and Gambell (local pollution).
2. Contaminants and their effects on plants and animals at Northeast Cape (local pollution).
3. Contaminants in quyngiq, fish, marine mammals and marine birds *not* necessarily associated with Northeast Cape (global pollution)

Contaminant levels in foods from St. Lawrence Island are compared to similar foods from other areas around the world and to foods commonly eaten by people in cities and the Lower 48.

One set of information, such as this, is not enough to provide the whole picture of the effect of contaminants in the environment and on the animals, birds, plants, and people of St. Lawrence Island. Much more work will be needed.

Northeast Cape/Savoonga

I. Local Pollution: Soil and Water Contamination at Northeast Cape

St. Lawrence Island is located 130 miles southeast of Nome, in the northern part of the Bering Sea. Two villages, with a total of 1400 residents, are on the island – Gambell on the westernmost end, and Savoonga in the middle of the northern coast. On a map, "Northeast Cape" refers to a sweeping coastline on the eastern tip of the island, about 50 miles from Savoonga. In this report, "Northeast Cape" refers specifically to the military complex at the foot of Kangukhsam Mountain, near Kitnagak Bay. Before the military arrived, Northeast Cape was an important subsistence camp, and some residents continue to use it for subsistence hunting, fishing, and plant gathering.

When the military left Northeast Cape in 1972, they left behind landfills and buildings. Thousands of rusted barrels and miles of wire littered the landscape. Toxic cleaning solvents, PCB-laden hydraulic oils and lubricants, petroleum fuels, and lead batteries were left on and in the ground. At least 220,000 gallons of diesel were spilled over the years; 160,000 gallons of diesel was spilled into the primary subsistence river, the Suqitughneq (Suqi) in one spill in the late 1960's.

The federal government initiated the Formerly Used Defense Sites (FUDS) cleanup program in 1984, and in 1985 the contractor URS Corporation took a preliminary look at Northeast Cape. No additional work was done until 1993, when the contractor Ecology and Environment, Inc (E&E) collected soil samples. In 1994, the contractor Montgomery Watson[8] (MW) collected soil and water samples, and in 1996 took samples and looked for signs of radiation (none were found). Since 1998, they have been out every year to take environmental samples, contracted under the U.S. Army Corps of Engineers (COE) who are in charge of remediation.

When the COE began looking to see what contaminants were at Northeast Cape, they divided the area into 29 "sites". Some of these sites have never been tested for contaminants, on the basis that they "looked all right". A review of which sites have been sampled for what toxins is provided in Appendix D (Contaminant Testing in Soil) and Appendix E (Contaminants Testing in Water).

For many years, the COE only tested soil and water for pollutants. Food samples – from fish, plants, and quyngiq-- have only been analyzed since 1999.

The primary pollutants found thus far at Northeast Cape are oil residues, PCBs, and some heavy metals. No radiation, has been found, and only minimal amounts of pesticides. Although there is evidence munitions were stored at Northeast Cape, no samples have been analyzed for chemical explosives or for traces of chemical warfare materials. If a lab does not specifically look for a contaminant, like chemicals from explosives, when it tests soil samples, no one will know if those chemicals are in the soil or not.

A. Oil and Petroleum Residues

1. What are Oil and Petroleum Residues?

"Petroleum products" are gas, oil, diesel, and any fuel or lubricant created from crude oil. "Petroleum Residues" could be actual sheens of fuel/lubricants or groups of hydrocarbon molecules that once made up petroleum products (see Figure 1: "Molecular Structure of Hydrocarbons"). While the term "petroleum" is more correct, because it includes lubricants and all petroleum based materials, I prefer to use the term "oil" because it is easier for most of us to picture. In this report, whenever the term "oil" is used, it refers to mineral based oils, like crude oil, not to vegetable oils.

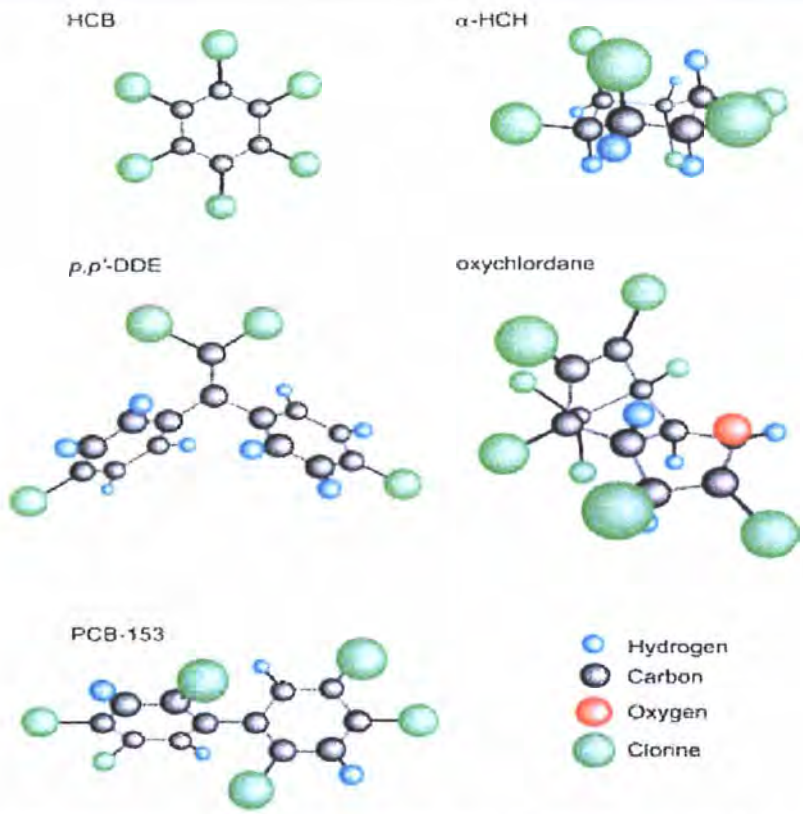
Oil/petroleum is made of plants and animals that died hundreds of millions of years ago. When a dead plant or animal transforms into fossil fuel, it becomes chains and rings of hydrogen and carbon atoms. When we make gas or diesel, we are keeping similar sizes of molecules together. Gasoline is mostly chains and rings of molecules with six to ten carbons. Diesel is chains and rings of molecules with ten to twenty five carbons. Labs refer to these as "Gasoline Range Organics" (GRO) and "Diesel Range Organics" (DRO). These are terms that are commonly used in government and lab reports.

[8] Now Montgomery Watson Harza (MWH)

There are several more terms and acronyms that are used. It is not important to know or understand these terms unless you are reading reports that use them.

Chains of hydrocarbons are called the "aliphatic" portion of petroleum, while rings are the "aromatic" portion. Aliphatics are further classified into alkanes, alkenes, and alkynes depending on the kinds of bonds holding the chain together. Aromatics (which have distinct and pleasant smells like glue or paint) are further classified into "light aromatics" and "heavy aromatics". An aromatic chemical with 2 – 4 rings it is called a "light aromatic"; 5 – 7+ rings makes it a "heavy aromatic".

Other terms that are used are "Volatile Organic Compound" or VOC – these usually have 1 – 2 rings and evaporate easily. "BTEX" refers to benzene, toluene, ethylbenzene, and xylene; these all have one ring and have similar chemical properties. Although the terms VOC and BTEX may sound exotic, they are actually chemicals that are found in very common items, such as glue, paint, paint thinner, marking pens, and so forth. "Polycyclic Aromatic Hydrocarbons" or PAHs sometimes refer to any aromatic, and sometimes refer only to aromatics with 3 or more rings.



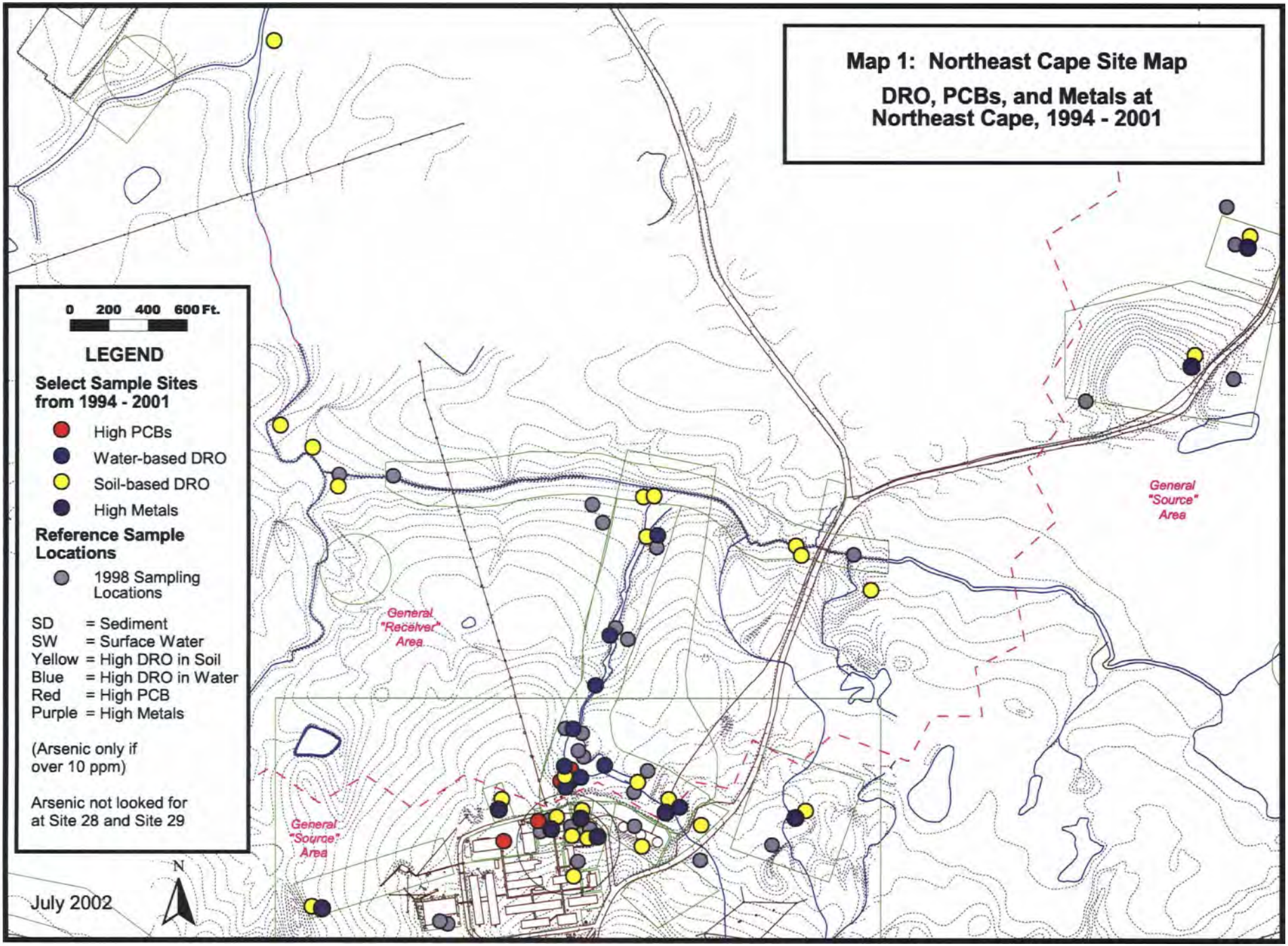
Shown are HCB (hexachlorobenzene, a pesticide), α-HCH (alpha-hexachlorohexane, a pesticide), p,p-DDE (a metabolite of the pesticide DDT), oxychlordane (a metabolite of the pesticide chlordane), and PCB 153 (a PCB congener).

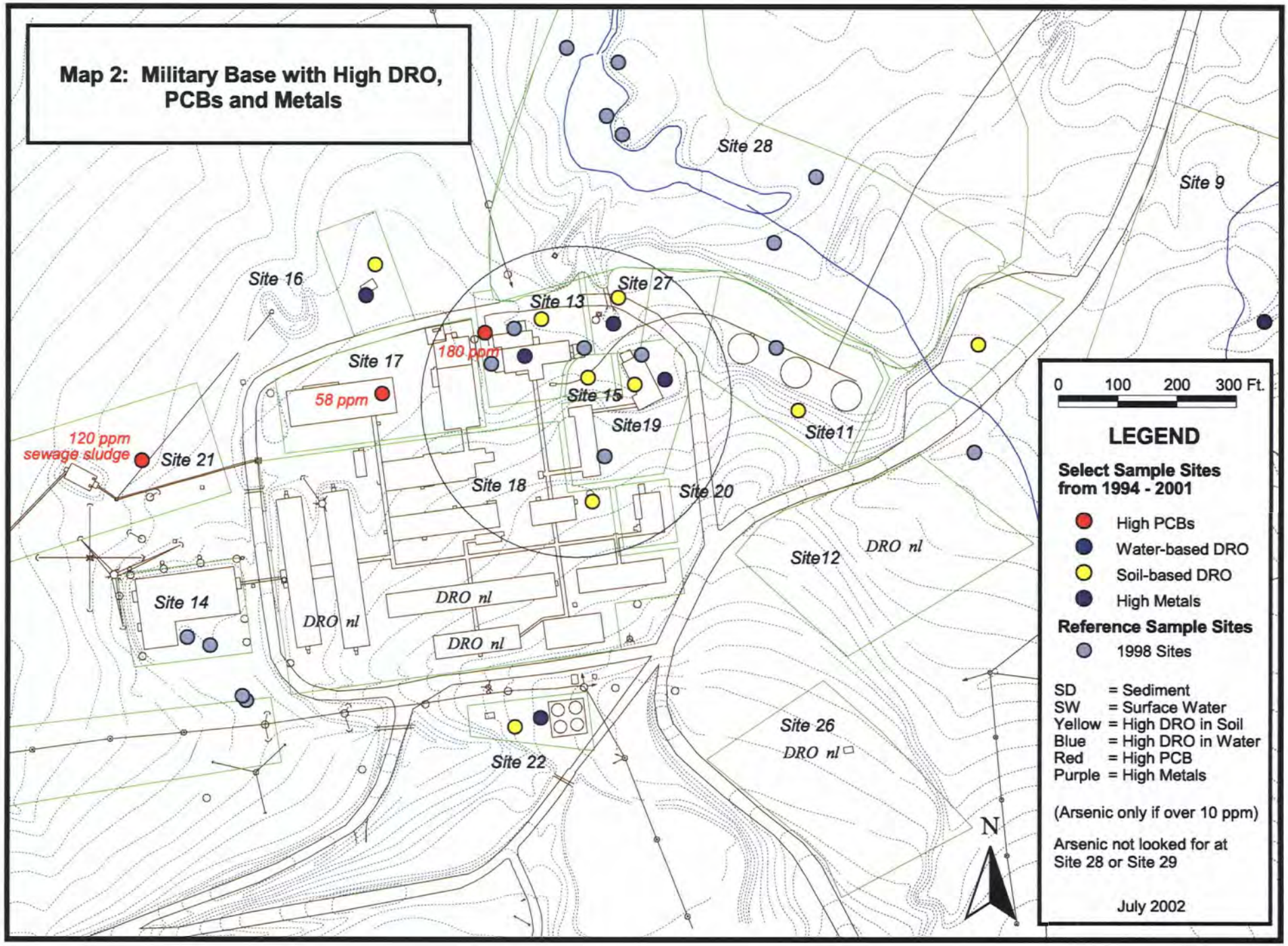
Figure 1: Molecular Structure of Hydrocarbon Molecules

2. Sources of Oil Contamination

The same hydrocarbon molecules that make up petroleum also occur naturally. If soil and oil have the same kinds of hydrocarbons in them, how can we tell if oil has been spilled?

To determine if there is oil in soil or water, tests analyze how many carbons are in the molecule. This is not a precise science, but if tests show lots of molecules with six to twenty five carbons, then it is very likely that gas or diesel has been spilled


Map 1: Northeast Cape Site Map
DRO, PCBs, and Metals at Northeast Cape, 1994 - 2001
0 200 400 600 Ft.
LEGEND
Select Sample Sites from 1994 - 2001
High PCBs
Water-based DRO
Soil-based DRO
High Metals
Reference Sample Locations
1998 Sampling Locations
SD = Sediment
SW = Surface Water
Yellow = High DRO in Soil
Blue = High DRO in Water
Red = High PCB
Purple = High Metals
(Arsenic only if over 10 ppm)
Arsenic not looked for at Site 28 and Site 29
General "Receiver" Area
General "Source" Area
General "Source" Area
N
July 2002


Map 2: Military Base with High DRO, PCBs and Metals
Site 28
Site 9
Site 16
Site 27
Site 13
180 ppm
Site 17
58 ppm
Site 15
Site19
Site11
120 ppm
sewage sludge
Site 21
Site 18
Site 20
Site12
DRO nl
Site 14
DRO nl
DRO nl
DRO nl
Site 26
DRO nl
Site 22
N
0 100 200 300 Ft.
LEGEND
Select Sample Sites from 1994 - 2001
High PCBs
Water-based DRO
Soil-based DRO
High Metals
Reference Sample Sites
1998 Sites
SD = Sediment
SW = Surface Water
Yellow = High DRO in Soil
Blue = High DRO in Water
Red = High PCB
Purple = High Metals
(Arsenic only if over 10 ppm)
Arsenic not looked for at Site 28 or Site 29
July 2002

At Northeast Cape, virtually every site had high to extremely high DRO or GRO, indicating that many areas of soil and water had been contaminated with petroleum products. The Suqitughneq River drainage had high DRO in virtually every soil and water sample tested, which is not surprising since oil sheens were seen in the drainage. Oil sheens can be from natural animal or vegetable sources, or from petroleum spills.
There are two important pieces of information we need to know from this.

1. Can we identify the sources of oil, so they can be removed?
2. Is the oil affecting plants, animals, or people?

There is no *single source* that can simply be removed to stop ongoing contamination. Spills occurred at several places, and leaking drums have contaminated several areas. Decades of rains, wind, and occasional floods have moved oil. In addition, studies show that plants contain some oil chemicals that have not been found at all in the localized military area; there may be a combination of local and global pollution.

3. Oil in the Environment

It is well known that at least one major diesel spill (160,000 gallons in 1969) and some smaller spills occurred in the military area of Northeast Cape. In addition, tons of 55 gallon drums, filled with a variety of petroleum – based oils and lubricants (called "POL" barrels), have been buried or were left lying on the tundra. Many of these are empty, but some have been found full or partly full and leaking. In the summer of 1999, northern phalaropes could be seen swimming through oil sheens still contaminating tundra ponds.

Although contractors began removing drums in 2000, only surface piles of drums were removed. During ACAT's visit to Northeast Cape in September 2001, partly crushed barrels jutted out from the Cargo Beach road, and some still lay in tributaries of the Suqi River. Unknown numbers of barrels and their contents may still be buried.

Not only does oil contamination still exist at Northeast Cape, oil is moving around in soil and water., and dust carries it onto plants. It is migrating out of the military compound into surrounding wetlands.

Figure 2: List of Sites at Northeast Cape

Site 1	Burn area southeast of Airport Landing Strip
Site 2	Airport
Site 3	Fuel Line Corridor and Pumphouse
Site 4	Subsistence Camp
Site 5	Cargo Beach
Site 6	Cargo Beach Road Drum Field
Site 7	Cargo Beach Road Landfill
Site 8	POL Spill Site
Site 9	Housing and Operations Landfill
Site 10	Buried Drum Field
Site 11	Fuel Storage Tank Area
Site 12	Main Operations Complex: Gasoline Tank Area
Site 13	Main Operations Complex: Electrical Power Building
Site 14	Main Operations Complex: Emergency Power Building
Site 15	Main Operations Complex: Buried Fuel Line Spill Area
Site 16	Main Operations Complex: Paint and Dope Storage Building
Site 17	Main Operations Complex: Supply Warehouse
Site 18	Main Operations Complex: Housing and Squadron Headquarters
Site 19	Main Operations Complex: Auto Maintenance
Site 20	Aircraft Control and Warning Facility
Site 21	Wastewater Treatment Facility
Site 22	Water Wells and Water Supply Building
Site 23	Power Line Corridor
Site 24	Receiver Building Area
Site 25	Direction Finder Area
Site 26	Former Construction Camp Area
Site 27	Main Operations Complex: Diesel Fuel Pump Island
Site 28	Suqitughneq River Drainage Basin
Site 29	Suqitughneq River

When oil is spilled onto *soil*, soil absorbs chains of hydrocarbons and heavy and light rings of PAH aromatics. When oil is spilled into *water*, heavy aromatics sinks to the bottom and stay stuck to river sediment, and only light aromatics will be found dissolved in the water itself.

Military soils had heavy aromatics, with only a few light aromatics, while Suqi River soils had more light than heavy ones. Heavy molecules tend to stay where they are and light ones move easily, indicating that the source of oil was the military site (where the heavy ones stayed) and light molecules moved downstream/downwind into the Suqi area. Heavy aromatics in the Suqi may indicate spots where barrels were dumped or leaked.

In general, DRO and PAH levels were much higher in the Suqi drainage than at the main military complex, again suggesting that contaminants have been migrating out of the military area into surrounding wetlands.

The kinds of PAHs being found in the drainage change, too. Halfway down the drainage, one soil sample in 2001 showed double the concentration of light aromatics seen in 1999. Another showed between 5x and 50x the levels of light aromatics seen in 1999. In both cases, the heavy aromatics seen in 1999 were not present.

How can the heavy aromatics have "disappeared"? Sun and bacteria break them down, or floods move them to a different place. If a contaminant is moved to a different place, we call this "remobilization". Remobilization can happen when wind, rain, or floods move contaminants attached to dirt. During rains, a contaminant can become "soluble" when it is surrounded by water and moves away from dirt into water. Some contaminants move into water more easily (are more soluble) than others. Any action that disturbs soil or water, such as bulldozing, has the potential to cause contaminants to remobilize.

How can light aromatics have taken their place? By traveling on air and water currents, from either nearby or distant sources. This is especially apparent when we find some PAHs on plants that are not in the surrounding soil. The only way they could have gotten to the plants is if they were carried by wind or rain.

4. Oil and Health

DRO can be dangerous depending on the *shape* of the molecule. Molecules in chains (the aliphatic portion of DRO and GRO) normally are not a health risk. Of the molecules found in rings, VOCs and BTEX, with one or two rings, evaporate quickly. They are a health risk when they are breathed, but have mostly evaporated within a couple of hours. These are the chemicals that hurt people who sniff gas or "huff". They can be a concern to cleanup workers, who may uncover VOCs trapped under the soil and may breathe them as they evaporate. They do not biomagnify in foods.

Molecules with more rings, the PAHs persist longer, and **can be** dangerous to animals and people over a period of years. Toxicity of a PAH molecule increases with each additional ring. They disrupt endocrine systems, and cause liver problems and cancer. If a fetus is exposed (through the mother), PAHs actually glue themselves onto the child's chromosomes, resulting in decreased birth weights[9]. When fish eggs are exposed to low levels of large PAHs in weathered oil, smaller fish result[10]. When ocean bottom sediment in Russia was studied, plants and animals on the ocean floor where PAH was elevated were found to be in a depressed state compared to surrounding areas: there were fewer species, and less numbers of each species[11]. The same was observed in the Suqi river, where downstream benthic communities (plants and animals on the stream floor) were found to be depressed compared to communities upstream of the confluence of the drainage[12].

The regulatory levels are listed in Appendix B ("Regulatory Levels of Contaminants"). Petroleum that has just been spilled is dangerous in the first several hours because of the small ring molecules, which can cause nerve damage; petroleum that has "weathered" (that is, was spilled months or years previously and exposed to air and rain) is dangerous because these larger, more toxic molecules cause severe health problems.

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[9] Steingraber 2001
[10] Rice et al 1999
[11] Petrova and Kiiko 2002
[12] Houston et al 1999

PAHs can move into plant and animal tissues, although they usually **do not** accumulate (see box "What are POPs" and "Bioaccumulation"). Instead, our bodies are able to *metabolize* them. If we *breathe* them at high levels we may increase our risk for cancer and alter the endocrine system. We breathe PAHs every day. The cancer-causing PAH benzo(a)pyrene is found in cigarette smoke, smoked fish, and exhaust from cars and 4-wheelers. The PAHs in air pollution may be the reason for decreased birth weights, body length, and head circumferences of newborns in highly polluted areas[13]. *Eating* a lot of foods with high levels of some PAHs (smoked fish, barbecued foods) may cause liver, kidney or stomach problems, but is not likely to cause cancer[14].

When Northeast Cape sites were analyzed, soil and water were high in DRO *but none were high in PAH*. Some levels *look* high, especially in Suqi drainage soils, but none are anywhere near the levels that require regulation[15]. This indicates that it is unlikely that oil residues remaining at the military complex are causing human health problems. However, new studies show that weathered oil can be dangerous in much smaller quantities than fresh oil and current regulations may be set too high[16]. In addition, people working for the military may have been exposed to high PAH during the oil spill in 1969 or from working around solvents. Past exposure may affect health years later.

What Does "Metabolizing" Mean?

When you eat a piece of food, your body breaks it into smaller parts physically as you chew and as your stomach churns. You also break it down chemically. A piece of meat is made up of molecules of fats and proteins. Chemicals in your body separate the fats from the proteins, and then break the proteins down into even smaller pieces called amino acids. Your body can use amino acids to make new proteins that a blood or skin or nerve cell needs. This process of breaking things down is called "metabolism". It's sort of like recycling.

When you eat something your body can't use, like grass, or toxins inside the meat, it separates those out, too. Chemicals will break them down into smaller pieces and try to get rid of them. This process of breaking toxins down is also called metabolism. The body will try to send things it can't use to the kidney (and out of the body in urine) or to the liver (and out of the body in feces), or to the lungs (and out of the body on the breath), or to the skin (and out through sweat). Sometimes toxins get broken down, but attach to fat or an organ and don't leave.

PAHs were found in low amounts in nunivagseghat and quyngiq -- low enough that it is unlikely they are causing problems. They were not found in water in the Suqi river or drainage; however, detection limits were set at around 10 ppb while as little as 1 ppb have been known to harm fish eggs. ACAT will sample Suqi water low levels of PAHs.

5. Cleaning up Oil Contamination

If animals are not continually being polluted, they will metabolize contaminants and eventually get rid of (eliminate) them. Higher organisms, like humans, are especially able to metabolize PAHs.

If the landfills, drum fields, power plant, and auto maintenance building, which are the sources of PAHs, are removed by the COE, the level of contaminants in the wetlands should eventually decrease and disappear as water flushes through soil, and as sun and bacteria break down pollutants.

Contaminated soil can be removed from the island, or it can be "remediated". Some ways to remediate soil:

- pile the contaminated soil in one spot and heat it, leaving clean soil.
- Put fertilizer on the contaminated spots so bacteria will break the oil down faster.
- Use a method called "peroxidation"

Other remediation methods are also available.

The gravel and soils that the buildings sit on may also need to be removed or remediated, since pads may be contaminated and represent potential for future contamination. It is necessary to be careful when these areas are remediated, to ensure that contaminants still on these sites do not *remobilize* and move downstream, where they may end up concentrating in a few areas, re-polluting them.

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[13] Sandra Steingraber, pg 186 of "Having Faith", discussing research by Frederica Perera of Columbia University.
[14] ATSDR, the Agency for Toxic Substances and Disease Registry, a federal agency under the Environmental Protection Agency (EPA).
[15] No samples were tested for PAH from Sites 13, 15, 19.
[16] Rice et al 1999;

B. PCBs

1. What are PCBs?

"PCB" is short for polychlorinated biphenyls. These are chemicals that are no longer produced in the U.S. but were commonly used as lubricants in hydraulic fluid, transmission oil, and in electrical transformers, as well as in carbon paper and light ballasts. PCBs are still made in some countries.

PCBs are one of the *persistent organic pollutants*, chemicals that stay in the environment for a long time and travel long distances. Because they move, we do not know automatically whether PCBs we find in soil, water, plants, animals, and people originated from somewhere close by or from very far away. Congener analysis helps determine this.

The terms "Aroclors" and "Congeners" are often used when talking about PCBs. *Congeners* refer to specific chemical compounds. There are 209 different compounds that are all PCBs, but which have slightly different structures. *Aroclor*s were industrial mixtures of many congeners; Aroclor 1254 was a mix that had 54% chlorine, Aroclor 1248 had 48% chlorine, etc.

PCBs are of greater concern than PAHs because they *do* biomagnify. Biomagnification is the process by which an animal gathers up all the pollutants eaten by all the plants and animals it eats. (See Figure 2 "Food Web"). Pollutants are thus passed up through the food chain, so that the animals highest on the food chain are exposed to the greatest concentration of PCBs.

2. Sources of PCBs

PCBs were not found all over Northeast Cape, the way DRO was (See Map 2 "Northeast Cape sites with high DRO, PCBs, and metals). They were found in high amounts in a couple of soil and water samples, and in fish and plants. However, many areas were never tested for PCBs.

We know that Sites 13 and 17 have PCB contamination. There is reason to suspect that Site 19, the auto maintenance building, may have PCBs, but it has not been tested. If you don't test for it, you can't find it!

Other sites not tested include: burn site near landing strip (site 1), POL spill site (site 8), gas tank area (site 12), buried fuel line spill area (site 15), squad headquarters (site 18), aircraft control building (site 20), former construction camp (site 26), and diesel fuel pump island (site 27).

Again, we want to look at two questions:

1. Can we identify the sources of PCB, so they can be removed?
2. Are PCBs affecting plants, animals, or people?

First we need to know whether the PCBs are originating from global or from local sources. We can determine this by looking at the "congener pattern". Local source PCBs at Northeast Cape (transformer fluids and lube oil) will contain different amounts of congeners than global sources. By doing specific tests, we can see how much of each congener is in a sample of soil, water, blood, plant tissue, muscle, etc. This pattern is called a "fingerprint". If we find congeners that indicate several industrial Aroclor types, this would indicate more than just a local source.

PCBs at Northeast Cape

Power Plant (site 13)	soil, (only one water sample taken)
Supply Warehouse (site 17)	soil and water
Wastewater Plant (site 21)	sewage sludge
Suqi River drainage (site 28)	water

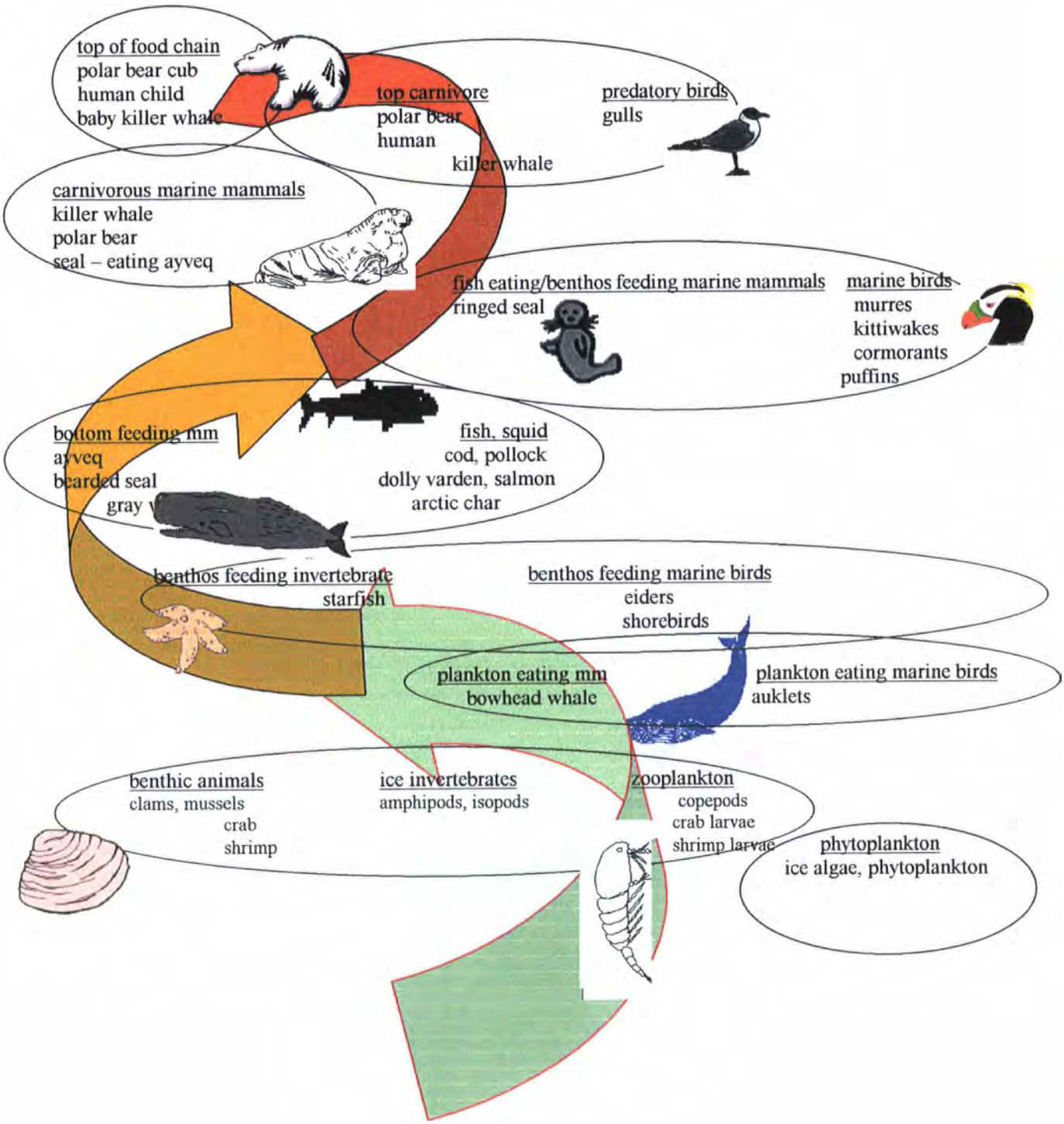
Not tested: Sites 1, 8, 12, 15, 18, 19, 20, 26, 27.

3. PCBs in the Environment

In the first soil sampling and analysis done (1985), no high levels of PCBs were found, although low levels were found near the fuel storage tanks, at the power building, and downstream of the culvert near the power building. More testing

Figure 3; Food Chain and Trophic Levels

Trophic levels increase as you move from the bottom of the page to the top. Due to biomagnification, a small amount of contaminant in an animal low on the trophic level can build up to dangerous levels in higher trophic levels. This is indicated by the arrow that changes colors.



adapted from Paul Becker in "Characterization of the Arctic Environment:" at Workshop on Arctic Contamination May 1993, Anchorage, AK

(1994 – 1999) verified elevated levels of PCBs in soil at the power building (site 13) and supply warehouse (site 17), but again, none were seen in water samples. Yet in 2000, one water sample from the Supply Warehouse and two water samples from the Suqi drainage were higher than allowable standards set by the Alaska Department of Environmental Conservation (DEC).

These results indicate that PCBs probably *are* moving through the soil and water. PCBs *never* occur naturally. Since high levels were not seen in water previously, these PCBs are probably not coming from a global source, but moving out of the military complex into the Suqi. Sampling in 2001 also indicates that PCBs are being blown onto plants. The recent activity associated with remediating the area is likely remobilizing PCBs.

4. PCBs and Health

In industrial accidents, PCBs discolor nails and skin, cause a rash called "chloracne", cause chronic bronchitis, and may cause jaundice, vomiting/nausea, fatigue, and abdominal pains. They affect the reproductive system and thyroid, damage the immune and nervous system, and damage livers and kidneys in adults. Infants exposed prenatally tend to have a higher incidence of upper respiratory tract infections. It is possible that if a mother is exposed, her baby may be small and have a small head. PCBs affect the mental and physical development of children. Some kinds of PCBs are suspected of causing cancers in the liver, skin, and intestines.

People are exposed to PCBs through contaminated food and direct contact. People who worked for the military in the 1950s may have had direct contact with PCBs while working with machine lubricants or electrical fluids.

The following food from Northeast Cape has been tested for PCBs: plants, fish (dolly varden, blackfish, pink salmon, sticklebacks), quyngiq (who may roam through the Northeast Cape area). Levels of PCBs in these foods are discussed in Section II "Local Pollution Effects on Plants and Animals" and "Section XII Human Health".

5. Cleaning up PCB Contamination

Sites 13 (Electrical Power building) and 17 (Supply Warehouse) have PCB contamination, and we have reason to suspect that Site 19 (Auto Shop) does. The auto shop sits right next to the Electrical Power building. Directly across the road from these two buildings is a culvert that flushes foul smelling water into the Suqi drainage. Although PCBs have no smell, soil, gravel, and groundwater around the Power and Auto Maintenance buildings need to be sampled and analyzed after the buildings are demolished to look for a PCB source. Soil and gravel will likely need to be excavated. In addition, there were at least six drains in the Auto Maintenance building. It is assumed that they empty into the main culvert and go from there into the Suqi drainage. There is no evidence that the drains have been followed to verify where they went, but it is likely that they flowed into the drainage.

Sewage sludge in the wastewater treatment tanks at Site 21 was also high in PCBs. The sludge needs to be removed, as well as the pipes going in and out of tanks. Holding tanks need to be cleaned or removed. Soil from underneath pipes and the holding tanks must be tested **before** the area is backfilled and declared clean.

The COE needs to do a more thorough examination of ground and surface water draining from the main military operations complex to zero in on the source of PCBs, and track how it is getting into the Suqi drainage. Demolition work needs to proceed carefully to minimize remobilization of PCBs; recent plant and water samples with PCB levels not seen previously indicate that remobilization is occurring.

C. Pesticides

Low levels of pesticides were found in soil, water, and quyngiq. Organophosphate pesticides have not been looked for. Plants and fish have not been tested for pesticides.

1. What are Pesticides?

"Pesticides" refers to chemicals specifically made to kill unwanted plants and animals such as insects, beetles, rats, ants, weeds, fungi, and so forth. They are used in huge quantities on crops such as corn, rice, wheat, cotton, and more. The term "-cide" means "to kill". "Pest – icide" means to kill a pest. We can be specific about what we are trying to kill by using various terms:

"insect – icide"	a poison made to kill insects (mosquitoes, flies, gnats, etc)
"rodent – icide"	a poison made to kill rodents (rats, mice, voles, shrews)
"herb – icide"	a poison made to kill plants (weeds)
"fung – icide"	a poison made to kill fungi (some fungi kill crop plants)

Many pesticides are POPs because they do not break down easily and can travel around the globe.

2. Sources of Pesticides

Pesticides come from both local and global sources. Military personnel sprayed bases with pesticides to kill mosquitoes; the Alaska Railroad sprayed along railroad tracks to kill plants. But pesticides can show up in the Arctic even if no one in the area has used mosquito-killing chemicals. All countries around the world use pesticides when they are growing crops. In the US, crop-dusting planes are often used to apply pesticides to huge agricultural farms. When the chemical is released from the plane, much of it travels into the air and gets into streams and lakes near the farm; it is estimated that often as less than 1% of the pesticide actually gets to the pest it is aimed at.[17] Whether pesticides are sprayed by plane or by workers carrying spray tanks on their backs, many of these chemicals rise up into the air and travel on prevailing winds to the Arctic and Antarctic.

Some pesticides-- like DDT, aldrin, dieldrin, chlordane, and heptachlor-- are banned or severely restricted in the US and many other nations, but continue to be used in some countries. DDT is still used in Africa to kill mosquitoes because mosquitoes carry malaria.

Because some countries continue to use DDT, and wind and water carry it to the Arctic, DDT continues to be found in arctic marine mammals. DDT and the toxic chemicals it breaks down into (DDE and DDD) are also found in humans throughout the world, and in the breast milk of women worldwide.

Figure 4: Half lives of new generation pesticides in cold water (39 or 43^{0}F)

Atrazine, 39^0	no degradation after 60 days
Azinphos-methyl, 39^0	no degradation after 60 days
Chlorpyrifos, 39^0	27 days
Cyprazine, 39^0	260 days
Diazinon, 39^0	125 days
Diazinon, 43^0	45 days
Dimethoate, 39^0	142 days
Dimethoate, 43^0	219 days
Ethion , 39^0	84 days
Fenitrothion, 43^0	224 days
Fensufothion, 39^0	82 days
Isofenfos, 43^0	224 days
Malathion, 43^0	41 days
Methadithion, 39^0	139 days
Mevinphos, 39^0	150 days
Ethyl parathion, 43^0	542 days
Methyl parathion, 43^0	233 days
Phosmet, 39^0	4 days
Terbufos, 39^0	34 days

CACAP p 157

3. Pesticides and Health

Pesticides were found at low levels at Northeast Cape, however, phosphate pesticides were not looked for.

Soil, water, plants, and animals were tested for pesticides, because pesticides are a real health problem if found in certain amounts. If a poison is made to kill insects, it does not kill only insects: if your child or your dog eats rat poison, it will kill your child or your dog. A poison is a poison. Anything that ends in "-icide" will harm you if you eat enough of it; it will harm plants and animals if they absorb or eat enough. In large doses, many will cause immediate poisoning. In lesser amounts, pesticides can harm your liver, kidneys, nerves, hormone systems, and immune systems. They can cause developmental problems in children. They may be linked to many kinds of cancers: breast cancer, leukemia, prostate cancer, ovarian cancer, liver and kidney cancers.

Pesticides were only found in extremely small amounts in the soil of Northeast Cape. They were found in small amounts in quyngiq, fish, and plants (see Section II: Local Pollution Effects on Plants and Animals). They are not considered a health risk right now, although phosphate pesticides need to be looked for.

[17] Steingraber, p 179

D. Toxic Metals

1. When are Metals Toxic?

We are all familiar with metals: iron, gold, lead, silver. There are many metals that we need in very small amounts (trace minerals): magnesium, zinc, copper, calcium, and others. Metals become toxic and pose a health threat when a plant, animal or person gets too much of the metals it needs, or when they absorb metals the body cannot use. Sources are natural metals or manufactured products that contain metals, like lead paint.

Metals that a person's body does not need at all – like lead, mercury, and arsenic – are hard for the body to detoxify and eliminate (through urine or feces) because the body has no cellular or molecular systems for dealing with the metal. On the other hand, because our bodies *need* metals like zinc, cells in the body have come up with ways of dealing with excessive amounts. First it will "package" excess into feces or urine and eliminate the metal from the body. If there is so much that the body can't use it and can't eliminate it, it will store excess in "compartments" like organs or bone. Then, later, it will try to pull them out of these "compartments" and use or eliminate them. Metals become toxic when a person is exposed to so much that the body is forced to store large amounts in organs, which eventually harm the organ (usually kidneys or liver). Metals are also toxic when one metal "competes" for a spot designed for another in the body.

How much of a metal is a "toxic" amount depends on many different factors.

- Whether the metal is "bioavailable", that is, is it in a form that a body can take up.
- Every species tends to have different abilities for absorbing and eliminating minerals. Scoters (a kind of sea duck) and ayveq accumulate cadmium, but herring gulls, polar bears, and seals do not.
- Individuals can have different ability to detoxify excess metals, depending on their own physical health. If a person's diet has plenty of the minerals the body needs in small amounts, it won't absorb much lead from plants eaten. If they are low on these minerals, they will absorb more lead, especially into bone. Since bone needs minerals, if the right ones are not available, it will grab any metal that is around.
- What organ the metal is stored in can affect the health of an animal. For example, in domestic animals, it takes less mercury to damage the liver than to damage the kidney.
- High levels of a metal does <u>not</u> necessarily mean the metal is harming the animal. For instance, birds with high levels of cadmium often also have high levels of selenium, which is a metal that detoxifies cadmium. High levels of mercury can be offset by zinc. It is possible that animals chronically exposed to a certain metal (like cadmium in the arctic) develop methods for detoxifying.
- A metal in an "organic" form is not toxic when eaten; a metal in an inorganic form might be.
- Plant uptake varies with the pH of the soil around it, what other metals are interacting, and other factors.

<u>Total and Dissolved Metals</u>
Total metals are usually attached to soil particles (dust, river bottom sediment). Dissolved metals are too tiny to see, and are free floating in water (they don't sink). Usually dissolved metals are considered to be more bioavailable than total metals, although this is not always true.

These factors make it difficult to say for certain whether elevated levels of metal found in an animal or plant will

1. Affect the plant or animal.
2. Affect a person eating the plant or animal.

At the military site, high levels of chromium, arsenic, cadmium, nickel, and beryllium, and occasionally high levels of lead, zinc, and mercury have been identified. Some water samples had elevated chromium, arsenic, cadmium, nickel, beryllium, lead, and zinc. High levels of *dissolved* lead and *dissolved* zinc were found in one water sample in the drainage.

Again,

1. Can we identify the sources of toxic metals, so they can be removed?
2. Are toxic metals affecting plants, animals, or people?

2. Sources of Metals

Soil at Northeast Cape is naturally high in metals. A survey by the USGS in 1976 showed that copper, lead, zinc, chromium, silver, and molybdenum were common to Northeast Cape, with tin, beryllium, and boron at the Tapisaghak (Tapi) River. They were looking for minerals to be mined, and did not test for trace amounts.[18]

[18] personal communication William Patton, 2001

Although metals occasionally exceeded state-recommended limits at the military base and in the Suqi drainage, they usually did not exceed by much and/or very often. Mercury was found to be high only rarely, but because it has such a potential to affect health, any high levels of mercury are a concern.

Chromium and arsenic were the only metals consistently found at elevated levels. *Every soil sample* at the military site, and *virtually all water samples*, were above the EPA (US Environmental Protection Agency) recommended levels for arsenic. DEC recommends that soil have no more than 2 parts per million (ppm), but natural background levels of arsenic throughout the state of Alaska are often as high as 10 ppm (See Appendix A "Understanding Very Small Numbers" for explanation of parts per million, ppm). This makes it difficult to tell if elevated arsenic in samples is natural in origin or whether it comes from a military source. What would the military be doing with arsenic? Arsenic is found in some pesticides and some chemical warfare materials.

At Northeast Cape, the highest levels were found at the outfall of the wastewater pipe at Site 21 in 1998 tests. Every single soil sample tested high in arsenic, with one sample as high as 170 ppm. Water had elevated levels of arsenic, lead, zinc, chromium, and nickel. During 2001 tests, no elevated arsenic levels were found in the soil. However, the final report on the 2001 tests is not published yet and it is possible that detection and reporting limits were set higher in 2001 testing than in previous tests.

In the Suqi drainage area, *no* soil samples were tested for arsenic. Only one water sample from the drainage area was tested, and did have elevated levels of arsenic.

Water from the Suqi River, tested for the first time in 2001, did not have high levels of any metals.

The consistently high levels of arsenic in soil and water at the military site are concerning, because

1. Background samples did not show definitely that natural levels of arsenic in soil were high.
   Eight background soil/tundra samples were tested, and two background water samples. Two of the eight soil samples were taken from areas that may have been contaminated (gravel pit, road); only these two had arsenic above the recommended limit. All the other samples were low. In background water samples, no arsenic was detected.
2. If arsenic turns out to be naturally high in soil, this is even more worrisome than if the military is the source, indicating that high arsenic is found over a much larger area.
3. Is it possible that elevated arsenic indicates the presence of chemical agents at Northeast Cape?

Indications that the arsenic is military in origin:

With most background soil and water samples being low in arsenic, and most soil and water samples from the military areas being high, it appears that the military may be the source. Vertical samples taken in 1999 showed that if arsenic was 10 ppm or less, levels remained the same at depth, but if samples were higher, levels decreased at depth,[19] indicating that arsenic has been "added to" the surface.

Indications that the arsenic is natural in origin:

Geologically, arsenic is often found with lead and zinc, and at Northeast Cape, every time arsenic was found, lead and zinc were found also. Arsenic is commonly found at elevated levels throughout Alaska.

It is likely that when arsenic exceeds 10 or 15 ppm, it is not natural.

Locations of Elevated Levels of Metals

Soil: Sites 2,5,7,9,16,19,21,22,24,29

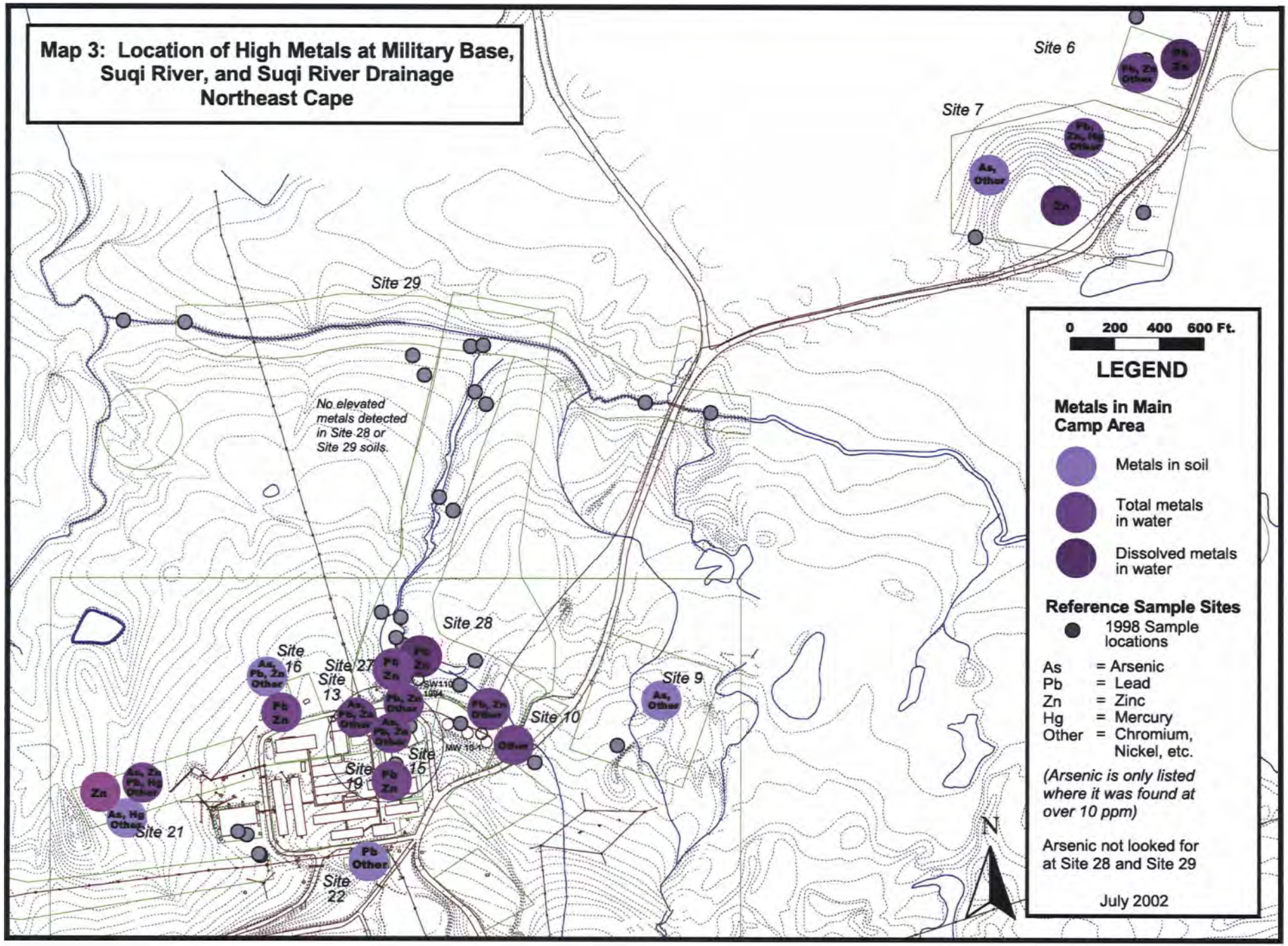
Water:

Site 6	dissolved lead
Site 7	dissolved zinc, mercury
Site 10	dissolved silver
Site 21	dissolved zinc
Site 25	dissolved zinc
Site 28	dissolved lead and zinc
Total arsenic:	site 7,9,13,15,21,27

3. Metals in the Environment

Unlike POPs, which are eventually degraded by bacteria, sunlight, and metabolism, metals never really leave. They are eliminated from an animal through feces, which go to the bottom of the creek or ocean and become part of the sediment, to be recycled through the food chain again.

[19] Montgomery Watson. March 1999. Vol 3,4. Samples MW 27-1, MW 21-2, MW19-1.


Map 3: Location of High Metals at Military Base, Suqi River, and Suqi River Drainage Northeast Cape
Site 6
Site 7
Site 29
No elevated metals detected in Site 28 or Site 29 soils.
Site 28
Site 16
Site 27
Site 13
Site 9
Site 10
Site 15
Site 19
Site 21
Site 22
0 200 400 600 Ft.
LEGEND
Metals in Main Camp Area
Metals in soil
Total metals in water
Dissolved metals in water
Reference Sample Sites
1998 Sample locations
As = Arsenic
Pb = Lead
Zn = Zinc
Hg = Mercury
Other = Chromium, Nickel, etc.
(Arsenic is only listed where it was found at over 10 ppm)
Arsenic not looked for at Site 28 and Site 29
July 2002
N

Unlike POPs, which magnify in concentration with increasing trophic levels, metal concentrations usually *decrease* with increasing trophic levels. Toxic effects of POPs will be seen first at high trophic levels (polar bears, humans), but toxic effects of *metals* will be seen first at the lowest trophic levels (zooplankton, shellfish, plants).

Dissolved lead, zinc, mercury, and silver were seen in water samples at military sites; dissolved lead and zinc were seen in one water sample from the Suqi drainage. No dissolved arsenic was found. It is unusual to have high arsenic in soil while water that runs through it has none. The soil pH may cause arsenic to bind to soil and not dissolve in water.[20] *Total* arsenic was at excessive levels in water at several military sites (7,9,13,15,21,27) and in the Suqi River drainage. None was found in Suqi River water. Arsenic in the water is dangerous because it is in the "inorganic" form (see information box "Fish and Arsenic").

Consistently high levels of arsenic in drinking water at Northeast Cape is very concerning. The State of Alaska recently changed its "safe" level of arsenic from 50 ppb to 10 ppb. Several water samples were above this.

How do chemicals interact?

The question of interactions of multiple contaminants, of contaminants with vitamins, and of one mineral with another is only just beginning to be studied.

For instance, birds with low levels of vitamin A are more susceptible to thyroid problems when exposed to PCBs, and new studies show the same may be true for human infants (Dallarie et al, 2002). In this case, a vitamin helps detoxify a contaminant.

The mineral selenium helps detoxify mercury. Arsenic detoxifies selenium. In these cases, one mineral makes a different mineral less toxic.

On the other hand, new studies show that if the contaminants HCB and p,p-DDE are mixed together, cells are damaged in several ways (Salmon et al 2002). Cell membranes can be damaged, and there are more breaks in DNA than is normal, which can lead to genetic problems. In this study, the interactions of two contaminants may be more toxic than if an infant is exposed to just one.

4. Toxic Metals and Health

Arsenic: Little is known about dangers *soil* high in arsenic might pose. In *water*, it can damage the liver, cause skin sores, and cause vascular disease[21]; very high levels can cause skin, lung and bladder cancer. Arsenic in water was over 10 ppb (state standard) at sites 7,9,13,15,21,27, and 28.

Mercury: Mercury poisons the nervous system, affects memory and vision, and can make a person insane. If an unborn child is exposed to mercury, it can damage their attention, memory, and language abilities. A certain form of mercury, called methylmercury, can accumulate through the food chain. No one has tested for methylmercury at Northeast Cape.

Lead: In fish, it can cause curved spines and eroded tail fins. In some birds, it can cause them to lay fewer eggs and become weak or uncoordinated. In humans, it can damage nerves and kidneys. In children, it is associated with learning problems.

Zinc: Although zinc is one of the metals our bodies needs in small amounts, excessive amounts can cause stomach cramps and nausea. Over time, it can damage the pancreas.

Chromium: Chromium is another metal that we need in small amounts. It comes in different forms, with "chromium VI" being more toxic than "chromium III". Breathing in lots of chromium VI can stimulate asthma attacks or allergic reaction, and eventually lead to lung cancer; ingesting (eating) excessive amounts can cause ulcers, convulsions, kidney and liver damage.

Cadmium: In birds, it can slow growth, thin eggshells, and damage the heart, kidneys, and testicles.

Selenium: In birds, it can cause reproductive failure and direct death to juveniles and adults.

Metals were found in plants and fish. Results are in Section II.

5. Cleaning up Metals Contamination

To humans, "metals" may be the "minerals" it needs. Plants need minerals, too. They absorb them from soil, and may concentrate them so much that the plant is unsafe to eat. However, plants taking up metals can provide a way for the ground to be remediated: metals move into plants, plants can be removed, and the ground will be clean. New, uncontaminated plants can then grow on clean soil. ACAT strongly encourages analysis of background soil samples away from roads. We encourage analyzing soil and water in the drainage for arsenic, sampling of Suqi River water during and after remediation, and sampling in the lagoon, where contaminants potentially could settle out and be available to benthic feeding birds and fish.

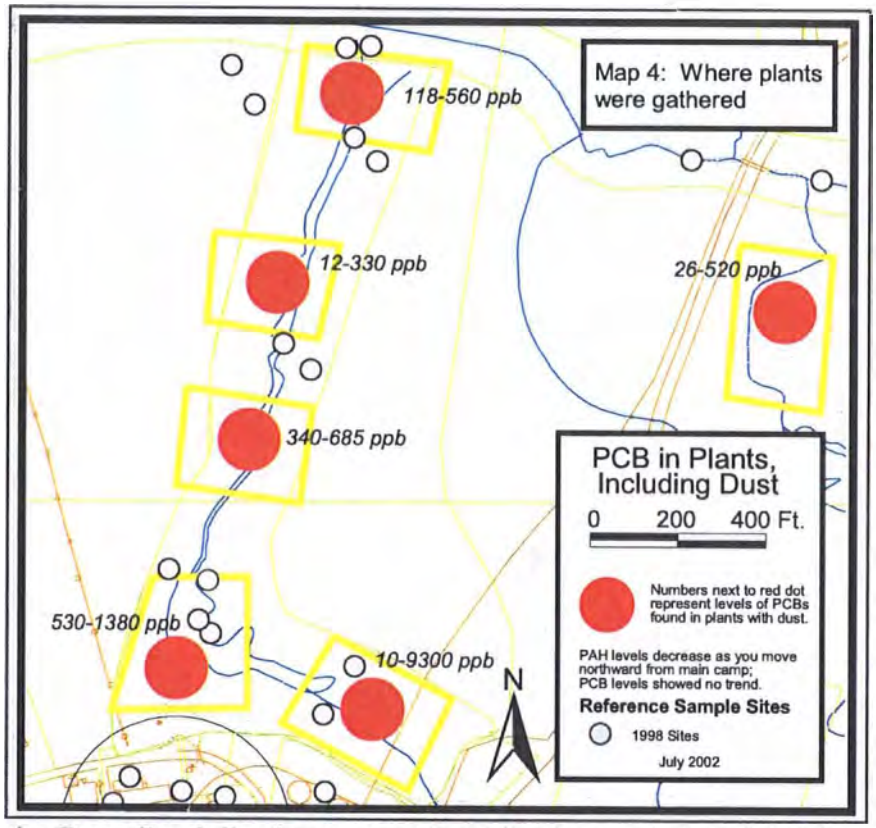
[20] Personal communication with James Weise of Alaska DEC.

II. Local Pollution Effects on Plants and Animals

We have seen how soil and water surrounding the military area of Northeast Cape contains a variety of contaminants. Some pollutants may come from global sources, but many originated with the military. The previous section looked at what contaminants are in the area and what their sources might be. This section is devoted to whether contaminants are high enough to harm plants and animals. Whether levels are high enough to affect people eating the plants and animals is discussed in Section XII "Human Health".

Our knowledge in this area is limited. Little is known about what happens when chemicals interact—some chemicals make others more toxic. For instance, new research shows that smoking causes a person to retain more contaminants.[22] No one knows what happens when a plant, animal, or egg is exposed to several contaminants at the same time; and little is known about how contaminants might be "de-toxified" by minerals or vitamins already in the plant, animal, or egg.

Not only does each species have a different ability to metabolize contaminants, each individual animal, plant, or person can be affected differently (see box on right).



A. Plants (nunivagseghat)

Plants were gathered by employees of Montgomery Watson, using the advice of local people, in the summer of 2001. Only preliminary data are available to review, and we will not know which species were gathered until August 2002. All species collected were ones that people or quyngiq eat. Five groups of plants were taken from the drainage and one from a "control" area near the upstream source of the Suqi.

All nunivagseghat were gathered from the drainage area or the uppermost part of the Suqi; no nunivagseghat were taken from the banks of the lower reaches of the Suqi or from the mouth of the river. No nunivagseghat from suitable background areas were tested; nunivagseghat gathered from next to the Cargo Beach Road were considered "background plants", but have been exposed to vehicle exhaust and road dust, making it difficult to compare whether PCBs on nunivagseghat are from global or local sources, or a combination.

1. Nunivagseghat and Petroleum Residues

Greens closest to the main housing complex had the most PAHs, compared to nunivagseghat collected further downstream. The further the nunivagseghat was from the main complex, the lower the level of PAHs it had. This indicates that the PAHs are almost certainly in dust that has blown away from the main complex.

It is interesting that the nunivagseghat near the fuel storage tanks had the highest PAH, since zero PAH had been found in the soil or water they grew in[23]. Yet nunivagseghat had both heavy and light PAHs

If virtually no soil around the nunivagseghat had PAHs in them, how were nunivagseghat contaminated?

[22] Deutch 2002

[23] except for one soil sample, which had very little PAH, mostly heavy aromatics

Demolition of the main complex during remediation is likely remobilizing PAH and PCB contaminants, allowing wind and dust to move them to the nunivagseghat, where they settle out. But if so, why are we seeing some light aromatic chemicals -- like acenaphthene, anthracene, and fluorene – in nearly all the nunivagseghat sampled, and in drainage soils, when these chemicals were not found anywhere at the military sites?

Some explanations may be:

1. Testing soils at military sites may have missed a source of light aromatics.
2. Contamination may be from both local (heavy and light aromatics from the military areas, remobilization of contaminants during remediation) and global (different light aromatics coming from far away on air currents)[24] sources.

a) Oil and Nunivagseghat Health

PAH in nunivagseghat are much lower than the regulatory levels for soil or water. It is unlikely that they are affecting nunivagseghat. Also, it may turn out that the PAHs found in nunivagseghat samples were primarily in dust that settled on the nunivagseghat. ACAT will collect nunivagseghat in summer 2002 and analyze both washed and unwashed nunivagseghat for contaminants.

2. Nunivagseghat and PCBs

The same nunivagseghat tested for PAHs were also tested for PCBs.

Unlike the PAH levels in nunivagseghat, which showed a general trend of increasing contamination the closer you got to the main complex, there is no trend for PCBs (see Figure 5: "Metals and PCBs In or On Plants from the Suqi River Drainage"). PCBs like to stay in fat cells. Nunivagseghat have very few fat (waxy) cells, so do not absorb PCBs as easily as animals. When ACAT collects nunivagseghat in summer 2002, they may find the PCBs are in dust particles on the leaves of nunivagseghat, not in the plants themselves. Some of the levels of nunivagseghat with dust had extremely high PCBs; others had low levels. Whether these levels of PCBs affect nunivagseghat is not known. Canadian studies found that nunivagseghat sometimes had lower PCB levels than the soil they grew in, indicating that some PCBs were not bioavailable or that the nunivagseghat lost PCBs through normal aging and growth. [25]

The source could be a mix of global and local. There are at least two local sources: the power plant and the supply warehouse. We suspect there may be PCB sources at the nearby White Alice site as well. However, we also know that PCBs are a global contaminant, found in air, soil, and water.

3. Nunivagseghat and Pesticides

Nunivagseghat have not been analyzed for pesticides.

4. Nunivagseghat and Metals

Nunivagseghat take minerals up from soil and water. They absorb the ones they need and heavy metals. Some nunivagseghat absorb metals so efficiently they are used to remediate soil. Absorption is different depending on nunivagseghat species, soil pH, and other factors.

Soil at the Northeast Cape military area has consistently high levels of arsenic and chromium, some of which is natural in origin. Lead, zinc, and a few other metals were also found in the soil, but not at consistently high levels. Because nunivagseghat can accumulate metals, they may have a higher concentration than soil.

Nunivagseghat from the Suqi River drainage area were tested for the following metals: arsenic, barium, chromium, cadmium, copper, lead, nickel, silver, vanadium, zinc, mercury, and selenium.

a) What metals are in nunivagseghat?

Arsenic, mercury, lead, and zinc were all found in nunivagseghat. How much was actually *in* the nunivagseghat and how much was in *dust* on the nunivagseghat is not known. Further sampling needs to distinguish metals *in* from those just *on* the nunivagseghat.

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[24] A Canadian study found four PAHs to be abundant in the high arctic of Canada: fluorene, phenanthrene, fluoranthene, and pyrene.

[25] CACAP pg 225

b) What are the sources of metals in nunivagseghat[26]?

Arsenic, lead, and zinc are metals commonly found in soils in Alaska. Mercury occasionally comes from volcanic eruptions. Natural soil may have levels of that exceed regulatory limits. However, metals can also come from man-made sources. Lead from dumped batteries or spills and combustion of leaded gasoline; mercury from waste incinerators, coal combustion, and steam generated electricity; zinc from chemical manufacturing, burning coal, and mining; arsenic from incineration, pesticides, and chemical warfare weapons.

5. Are Contaminants Affecting Nunivagseghat?

The main contaminants of concern at Northeast Cape are petroleum residues, PCBs, and metals.

Oil Residues: Nunivagseghat do not contain enough PAH to be of concern.

Pesticides: Nunivagseghat were not analyzed for pesticides.

PCBs: Some nunivagseghat had high levels of PCBs, others had low levels (see Figure 5 "Metals and PCBs in and on Plants in the Suqi River Drainage"). We need to know whether the PCBs are in the nunivagseghat itself, or just in dust on the plant.

Metals: Some nunivagseghat had high levels of metals; others had low levels. We need to know what level of metals is in dust on the nunivagseghat, which species are concentrating metals, and the extent of contamination. Are the metals from natural rock? Are the high away from the military base?

Figure 5: Metals and PCBs In or On Plants from the Suqi River Drainage[27] *(ppb)*

Plant sample	*Arsenic*	*Mercury*	*Lead*	*Zinc*	*PCBs*
PT1101	180	9	133	3510	118
PT1102	770	61	1300	30,600	560
PT2101	230	30	794	67,500	330
PT2102	0	5	160	**76,100**	12
PT3101	0	120	1310	15,800	340
PT3102	0	99	955	21,500	not looked for
PT3103	60	10	358	12,700	685
PT3104	2140	21	1200	7680	620
PT4101	120	8	6170	14,800	1380
PT4102	**2380**	17	2820	27,300	530
PT5101	1470	33	**11,300**	30,100	**9300**
PT5102	0	3	290	8470	187
PT5103	370	**160**	11,100	27,700	99
PT5104	290	14	3430	14,200	197
PT5105	0	27	1360	14,900	228
PT5106	0	8	384	49,700	85
PT5107	**0**	**0**	**65**	**1290**	**10**
PT5204	800	27	6540	24100	440
PT6101	620	39	3930	39800	520
PT6102	0	8	682	56,700	160
PT6103	560	21	3480	27,600	20
Regulation limits for soil	5500[28]	1400 [29]	400 – 1000[17]		1,000-10,000

B. Fish (iqalluget/kayut)

Fish cannot be thought of as <u>one</u> animal to be tested.

- Depending on what they eat, they occupy different trophic levels. For instance, fish that eat mostly algae, phytoplankton, and nunivagseghat will be lower on the trophic level (and less likely to accumulate toxins) than fish that eat other fish or scavenge dead animals from the sea bottom (See Figure 3: Food Chains).
- Fatty fish may contain more toxins than lean fish, because many toxins collect in fat tissue.

[26] Information on metal sources is from AMAP 1998.
[27] High and low levels are printed in bold.
[28] Allowable level for soil that could be ingested (eaten)
[29] Allowable level for contaminant in soil where contaminant could migrate to groundwater

- Toxin levels may depend on where the fish lives. Those spending much of their life in polluted areas like the Suqi River drainage, Puget Sound, or populated coastal areas may have more toxins than fish that spend much of their life in the open sea.
- Older fish may have more toxins than younger fish.

Fish from the Suqi River were collected in 1999 and 2001.

They were compared to "control" fish caught in unpolluted rivers. The 1999 control river was the Quangeghsaq, a mile west of the Suqi and similar to the Suqi in stream flow and sediment. The 2001 control river was the Tapisaghak, three miles east of the Suqi, a larger, faster river. Different control rivers, sampling methods, sample sizes, detection limits, sizes of fish, and not testing the same kinds of fish both years makes it difficult to compare studies.

Anadromous and Resident Fish

Anadromous fish are born in a river, go to sea and return to the river later. Salmon are anadromous fish.

Resident fish stay in the river where they were born. Trout and blackfish are resident.

The people who collected the fish said the Suqi had both dolly varden that stayed and dollies that went to sea. The Tapisaghak and Quangeghsaq only had dollies that went to sea.

Fish were tested for PAH and PCB in 1999. In 2001, they were tested for PAH, PCB, and metals.

1999 Fish Tested:	Suqi River –	90 dolly varden, 75 stickleback, 3 blackfish. Total 168 fish.
	Suqi drainage—	11 blackfish
	Quangeghsaq River –	17 dolly varden, 20 stickleback, no blackfish. Total 37 fish.
	Tapisaghak River –	dolly varden and pink salmon seen, but not tested
2001 Fish Tested:	Suqi River—	8 dolly varden
	Suqi River drainage –	3 blackfish
	Tapisaghak River—	3 dolly varden, 3 pink salmon

In the Suqi River, both resident and anadromous dolly varden were found. In the Quangeghsaq and Tapisaghak rivers, only anadromous dolly varden were found.

In 1999, only small fish were analyzed. Whole fish were ground up to determine an overall level of contamination. In 2001, larger fish were collected. Blackfish were ground up whole, as before, but dollies and pinks were separated into several different parts that people eat: eggs, fillets, heads, and "remains" (the entire fish without the fillet). This was in order to see if any one part of the fish tended to concentrate contaminants.

1. Fish and Oil

In 1999, blackfish, sticklebacks, and dollies from the Suqi were tested for PAHs and compared to stickleback and dollies from the Quangeghsaq. In 2001, dollies and blackfish from the Suqi were compared to dollies and pink salmon from the Tapisaghak. Results are shown in Figure 6 "PAHs in Northeast Cape Fish, 1999-2001".

No fish (sticklebacks, dolly varden, pink salmon) from the Quangeghsaq or the Tapisaghak had any PAH. Oddly, PAHs were not detected in Suqi River dollies (anadromous and resident) in 1999, but were detected in 2001[30]. During the same tests, blackfish from the drainage had the same levels of PAHs in both years, and fish in the control rivers had no PAHs detected. This indicates that something has changed in the Suqi River itself, downstream of the drainage area where blackfish were caught and tested.

How lab tests are done can make results look different. They may test different numbers of fish, different parts of fish, or a test used in one year may be more "sensitive" (find smaller amounts of chemical) than a test used in another year. By comparing lab tests in 1999 and 2001, we found the difference in results for Suqi River dollies

- is not due to number of fish
- is not due to different detection limits; detection limits were about the same for both years

[30] "Not detected" does not mean there is no chemical at all in the fish; it means that if the chemical is there, it was in too small of an amount for the test to find. Lab tests can be set to different detection limits. A test with a very low detection limit can find much smaller amounts of a chemical than a test with a high detection limit, but it is more expensive. When comparing lab tests, it is important to see if the detection limits are the same.

- may be due to *size* of fish: fish collected in 1999 averaged 4 inches long; in 2001, collectors were going to attempt to catch larger fish.
- may be due to contaminant remobilization. When fish were sampled in 1999, building/drum removals had not started yet. By 2001, two seasons of removal had been going on, and disturbed soil and water could have released contaminants into the Suqi where fish absorbed them.

No *one* part of the fish was significantly higher than another; all had low levels. Organs were not tested.

Questions remain as to why blackfish have acenaphthene and fluorene in them, when these chemicals were not found at the military base. It is possible that they are coming from a global source—fluorene was abundant in arctic air in Canadian studies -- but if so, we would expect Tapisaghak fish to also be contaminated by them.

Questions remain as to why Suqi River dollies had light and heavy aromatics, while blackfish had only light. Tapisaghak dollies had none. This indicates the source of aromatics is military, not global.

Questions remain as to whether PAHs in sediment and water may damage fish *eggs*. Jeff Short of Auke Bay Labs in Juneau has studied pink salmon eggs and oil extensively in Prince William Sound. Auke Bay found that fish embryos are sensitive to very low levels of highly weathered oil. Oil that has been exposed to the environment for several years is called "weathered oil". As oil "weathers", it loses the small, light 1 – 2 ring molecules but the larger molecules remain. Weathered oil is more toxic than fresh oil. The small molecules are dangerous in the short term if they are inhaled; the larger molecules are toxic in the long term.

a) Oil and Fish Health

Stress created by exposure to hydrocarbons (petroleum) has been known to cause the livers of burbot to become small and dark and the flesh to become watery[31]. PAHs affect the development of fish eggs.

Sticklebacks, from the mouth of the Suqi, , and fish from control rivers had no PAHs. **Blackfish** living year round in the most polluted areas of the river, and **dollies**, had low levels.

While PAHs have been known to cause gene mutations, current studies indicate that the damage seen in pink salmon and herring after the *Exxon Valdez* oil spill is probably not genetic (that is, not passed from parent to offspring), but is more likely due to weathered oil that continues to seep into streams. The result has been that eggs exposed to as little as 1 ppb of very weathered oil, can produce small fish. The fat-rich yolk of larval fish attracts and retains PAHs that are in the water. Tiny, emerging fish then have to spend so much energy getting rid of the PAHs that less energy is available to help them grow. The fish are smaller, smaller fish find it harder to get away from predators and fewer return to spawn [32].

Relatedly, could low PAH levels be affecting microbial (bacteria) activity, which in turn could affect animals in the Suqi? In 1999, ENRI tested sediment toxicity using bacterial assays. This method does not look for particular contaminants; instead it looks at bacteria metabolism. ENRI found the lower reaches of the Suqi and the Suqi drainage areas to be more toxic to bacteria than the upper, uncontaminated reaches of the river.

2. Fish and PCBs

The same fish and fish parts tested for PAHs were also tested for PCBs.

Stickleback had PCBs below detection limits in 1999; they weren't tested in 2001. **Blackfish** (whole fish) from the drainage had PCB levels of 100 ppb in 1999, although those from the mouth of the river had none. In 2001, blackfish levels were 60 – 140 ppb. Blackfish from the Quangeghsaq and Tapisaghak were not tested.

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[31] AMAP 1998 pg 298

[32] Information on fish and oil is from Short et al 2001, Roy et al 1999, Bue et al 1998, Heintz et al 1999.

In 1999, **Dolly Varden** from the Suqi had PCB levels of ND[33] – 160 ppb. In 2001 the parts of fish (eggs, heads, etc) were low. Dollies from the Quangeghsaq had no detectable PCBs in 1999, but dollies from the Tapisaghak had low levels (20 – 35 ppb) in 2001. **Pink salmon** from the Tapi (2001) also had 20 – 35 ppb[34].

a) Discussion on PCBs in fish:

What does this information tell us? The differences in results is due to the lab using *more sensitive tests* in 2001 than in 1999. In 1999, tests detected PCBs at 50 ppb or more (less would show up as ND); in 2001, they detected levels as low as 2 ppb. Had they used the 50 ppb detection limit in 1999, no fish would have had detectable PCBs. This makes it difficult to compare our results (see Figure 7: PCBs in Northeast Cape Fish).

In addition, different fish had different potential exposures because some lived in the Suqi throughout their lives, while others migrated back and forth to the ocean. The 1999 report mentions that, by visual inspection, some Suqi River dollies appeared to be residents and some anadromous. However, they were not tested separately. This is unfortunate; separate testing could have provided information on global versus local contaminant levels. A quick summary of information on dolly varden shows:

1999 Suqi River	ND – 160 ppb	detection limit 50 ppb
1999 Quangeghsaq	ND	detection limit 50 ppb
2001 Suqi River	8 - 30 ppb	detection limit 2 ppb
2001 Tapisaghak	6 - 30 ppb	detection limit 2 ppb

Blackfish from the Suqi drainage consistently ran 60 – 160 ppb in 1999 and 2001, but those from lower down the Suqi River had no PCBs (1999).

We can make some educated guesses about contaminant movement. Water samples from the *drainage* had high PCBs in water, but none were detected downstream in the Suqi River itself.. We can guess that fish going into the mid- and upper-reaches of the river (blackfish, resident dolly varden) absorbed 50+ ppb of PCBs, originating from the military complex. Fish are exposed by water moving across gills, by PCBs in sediment moving into bottom-feeding fish that sift through mud, and by food they eat (if food absorbed PCBs).

Fish near the mouth of the river (sticklebacks, some blackfish), or living part time in the ocean (anadromous dolly varden) end up with less than 50 ppb of PCBs in their tissues because PCBs tend to stick to suspended sediment in the river and sink before reaching the mouth. Water and sediment at the mouth of the Suqi would likely have few PCBs, so fish would have virtually no exposure from water coming across their gills, or from sifting bottom sediments. They could still be exposed through food.

To get a better picture of what is going on, ACAT needs to collect sediment from the mouth of the Suqi (to see if PCBs are traveling that far), and find out what fish are eating while they are in the river.

We don't know whether PCBs in Tapi fish originate from the Suqi or global sources. Anadromous dollies may pick up PCBs in the drainage before swimming to the Tapi. If they lay eggs in the Tapi or die there, PCBs would transfer when eggs are eaten, or from carcasses, to pink salmon[35].

Or there could be a global "background" of PCBs that we see; lab tests in 1999 would have picked this up in Quangeghsaq fish and sticklebacks, dollies and blackfish in the Suqi mouth had they been more sensitive. PCB levels in fish around Alaska (see Appendix H "Contaminants in Fish"), may indicate background levels in the state. Cook Inlet salmon had 1 – 3 ppb[36]; Copper River grayling had 10 ppb; 20 ppb or more were in salmon. The amount in each <u>individual</u> fish depends on the fatty content of the

[33] ND means "non –detect", lower than the level the test could see. It is used throughout the report.

[34] Preliminary data from the 2001 season does not tell us which samples were dolly varden and which were pinks.

[35] Ewald et al 1997 showed that migrating salmon brought organic pollutants into inland lakes; grayling in lakes with sockeye salmon had higher organic pollutant levels than grayling in nearby lakes that did not have sockeye salmon runs. In the same manner, Dolly Varden moving from the Suqi to the Tapi could potentially transport PCBs to an uncontaminated river and the fish in it.

[36] EPA Subsistence Contaminant Study at Port Graham, 1997, 1998, unpublished.

fish, where they eat on the food chain, whether they are going through starvation, migration, or spawning, age, and other factors.

Blackfish and dollies in the Suqi River probably have a mix of global background PCBs and PCBs flushing out from the military base. Fish in the Quangeghsaq and Tapisaghak probably have only background PCBs, or small amounts transferred to the other rivers by dolly varden moving around.

b) PCBs and Fish Health

PCB information has been collected for fish throughout the world, but to date no studies have been done to see what amount of PCBs harm arctic fish. We know eggs and fry are more sensitive to PCBs than adult fish are. Lake trout exposed to PCBs had decreased eggs hatching, increased death of small fish, and lethal malformations. The levels of PCBs necessary to cause these problems was not listed, but PCB in muscle (fillets) ranged from 12 ppb - 898 ppb wet weight, with most averaging under 70 ppb. Pike studies showed similar effects, with muscle tissue ranging from <0.2 ppb – 341 ppb, with most averaging under 90. The lowest levels known to cause deformities in chickens is 290 ppb[37].

Note that all sticklebacks, many dollies, and some blackfish, in the Suqi had non-detectable (1999) or low (2001) levels of PCBs. Fish from the Quangeghsaq and Tapisaghak rivers had low levels.

3. Fish and Pesticides

Fish were not tested for pesticides. Virtually no pesticides were detected at Northeast Cape (were below detection limits). However, phosphate based chemicals were not looked for.

Figure 6: PAHs in Northeast Cape Fish (iqalluget/kayut), 1999 - 2001

1999	Suqi River			River drainage	Control river: Quangeghsaq		Control river: Tapisaghak
	DV	SB	BF	BF	DV	SB	
PAH (ppb)							No fish tested
ace				7			
ant				nl			
fla				nl			
flu				11			
nap				16			
other				80			
total	ND	ND	ND		ND	ND	

2001	Suqi River	Drainage	Control River: Quangeghsaq	Control river: Tapisaghak
	DV	BF		DV and PS
PAH (ppb)			no fish tested	
ace*	ND-9	6 to 30		
ant	ND-18			
fla	ND-2	ND to 4		
flu	ND-19	4 to 7		
nap	ND-12	ND to 7		
other	ND-114			
total	ND-174			ND

**Ace=acenaphthene Ant=anthracene Fla=Fluoranthene Flu=fluorene Nap= naphthalene*

[37] AMAP 1998 pages 207 and 349

Figure 7: PCBs in Northeast Cape Fish (iqalluget/kayut), 1999-2001

	Suqi River				River drainage	Control: Quangeghasaq		Control: Tapisaghak			
1999	DV	SB	BF		BF	DV	SB				
PCB	ND – 160	ND	ND		100	ND	ND	No fish tested			
	Suqi River				River drainage	Control: Quangeghasa1		Control: Tapisaghak			
2001	DV				BF	No fish tested		DV and PS			
	Egg	Fillet	Hd	rmn	Whole fish			Egg	Fillet	Hd	rmn
PCB	8-13	6-16	23-30	15-18	60 – 140			9-17	6-11	16-28	6-9

**DV=dolly varden SB= stickleback BF = Blackfish* ***All fish in 1999 were whole fish samples*

4. Fish and Metals

Fish were tested for metals in 2001: antimony, arsenic, barium, cadmium, lead, nickel, silver, vanadium, zinc, copper, chromium, mercury, and selenium. All but chromium were in Suqi and Tapi River dollies, although antimony was rare. No silver or chromium was in blackfish from the Suqi drainage.

Although metals were found in fish, what this means is not yet known. Recall that some species continually absorb and eliminate some metals, but accumulate others to toxic levels. Metals in sediment and water are inorganic, and high levels of some types are dangerous. How much did dollies absorb in the inorganic form, from arsenic in sediment and water, and how much did they absorb in the organic form by eating other animals?

Tests did show that different parts of a fish absorb metals at different rates. For instance, dolly varden/pink salmon eggs seemed to have distinctly less arsenic and mercury than the rest of the fish, while fillets had distinctly less zinc, although we need to keep in mind that numbers are based on only one or two samples. It is odd that dolly varden and pink salmon have more arsenic than blackfish. Is this a difference in ability to eliminate it? Difference in diet? In lifespan? Is there an ocean source that dollies and pinks are receiving?

Fish and Arsenic

Arsenic comes in different forms. The kind that in rocks is called "inorganic arsenic". It is dangerous because it wants to insert itself in places inside cells where other metals are needed. The arsenic in drinking water is inorganic.

If inorganic arsenic becomes strongly bound to and surrounded by carbon-based molecules, in a process called complexation it is called organo-arsenic. The organic molecules that surround it keep arsenic from interfering with other metals the body needs, and thus it is not toxic.

Arsenic in water is inorganic and dangerous. Arsenic in fish and marine mammals is probably organic and nontoxic.

When dollies from the Suqi are compared to dollies from the Tapi, they seem to have about the same amounts of metals, indicating metals are most likely coming from natural soils, rather than from local pollution.

a) Metals and Fish Health

Metals of most concern in the arctic are mercury, lead, and cadmium. Selenium and zinc are sometimes measured, because they can be toxic by themselves if found at high enough levels, and because they help to *detoxify* cadmium and mercury.

Mercury is low in all fish except blackfish. Only total mercury was measured; methylmercury (the mercury that accumulates) was not. Blackfish should be analyzed for methylmercury, and have kidney and liver analyzed to compare with levels known to be toxic in other animals.

Lead and zinc are low. Dissolved lead and zinc were in drainage water, but sources are not specifically identified, and may be many and varied. Lead and zinc are natural to soils in the area; batteries dumped by the military are also a source.

Arsenic was low in blackfish, higher in dollies and pinks. Organo-arsenic is not toxic to fish or the people eating them.[38] Arsenic is natural to soils, but some may be military in origin. Arsenic was also found in water at Northeast Cape (in total, not dissolved form).

5. Are Contaminants Affecting Fish?

PAH: Levels of PAHs in the Suqi may be high enough to affect **fish eggs**; testing in summer of 2002 will help determine this. The levels that affect fish quality (taste of meat, color of liver) are not known.

PCBs: Levels seen in 1999 may approach levels known to cause deformities and reduced growth in fry. This is not an area that has been studied well, and no arctic fish have been studied. Fish in control rivers, and Suqi dollies in 2001 had levels too low to affect their health.

Metal: PCBs and mercury in **blackfish** may be a concern; methylmercury should be measured. In the Tapi, **pink salmon and dollies** have low levels of metals compared to other arctic fish (Figure 16: Circumpolar Comparison of Metals and PCBs in Fish") or to levels known to harm other animals (Figure 8: "Toxic Levels of Metals in Animals"). Testing fish organs would allow us to compare with levels known to be toxic in other animals.

As remediation progresses at Northeast Cape, contaminants can remobilize, becoming more available to fish. In the long run, *sources* of toxins will be removed, but in the short run, *exposure* to toxins could be greater.

Metal	*Liver* Toxic levels in domestic animals	*Liver* Toxic levels in birds	*Egg* Toxic level in bird eggs	*Liver* Toxic levels in marine mammals	*Liver* Toxic level, land mammals	*Eggs, Fillets, Head, Remains* Max Levels NEC Dollies, Pinks	*Whole Fish* Maximum Levels Found in NEC blackfish
As	10,000					900	80
Cd	20,000	40,000		20,000 – 200,000[39]		40	10
Cu	150,000					3,000	1,200
Hg	5,000	30,000	3,000	60,000[40]	30,000	30	100
Pb	10,000	15,000[41]				50	30
Se	2,500	9,000	9,000[42]		7,000[43]	500	10
Zn	200,000					37,000	51,000

Figure 8: Toxic Levels of Metals in Animals
Comparison of levels of metals in fish from Northeast Cape with levels toxic in domestic animals, birds, and marine mammals (*ppb*)

C. Reindeer (quyngiq)

Quyngiq samples were taken by ATSDR during a roundup and slaughter. It is not known how much time they spent at Northeast Cape. Because we do not know the range the quyngiq were foraging in, we don't know how much contamination is due to various local pollution sources and how much to global. However, contaminant levels were low in quyngiq blood, muscle and fat, indicating they are unaffected by contamination.

1. Quyngiq and Oil

Quyngiq had low levels of PAHs in muscle. Although they had a little of all 15 PAHs looked for, the levels are so low they should not be a threat. Maximum levels can be seen in Appendix C "PAH in Plants and Animals at Northeast Cape".

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[38] Personal communication, Dr. David Carpenter.
[39] Potential kidney dysfunction
[40] Liver damage
[41] Toxic level of lead in livers is for waterfowl. While 15+ ppb causes severe poisoning, as little as 2 ppb can cause subclinical poisoning in waterfowl (AMAP 1998 p 437)
[42] Selenium over 9 ppb in eggs causes deformed embryos (AMAP 1998 p 437)
[43] Liver damage

Three of the top four PAHs found in quyngiq are on the Canadian list of the four most abundant global PAHs in the arctic, indicating that at least some, if not all, of the contamination is from global sources.

2. Quyngiq and PCBs

Quyngiq eat nunivagseghat, and are thus low on the trophic level (see information box "What is a Trophic Level"). They were not expected to have high levels of PCBs, and, indeed, no PCBs at all were detected[44]. Muscle and fat from eight animals and blood serum from 25 animals were analyzed.

3. Quyngiq and Pesticides

Extremely low amounts of pesticides were found in quyngiq. Of 19 pesticides tested for, only 6 were found. The maximum amounts are listed here:

DDT	5.0 ppb[45] (in the serum of 3 out of 25 quyngiq tested)
Endosulfan sulfate	0.87 ppb (in muscle of 1 out of 8 quyngiq tested)
Endrin	3.0 ppb (in muscle of 4 out of 8 quyngiq tested)
Endrin aldehyde	1.9 ppb (in muscle of 3 out of 8 quyngiq tested)
Heptachlor	0.56 ppb (in muscle of 4 out of 8 quyngiq tested)
Alpha chlordane	1.0 ppb (in muscle of 1 out of 8 quyngiq tested)

Again, there is strong reason to suspect much of the contamination is from global, rather than local, influences. Canadian studies show that chlordane, endosulfan, DDT, dieldrin, and endrin are among the twelve most abundant global air contaminants in the arctic. DDT and chlordane were among the top five found in snowpack.

4. Quyngiq and Metals

Quyngiq were not tested for metals in the ATSDR study we reviewed. The UAF Reindeer Research Program analyzed St. Lawrence Island quyngiq for metals in organ meat (liver, kidney), which is where metals tend to concentrate, but that report has not been published yet.

5. Are Contaminants Affecting Quyngiq?

Information so far indicates quyngiq are not affected by contaminants. Metal information needs to be reviewed.

D. Summary of Local Pollution Effects on Plants and Animals

1. Summary of Contaminants in Soil and Water

Here is a brief summary of pollutants in the soil and water at Northeast Cape (Suqi drainage and river in bold):

Soil:	High DRO	(sites, 3,4,6,7,9,10,11,13,15,19,21,22,24,25,27, **28, 29**)
	High PCB	(sites 13, 17, **28**)
	High metals	(sites 2,5,7,9,16,19,21,22,24,**29**)
Water:	High DRO	(sites 3,4,6,7,9,11,13,15,19,27,**28**)
	High PCB	(sites 17, 21, **28**)
		Site 21 had high PCB in the sewage sludge, not in ground or surface water
	High dissolved lead	(site 6, **28**)
	High dissolved zinc	(site 7, 21, 25, **28**)
	High dissolved mercury	(site 7)
	High dissolved silver	(site 10)
	High total arsenic	(sites 7, 9, 13, 15, 21,27, **28**)

These are the <u>sources of local pollution</u> that we know of.

[44] Detection limits were 25 ug/l (25 ppb) in serum; 3 ng/g (3 ppb) in muscle and fat.

[45] Serum was 5.0 ug/l (micrograms per liter); contaminants in muscle were in ng/g. All are the same as ppb. Liquids are measured in ug/l; solids in ng/g.

2. Summary of Contaminants in Nunivagseghat, Fish (iqalluget/kayut), and Quyngiq

Foods gathered at Northeast Cape are subject to both local and global pollution. Nunivagseghat receive *global* pollutants from the air, when contaminants travel north and settle on them. They receive *local* contaminants when wind and floods carry oil, trace metals, and PCBs from the military base. Fish may come in contact with *global* pollutants in both water and air; anadromous fish are especially likely to carry contaminants from far away. *Local* oil, dissolved metals, and PCB pollution are found in the drainage beneath the military base. Quyngiq may breath *global* air pollutants, or eat nunivagseghat that have *global or local* contaminants on or in them. It may be very difficult to tell how much contamination is due to the military base and how much comes from "outside".

Contaminants that may be affecting the health of nunivagseghat and animals are:

Plants (nunivagseghat)

DRO/PAH	not a concern
PCBs	Contamination may be in dust, not nunivagseghat. Effect of PCBs on nunivagseghat unknown.
Metals	arsenic, mercury, lead and zinc are all **potentially a concern**; need to know which nunivagseghat species were tested, how much metal was in dust

Fish (iqalluget/kayut):

DRO/PAH	may affect fish eggs or quality of fish meat; more testing needed
PCBs	levels that affect fish health are not known
Metals	in blackfish – mercury is **potentially of concern**

Quyngiq (quyngiq):

DRO/PAH	not a concern
PCBs	none found
Metals	not known; need to wait for UAF data to be published

III. Local Pollution: Drinking Water in Savoonga

The military base at Northeast Cape does not affect the water in the village of Savoonga itself. However, because clean drinking water is so important to maintaining health, ACAT reviewed records of City drinking water tests, which have been conducted since 1985. Testing is required regularly.

Water Testing Schedule, April 2002 Report

	Contaminant tested for	Last Test	Next Test Due
Monthly	coliform bacteria	April 2002	May 2002
Yearly	nitrates	April 2001	2002
	lead and copper	2001	June-Sept 2002
Occasional	nitrite	Sept 1995	None
	pesticides	never tested	Need to apply for waiver
	radiation	Sept 1999	2003
	arsenic	1995	2002[46]
	metals Be, Ni, Sb, Th, cyanide	April 2001	2004
	metals As, Ba, Cd, F, Pb, Hg, Se	April 1994	2002-2010 (one sample every 9 yr cycle)
	asbestos	never tested	Waiver 2002 – 2004
	volatile organics	Jan 2000	Waiver 2002 - 2004

The 1999 report of water tests, posted in the Savoonga Post Office, showed elevated coliform levels in June and September 1998, but recent tests (January 2001 - June 2002) found none. Coliform bacteria are found in human and animal feces, and can make people sick to their stomach, although they are not usually deadly.

[46] One-time sample due in 2002 because of new regulations for lower arsenic levels going into effect this year throughout the state.

The 1999 report also showed high lead and copper in some 1995 samples taken from the homes of people. However, tests from 40 homes from January to December 2001 showed only one instance of elevated lead. Below are the highest levels found:

Cu:	1995	**2.02** ppm	2001	0.15 - 1.19 ppm	regulation 1.3 ppm
Pb:	1995	**19** ppb	2001	ND - 29 ppb	regulation 15 ppb

Problems with occasional high levels of coliform bacteria, lead, and copper appear to be solved. Lead and copper get into drinking water from corroding pipes; replacing the pipes solves the problem. It is important to make sure that lead and copper levels remain low; continued exposure to lead can cause physical and mental problems in children while copper can cause stomach/intestinal problems.

SAVOONGA CITY WATER, RESULTS 2001				
CONTAMINANT TESTED FOR	DATE	RESULTS	DETECTION LIMIT	LEVEL CONSIDERED HIGH
Alpha radiation	March 1999	ND		
Metals	April 2001			
Be		ND	0.0009 ppb	
Ni		ND	0.01 ppb	
Sb		ND	0.003 ppb	
Th		ND	0.001 ppb	
Metals	April 2001			
As		ND	5 ppb	10 ppb
Ba		ND	5 ppb	
Cd		ND	5 ppb	
Cu	2001	1.2 max		1.3 ppb
F	1994	10 ppb		
Pb	2001	29 max	5 ppb	15 ppb
Hg		ND	1 ppb	2 ppb
Se		ND	2 ppb	
Nitrate	April 2001	270 ppb		10,000 ppb
Cyanide	April 2001	ND	20 ppb	
Volatile Organics	Jan 2000	All okay	various	

*ND = not detected; below detection limit of test, numbers in paranthases are the detection limit of the test

Gambell

IV. Community Concerns

Despite years of testing and the initiation of cleanup work, some community members express concern over the cleanup process. The primary concerns involve remaining metal debris, buried ordnance, the potential of oil beneath the gravel, and the possibility that some transformers may still be buried.

Remaining debris may have to be addressed under NALEMP, rather than FUDS. Buried ordnance was searched for on land by the Huntsville, Alabama COE, and Earthtech did a geophysical survey of Troutman Lake.

Concerning oil that may remain under the gravel, there is a disagreement between contractors and some residents as to how far the contractor needs to drill to discover oil in potentially active soil layers beneath initial frozen ground. Contractors have been drilling, on average, 8 to 12 feet beneath the surface (permafrost is usually encountered at 8 feet), while some residents say they need to drill 14 feet beneath the surface. Oil has been encountered while laying sewer lines, which are usually laid 12 – 14 feet beneath the surface.

Concerning transformers, three transformers were found and removed from the top of Sevuokuk Mountain. Although there were several reports of transformers buried near the village water supply, numerous geophysical surveys failed to find them (although they did find other metal debris). Geophysical surveys were conducted in 1994, 1996, and 2000. It is unlikely that the COE will look any further for buried transformers.

Concerns also remain about sulfuric acid that may be buried at site 3.

For the future, ACAT would be interested in pursuing reports of radiation testing. The military is known to have experimented on Alaska Natives by having them take a radioactive pill (containing Iodine^{131}) to see how their thyroids worked, to see if they could figure out how they stayed warm during long, cold winters. Conrad Oozeva spoke to ACAT about his experiences. ACAT is interested in pursuing an investigation in the future.

V. History of Contamination

The military affected the villages of Savoonga and Gambell in different ways. The White Alice site and military base at Northeast Cape contaminated a prime subsistence harvesting area used by residents of Savoonga for generations; however, they built a base right *in* Gambell.

Gambell had a military base built in it, and a radar station built on the mountain overlooking it. Residents of Gambell have to deal every day with debris the military left behind. No PCBs have been found in Gambell, and only very limited metal contamination; however, soil in and around the village shows signs of petroleum contamination. In addition, rusty metal debris, which becomes exposed during storms, is a continual hazard to ATVs, snowmachines, pedestrians, children, and boats being pulled ashore.

The citizens of Gambell want military debris and contamination removed. They worry about old military fuel spills, buried transformers, and buried machinery causing increased cancer and other health problems in their community. Accidents occur when ATVs hit debris uncovered through wind and erosion. There are also economic factors. Every spring and summer, birdwatchers from around the world come to Gambell; exposed debris and rust is not what they came to see. Also, as the population in Gambell grows, new housing will need to be built. Much of the land available to build on contains debris or contamination.

Population of Gambell

1910	221
1930	250
1940	296
1950	309
1960	358
1970	372
1980	445
1990	523
2000	~600

Unfortunately, while rusty debris is a daily pressing concern, the clean up currently being conducted by the COE focuses on *chemical* contamination, such as remediating soil contaminated with fuel and solvents. The COE claims that hazardous debris was removed in 1999, and Gambell will have to work through NALEMP, a separate government program, to have remaining debris removed.

The contaminants identified thus far by the COE are DRO and a few spots of metals.

A. History of the Military in Gambell

The military arrived in Gambell during World War II, when the Alaska Territorial Guard was formed. About 100 people from Gambell joined the ATG, patrolling and scouting the island. Elders Winnie James and Conrad Oozeva relate first hand experience about hauling heavy equipment and generators to the top of the mountain.

The military maintained interest in Gambell during the Korean and Cold Wars because of its proximity 40 miles from Russia. From 1948-1954, Gambell was used as a temporary radar site gathering information on Russian shipping activities, until these operations were transferred to Northeast Cape. In September 1950, the Air Force came to Gambell; in 1954, the Army came in. Both the Army and the Air Force established landing areas on the beach. The main army camp was right in Gambell, and they used land between Troutman and Nayvaqhag Lakes. The Air Force based itself on top of Sevuokuk Mountain. The Navy, also, had operations in the area, laying communication cables from the village up Sevuokuk Mountain and across to Dovelawik Bay (2 miles east of Sevuokuk Mountain) and south to Brunnell Cape (25 miles south of the mountain).[47] The Army continued intelligence operations there until 1963.

Residents of Gambell fear that biological or chemical weapons may have been tested. According to the Alaska District COE January 2000 report "Gambell Site Visit", data regarding Gambell is still classified and "very little is known about the purpose and missions of the units stationed here".[48]

B. History of Contractor Testing

The federal government initiated the Formerly Used Defense Sites (FUDS) cleanup program in 1984, and in 1985 the contractor URS Corporation took a preliminary look at Gambell. Material left by the military was inventoried; a few soil and water samples were collected. Groundwater collected from the Communications Facility and the Radar Power Station in 1985 showed elevated levels of oil, grease, and metals (arsenic, barium, cadmium, chromium, lead). Soils were only tested for PCBs, and none were found.

In 1991-92, the contractor Ecology and Environment, Inc (E&E) interviewed residents. In 1994, the contractor Montgomery Watson (MW) took soil samples based on recommendations by URS and E&E. Debris, DRO, and occasional elevated metals were found. Explosives residue in soil and water, and VOCs in air were tested for, with none found. Site 6 (where human waste was buried in drums) was tested for coliform bacteria and none found. In 1996-97 MW investigated an area where transformers were reportedly buried near the water supply. Extensive testing was done for PCBs. Trace amounts of petroleum residues were found in monitoring wells, but none in the water supply. A geophysical investigation found buried debris, but no transformers. In 1998, MW did more sampling in order to see how far and how deep contamination went.

Actual cleanup began in 1999, when Oil Spill Consultants, Inc. (OSCI) removed contaminated soils and debris. When they had finished, some areas still showed high levels of dioxin, fuel and/or metals, and would need to be cleaned again.

In 2000, MW added four new sites, based on information from questionnaires, historical photos, and geophysical surveys: sites 25B, 26, 27, and 28. The first surveys to look for buried ordnance began in 2000. In 2001, final survey investigations for buried ordnance were completed.

The next step will be to determine a "risk assessment". This is a report full of calculations about whether people, plants, or animals are at risk of health problems from contamination. It is used as a guide for final remediation plans.

Explosives Tested for at Gambell

At site 2, the following was tested for in soil and water. Only site 2 was tested for explosives residue.

1,3,5-trinitrobenzene
1,3-dinitrobenzene
2,4,6-trinitrotoluene
2,4-dinitrotoluene
2,6-dinitrotoluene
HMX
Nitrobenzene
RDX
Tetryl

[47] From "Site Inspection Report" September 1994 by Roy F. Weston, Inc for EPA.
[48] The note about classified data is handwritten in the margins of ACAT's copy of the Site Inspection Report; it is not known who wrote the note. The quote about missions is directly from the report.

List of Sites in Gambell Investigated for Contaminants

1A	North Beach. Army Landing Area.
1B	North Beach. Air Force Landing Area.
2	Military Housing and Operations. Base of Sevuokuk Mountain.
3	Military Communications Facility. Base of Sevuokuk Mountain.
4A	Quonset Huts on top of Sevuokuk Mountain.
4B	Radar site on top of Sevuokuk Mountain.
4C	Stream Drainage on top of Sevuokuk Mountain.
4D	Transformers on top of Sevuokuk Mountain, near streams that are a water source.
4E	The whole west side of Sevuokuk Mountain.
5	Village Water Well; Former Tramway.
6	Military Landfill
7	Military Power Building/Military Motor Pool
8	Army Landfill. West Beach.
9	Asphalt Barrels near runway.
10	Army and Air Force trails on top of Sevuokuk Mountain.
11	Communication Cable Route
12	Nayvaghaq Lake Disposal Areas
13	Former Radar Power Station
14	Navy plane wreck, 8 miles south of Gambell
15	Troutman Lake Ordnance Burial Site, north end of Troutman Lake.
16	Gambell Municipal Building
17	Army Landfills near North Beach
18	Main Army Camp
18A	Municipal Water Treatment Building
19	Diatomaceous Earth (NALEMP)
20	Schoolyard (NALEMP)
21	Toe of Sevuokuk Mountain, southwest of Village Water Supply (NALEMP)
22	Former CAA Housing (NALEMP)
23	Debris from High School Construction (NALEMP)
24	South of Gambell Municipal Building
25A	Village Housing
25B	Low Drainage area southwest of armory
26	Debris Burial Feature from 1953 photo. Northeast of High School.
27	Drum Storage Area from 1955 photo. North of Municipal Building.
28	Disturbed Ground from 1972 photo. South of Troutman Lake.

Ordnance Investigation Sites

A	gravel spit northeast of town, base of Sevuokuk Mountain
B	Radar site on top of mountain
C	North end of Troutman Lake
D	West Beach ammunition cache
F	High School yard
G	Remainder of Troutman Lake

History of Site Investigations--Gambell

1985	Site inventory Soil samples for PCBs (none found) Groundwater samples for VOC, metal, PCB, petroleum residues (oil and grease found)
1992	Site Inventory Interviews Develop a guide for further investigation (called the Chemical Data Acquisition Plan)
1994	Phase I Remedial Investigation Soil samples (high DRO and metal found, low PCB and dioxin and furans) Groundwater samples (low DRO and solvents found) Test for asbestos in building materials Test for coliform bacteria at site 6 (landfill where human waste was buried in drums) Geophysical surveys (4 areas in Gambell, 4 at mountain base, 2 south of Troutman lake) *Recommend further investigation of several sites*
1996	Geophysical Surveys of Site 5 (metal found but not excavated)
1997	Excavation at Site 5 (excavated non hazardous materials, no transformers found)
1998	Phase II Remedial Investigation Soil samples (high metals found in two samples, high DRO in one sample) Groundwater samples (no high levels of contaminants found) *Recommend extensive debris removal and further investigation of a few sites*
1999	Cleanup work: removal of 71 tons of metal debris, 26 tons of hazardous waste, 72 tons of soil[49] *Recommend further remediation of a few sites*
2000	Geophysical Survey (7 areas in Gambell, 1 by Nayvaghaq Lake) Geophysical Survey for ordnance (North Troutman Lake, four areas on land) Historical Photo review, Interviews *Recommend investigating four new sites*
2001	Geophysical Survey for ordnance (remainder of Troutman Lake) Soil samples (high metal confirmed still present at 3 sites, high DRO still at 5 sites) Soil samples of new sites (no contaminants found) Groundwater samples of new sites (no contaminants found) Fuel fingerprints (inconclusive)

History of Ordnance Investigations—Gambell

May 8, 2000	geophysical survey and investigation of frozen lake, north end of Troutman Lake
July 2000	geophysical survey and investigation of land sites A, B, D, F
Sept 2000	geophysical surveys and investigations of A1, A2
April 24, 2001	geophysical survey and investigation of frozen lake, south end of Troutman Lake
May 2001	geophysical survey and investigation of south end of Troutman Lake continues
Aug 2001	investigation of lake using boat, underwater camera, anchor drag

[49] 20 tons of "stained soil" were removed from sites 2, 4A, 4D, 8, 10, and 12. 52 tons of "contaminated soil" were removed from site 4B.

C. Remediation

Cleanup began in 1999 but has not been completed. Some of the areas still have contamination and need further remediation. Other areas are still being investigated.

Sites Never Remediated

7: High DRO. Reportedly drums were punctured prior to being removed from the island. On the list to be cleaned.

9: Decaying asphalt barrels near runway are FAA, not the DoD. The FAA left them when they built the runway.

11: Sonar cable on mountain was determined not a hazard and there are no plans to clean it up

14: Navy plane wreck outside scope of work. No samples taken to see if radioactive waste or other contamination are present.

15: North shore Troutman Lake investigated in 2000 and 2001; it is renamed Site C. No ammo was found.

16: Stained gravel suspected to be from city spill. Recommendation is for no further action.

17: Geophysical anomalies were found, not removed. No contamination found, Resident concerns over buried human waste .

18: Main camp area on north shore of Troutman Lake not investigated, and there appear to be no plans to investigate.

18A: Fuel contamination suspected to be from City spill. Will be dropped if fuel fingerprint shows the fuel is recent, not old.

19: "White substance" on northeast shore of Troutman Lake is diatomaceous earth, material used for filtering water.

20: Debris in schoolyard. Cleanup can be pursued under NALEMP. No ordnance at schoolyard (called Site F).

21: Buried wire and metal debris at toe of Sevuokuk Mountain. Cleanup can be pursued under NALEMP.

22: Former CAA housing. Not eligible for cleanup under FUDS because housing was used by residents. Visual survey by MW in 2000 noted that heating wrap on pipes could potentially contain asbestos. Cleanup can be pursued under NALEMP.

23: Debris dug up during High School construction not eligible. No investigation was conducted and no further action is expected.

24: South of Municipal Building. No contaminants detected and no further action is expected.

25A: Housing near Troutman lake. No contaminants detected and no further action is expected.

25B: COE suspects petroleum is from City spill. Likely will be recommended for no further action.

26: Sampling in 2001 indicated no contamination, and no further action is expected.

27: Potential drum storage area next to site 7. No contaminants found, and no further action is expected.

28: No contamination was found, and no further action is expected.

Sites Partly Remediated

2: Stained soil removed. OSCI stopped removing soil because it was an "oil spill site", not a "stained soil site". Contaminated soil could still be there.

4A: Soil, debris, and hazardous waste removed, but "hotspots" of high metal and high DRO remain. Will have further remediation.

4B: Soil, debris, and hazardous waste were removed, but "hotspots" of high DRO remained. Will have further remediation.

6: Debris and hazardous waste removed. High DRO still in the area, so further investigation and/or remediation will occur.

8: Debris, hazardous waste, and contaminated soil removed. OSCI estimates that they removed about half of the landing mat in the area, because the rest was too close to live power lines and could not be removed.

12: Debris, hazardous waste, contaminated soil removed. Hotspots of metals and DRO remain and will need to be remediated.

Sites Fully Remediated (considered fully remediated by the COE, no further action will occur)

1A, 1B: Exposed debris removed. Erosion will expose debris that is currently buried, but there are no plans to excavate and remove buried debris. Despite reports of buried ammunition, and unexplained anomaly at site 1B, there are no plans to excavate.

3: Debris, hazardous waste removed; no further action expected. Residents concerns that transformers and acid may be buried.

4D: Transformers, soil, debris, and hazardous waste removed. No PCB contamination of soil or streams. No further action.

4E: Barrels on the side of Sevuokuk Mountain were removed. No further action will occur here.

5: Debris and hazardous waste removed. Geophysical anomalies excavated and removed; no transformers found. Water is not contaminated. No further action is expected at this site, despite resident concerns that a transformer may be buried in the area. Residents have also expressed concerns that alcohol may be buried in this area, however, a 1986 letter from Edna Apatiki, mayor of Gambell, notes that "alcohol has been unburied".

10: Debris, hazardous waste, and contaminated soil removed from trails. No further action is expected.

13: Debris removed from old Aircraft Station south of Troutman Lake, and no further investigation is expected.

IX. Soil Contamination

A. Petroleum

Elders tell of the army punching holes in thousands of drums holding oil and lubricants, before loading landing craft with the empty drums and dumping them at sea[50]. There may be pools of oil beneath the gravel, on top of permafrost or sandwiched in an active layer between frozen layers of ground. Several boreholes drilled by MW went 2 – 3 feet into the permafrost, but only once was an active layer found beneath (site 25B). Some residents believe holes need to be drilled deeper.[51] Sewer lines are commonly 12' – 14' below the surface, and oil has been found during excavation to lay city sewer lines; it seems reasonable that boreholes be drilled to 14' when looking for oil. Most permafrost was found at about 8'; holes drilled into permafrost went 10 – 12'.

There may have been a 10,000 gallon fuel spill when a barge unloaded at the City of Gambell in 1997. It is not known whether there actually was a fuel spill, or whether there was a mistake in the books. The US Coast Guard noted that 10,000 gallons apparently left the barge but did not make it to the fuel storage tanks. The COE would not be responsible for cleaning up this fuel.

Evidence of petroleum contamination has been found throughout Gambell, usually just above the permafrost layer. However, no pool of oil has been found, despite attempts to drill boreholes and take samples in locations where Sivuqaq Board suspected oil may have migrated and collected.

In 2001, signs of petroleum were found at:

Sites 4A and 4B — High DRO

Site 6 — High DRO
4 out of 5 boreholes showed evidence of fuel contamination (black gravel, odor, sheen), always 4' to 7' below the surface; 2 of the 5 had samples with high DRO. Surface soil samples were clean. Samples were not taken for fuel fingerprinting.

Site 7 — High DRO
1 out of 3 boreholes had high DRO, at 2' and 7' below surface.Samples were not sent to the lab for fuel fingerprints.

Site 12 — High DRO in surface soils in 1999; not in 2001 No boreholes drilled in this area.

Site 18A — High DRO (possibly recent, possibly not DoD)
1 out of 1 boreholes had high DRO. Surface soils showed no evidence of fuel contamination.

Site 24 — Faint DRO indications (possibly recent, possibly not DoD)

Site 25B — Faint DRO indications (possibly recent, possibly not DoD)

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[50] Winnie James and Conrad Oozeva spoke to ACAT about this incident during a visit to Gambell in April 2002.

[51] Winnie James describes geology as often having an active layer, then 3 – 4' layer of frozen ground, then an active layer, and then permafrost. Several references refer to the possibility of an active layer sandwiched between frozen layers in places where there is discontinuous permafrost (Munter and Noll, 1994; E&E Chemical Data Acquisition Plan 1993; Williams 1970)

Samples have been collected from surface soils (on top of the mountain, near radar station and Quonset huts, and also at the west beach of Troutman Lake and near Nayvaghaq Lake) and examined for petroleum residues.

A large number of samples have been collected from boreholes drilled between houses and city buildings. Samples are collected from the top, middle, and bottom of the borehole. All went as far as the permafrost and several boreholes were drilled 2 feet to 3 feet further into the permafrost. Extra boreholes were drilled, at the request of residents, in the following locations: at the old military landfill, north of the water treatment plant, south of the city building, and in the area where the military had stored drums. Boreholes were drilled with guidance from Sivuqaq Board members.

In 2001, the COE attempted to have the lab analyze soil samples for "fuel fingerprints" in three areas (sites 18A, 24, 25B) where there was fuel contamination, but the COE suspected that the spill was new, and not from old DoD activities; the COE will only clean up petroleum spilled by the Department of Defense. The lab was unable to get a good fingerprint, but the COE still suspects that any contamination in these areas is due to City spills. New fuel looks and smell different than weathered oil. The smell and feel of petroleum residues found at three sites seemed like new fuel.

B. Metals

Arsenic was consistently high in nearly every single soil sample taken, both at the surface and beneath the surface. The fact that arsenic levels remained consistent throughout the depth of a borehole indicates that the arsenic is natural to the soils; if it were military in origin, arsenic would likely be high at the surface but decrease at depth.

The city tests drinking water for arsenic levels regularly. It was last tested in 1995, and was low enough that the State granted a 9 year waiver to the city of Gambell, meaning that it normally would not need to be tested again until 2010. The State of Alaska has changed the "safe" level of arsenic in drinking water recently, so Gambell will be required to do a one time test for arsenic again this year.

Other than arsenic, high levels of metals were only found at Site 12 (between Troutman and Nayvaghaq Lakes) Extremely high levels of lead and chromium were in the northern barrel dump area. The COE believes that the metal contamination is in a very small area (a "hotspot") and will not require removing large amounts of soil.

C. Dioxins

Dioxins were only tested for at Site B, the radar building that burned. Dioxins are formed during incineration (waste incineration, burning buildings, burning off spilled oil), open burning, and from detonating explosives. Dioxins were found at Site B after the cleanup by OSCI, so more soil will need to be removed.

D. Unexploded Ordnance (UXO)

1. Ammunition

Because of the potential danger of setting up live ammunition, contractors investigating contamination around Gambell specifically avoided areas where residents told them there might be buried ordnance. Instead, they noted the areas and contacted professionals to survey the areas and dig up suspected ammunition.

In the summers of 2000 and 2001, experts from Earth Tech corporation, from the Huntsville, Alabama Army Engineering and Support Center, and from the Alaska District COE worked with the City, Village, and Corporations of Gambell to investigate areas that were said to have buried ordnance. They worked with Mayor James, Mr. Morgan Apatiki, Mr. Ivar Campbell, and Mr. Vernon Slwooko to locate areas where buried ordnance was suspected.

a) Land Investigations

Four areas on land (total of 3 acres) were investigated: sites A (including A1, A2), B, D, and F.
All land areas were located with the help of residents.

First, investigators walked over the areas, with several people walking next to each other, and picked up any metal debris that was 1" x 2" size or larger. This was called a "surface sweep". The surface sweep was done at each location before geophysical surveys were started; signs of ordnance seen on the surface would give an indication of how extensive the survey should be.

Once the surface sweep was completed, and all surface debris was removed, the subsurface investigation began. Geophysical equipment (magnetic and electromagnetic) was used to locate "anomalies"; that is, anything different from the background. Then metal detectors were brought in to find the center of anomalies. If metal detectors could not locate an anomaly, marking paint was used to define the general area located by the geophysical equipment. Once an anomaly location was marked, investigators dug down until a source was found. Excavations were examined by the UXO supervisor, who made sure that no more metal was at the location. After sources had been identified and removed, pits were backfilled.

On land, 173 subsurface anomalies were found. All of them were investigated in summer 2000.

b) Results of Land Investigations

Site A, A1, A2 (Air Force Burial Site, 0.5 acres on gravel spit northeast of village)
Residents reported 120 cases of .30 caliber and .50 caliber ammunition buried 6 – 8' deep. Sites were located with the help of Mayor Winfred James, Mr. Morgan Apatiki, Mr. Ivar Campbell, and Mr. Vernon Slwooko.

During subsurface investigations of site A, 46 anomalies were found. The source of every anomaly was non hazardous, non ordnance scrap metal.

Site B (Radar Site, 0.06 acres on top of Sevuokuk Mountain)
A fire occurred at site B (radar site) destroyed all buildings and exploded the ordnance in them.

During the surface sweep, five .50 caliber casings were found. During the subsurface investigation, fourteen anomalies were found; five anomalies were ordnance. Found were:3 .30 caliber brass casings, 1 .30 caliber link, 1 case of .22 ammo. Site was located with help from Mayor Winfred James and Mr. Morgan Apatiki.

Site D (Beach Burial Site, at West Beach, south of Troutman Lake, 0.5 acres)
Small arms ammunition and hand grenades were reportedly buried in a cache on the West Beach. Located with help from Mayor Winfred James and Mr. Morgan Apatiki.

During the surface sweep, one live .30 caliber shell was found, and 3 spent .30 caliber shells. During the subsurface investigation, five anomalies were found. One was non ordnance scrap, but the other four were ordnance. Three pits were found, 4' wide by 2' deep, and in them were wood pieces from ammunition outer packs, two metal ammo cans, and 880 live rounds of .30 caliber cartridges. *More live ammunition remains in the area.* The remaining ammunition is mixed in with about 100 cubic feet of loose gravel, and will take a lot of sifting to separate.

Site F (High School yard, 2 acres):
Small arms ammunition, and grenade pins and spoons were found when the high school was being built. During subsurface investigation, 108 anomalies were found; no ordnance related materials were found.

c) Lake Investigations

The lake was first surveyed when it was frozen (May 2000, April and May 2001) so that equipment could be towed in a grid system to make sure that the entire area of the lake was thoroughly covered. The instruments used were magnetic and electromagnetic systems capable of detecting metallic debris to at least 20' below ice surface, and able to detect metal scrap as small as 1"x3".

During the survey, 64 anomalies were found. Many were investigated while the lake was still frozen, by drilling holes in the ice with an ice auger and lowering an underwater camera through the hole to photograph the cause of the anomaly. 55 gallon drums and pipes were found.

The ice auger method could not be used to investigate targets where the ice went all the way to the lakebed, and it was limited in that only areas right near an ice hole could be photographed.

To do more thorough investigation, they went back in August 2001 when the lake had thawed and used an inflatable boat with underwater camera, sea view boxes, depth sounding lead, dredging anchors, and geophysical equipment. If an anomaly source could not be identified by sight, geophysical equipment was used to verify whether an anomaly was there. If the location of an anomaly was verified, but no source could be seen, the lake bottom was dredged and samples collected. During the investigation, visibility to bottom of lake was high.

d) Results of Lake Investigations

Surprisingly, there was no evidence of ammunition in the lake.

With the equipment used, "even loose rounds would present a very pronounced magnetic anomaly"[52], and scrap as small as 1" x 3" was detected. Of 64 anomalies found, 17 were geologic in origin and 29 were non ordnance scrap such as runway matting, drums, and pipes.

No metallic or geologic source could be identified for 9 anomalies, but the area where all nine were found was flat lakebed. This area was studied in detail. An anomaly was found that appeared to be 500' in width. During the winter investigation, ice auger holes indicated a flat lakebed with no mounds or piles. Samples of lakebed found only gravel and fine sediment.

The area was reinvestigated in August 2001. Investigators found dark, smelly, sludgy to silty sediments, indicating high levels of minerals, probably iron. The underwater vegetation was different in this area. No metallic sources were seen, and none were found with anchor dredging. The anomaly is near a drainage entry point; the anomaly was assumed caused by iron minerals in the lakebed sediments.

e) Summary of Ordnance Investigation

Area B has had all ammunition removed from it. A large amount of ammunition was found at area D, but because many of the bullets were so mixed in with the gravel, some live ammunition remains. Aboutt 100 cubic feet of gravel still need to be sifted through to find all the bullets. No ammunition was found around the schoolyard.

It is puzzling that residents were able to describe very specifically the amount and type of ammunition buried at site A and in the lake, yet investigators were unable to find any evidence of ordnance despite help from eyewitnesses and very good equipment.

The report that came out of the 2 – year ordnance investigation recommends distributing pamphlets and putting up posters on how to handle ordnance if any is found. The military ammunition is different than regular sporting bullets in that it has a full metal (steel) jacket. This means that it is not a hazard unless it is actually shot from a gun. If it is thrown in a fire, it may discharge, but at a low velocity, not in a blast.

[52] Quote from May 2002 Gambell EE/CA

Results of Ordnance Investigations

A	gravel spit, base of Sevuokok Mt.	no ordnance	46 anomalies – all non ordnance scrap
A1	gravel spit, base of Sevuokok Mr.	no ordnance	no anomalies
A2	gravel spit, base of Sevuokok Mt.	no ordnance	2 anomalies –both non ordnance scrap
B	Radar site	**ordnance found**	
		14 anomalies – 1 mistake, 8 non ordnance scrap, 5 ordnance related .50 cal brass casings (5), .30 cal brass casings (3), .30 cal link (1), case of .22 cal (1)	
C, G	Troutman Lake	no ordnance	
		64 anomalies—17 geologic, 29 non ordnance scrap, 9 possibly iron in sediment	
D	West Beach	**ordnance found** 5 anomalies – all ordnance live .30 cal cartridges (880), spent .30 cal cartridges (3), wood pieces from ammo packs, 2 ammo cans. *Live rounds remain in the gravel.*	
F	High School	no ordnance	108 anomalies – 1 mistake, 2 surface debris, 105 non ordnance scrap

2. Explosives Residue

When explosives are detonated, dioxins and certain residues are left behind. At site 4B, where a fire destroyed a building and ammunition, dioxins were tested for and found. Other explosive residues were not tested for. Site 4B was the only place in Gambell that dioxins were looked for. Site 2 (Former Military Housing) was the only place that explosives residues were looked for; dioxin testing was not done (see information box "Explosives Looked for in Gambell"). Water and soil were tested for chemical residues, and none found. Background sites had soil and water tested for chemical residues, with none found.

VI. Water Contamination

A. Surface Water and Groundwater

Virtually no groundwater has been found in boreholes and monitoring wells drilled throughout the Gambell area. Groundwater was only found around "thaw bulbs" (unfrozen ground around buildings), lakes, and the beach. No contamination was found in any groundwater, except at three locations.

Site 6	Arsenic levels in water were elevated (36 – 50 ppb; regulation is 10 ppb)
Site 7	In 1994, trace amounts of DRO and VOCs (naphthalene, toluene, xylenes) were found. No groundwater has been tested since then. Subsurface soil, tested in 2001, had high levels of DRO.
Site 17	Arsenic levels in water were elevated (13 – 26 ppb)
Site 18	Arsenic levels in water were elevated (19 ppb)
Site 18A	Fuel was found in groundwater. However, it was clean product and smelled like fresh fuel. It was assumed that this was from the City of Gambell fuel spill.
Site 5	In 1997 or 1998, slightly elevated concentrations of DRO were found in a monitoring well. This is discussed under "Drinking Water". Metals were not tested for.

No surface water was tested for contaminants, but sediments in streams on top of Sevuokuk Mountain were tested for PCBs. Trace levels of PCBs were found in the sediments from site 4D; because of this, extensive testing for PCB and other contamination was done at site 5, below 4D (see "Drinking Water").

B. Troutman Lake

Troutman Lake and Troutman Creek were tested by the DEC in 1991. Water was tested for PCBs, VOCs, herbicides, pesticides, and metals. No arsenic was detected. No contamination was found, but lead levels in Troutman Creek were at EPA recommended levels, and above recommendations in Troutman Lake. The water was *not* tested for explosives residues.

C. *Drinking Water*

Extensive testing has been done on Gambell's drinking water supply (site 5) by the COE and City of Gambell (in cooperation with Alaska Department of Environmental Conservation and Norton Sound Health Corporation).

1. Testing by the COE

In 1996, groundwater was tested from monitoring wells and from the infiltration gallery (where water collects before being pumped). There was no DRO, VOC, BTEX, or PAH contamination. They did not test for metals.

In 1996, geophysical surveys showed that metal was buried at Site 5. There were concerns that this could be transformers, which could pollute the water supply, but when it was excavated in 1997 it turned out to be non-hazardous debris. Groundwater from the water well was collected before and after the excavation. Trace amounts of DRO were found before and after excavation. BTEX, VOCs, PCBs, RRO and GRO were below detection limits.

In 1998, five monitoring wells were installed around the village water supply to provide "early warning" of potential contamination, and to provide groundwater samples. Samples were tested for odor, taste, BTEX, GRO, DRO, and PAH. Trace amounts of GRO, and one slightly elevated concentration of DRO was found in the monitoring wells (*not* in the village water tested). The level found was 1.9 ppm, and the regulations require 1.5 ppm or less. No high DRO was found in later testing.

2. Testing by the City of Gambell

The city is required to run several tests on drinking water. Village Safe Water did extensive testing in 1991 (for inorganic chemicals, pesticides, and VOCs) and found no contamination. Further testing in 1992 (for pesticides, PCBs, VOCs, and BTEX) also found no contamination.

The following information is from the City report of April 1, 2002.

Monthly: tests for coliform bacteria

Yearly:
- Nitrates (tested October 2001; due 2002)
- VOCs (tested October 2001; due 2002)
- lead and copper (due October 2002)
  - *note: high concentrations of copper were found due to pipe corrosion

Occasional:
- asbestos (never tested for, waiver until 2004)
- Nitrite (one time sample, done in 1995)
- Organic pesticides (never tested for, waiver until 2004)
- Radiation (tested in 1999; next due in 2003)
- Arsenic (one time sample required 2002 due to new regulations)
- Metals: Sb, Be, Ni, Th, cyanide (tested October 2001; next due 2002 - 2010)
  Tested every 9 year cycle
- Metals: As, Ba, Cd, Cr, Fl, Hg, Se (tested September 1995; next due 2002-2010)
  Tested every 9 year cycle

Arsenic was not detected at all. Copper and lead have been found at elevated levels. These metals get into the drinking water when copper pipes or lead solder corrode. Information from the April,2002 report shows the following information on the highest levels found, of ten homes randomly tested each year.

	5/94	10/94	12/95	3/96	6/96	11/99	11/00	10/01	EPA Action Level
Pb	0.015	0.013	0.015	0.002	0.003	0.005	0.006	0.01	0.015
Cu	0.359	1.02	1.43	0.347	0.652	1.45	1.12	1.458	1.3

Although lead levels never exceeded EPA action levels, they are somewhat high. High levels of lead can cause many health problems, including: delays in physical and mental development in children; kidney problems and high blood pressure in adults. High levels of copper can cause stomach/intestinal problems during short term exposure; kidney and liver damage during long term exposure. It is important that residents be aware of their plumbing, and the fact that corroded pipes may possibly impact health.

Savoonga and Gambell

Global Pollution: Oceans and Air

The next two sections focus on global pollution and marine food sources.

A. How Does Pollution Get to the Arctic?

1. POPs

Pollution is any kind of waste that contaminates our land, water, or air. Some pollution never makes it to the Arctic: for instance, waste from pig farms may contaminate nearby ponds, but bacteria and sunlight break down the waste. It does not travel. Other toxics, like PAHs and metals, travel but do not biomagnify.

If pig waste took years to break down, we would say that it "persists" in the environment. Persistent waste, which we call persistent organic pollutants (POPs), affects the Arctic. "POPs" refers to any chemical that

breaks down very slowly
biomagnifies in fats and animal tissues
is toxic

Some POPs of concern are: PCBs, pesticides (DDT, chlordane, heptachlor, aldrin, dieldrin, mirex, etc).

POPs evaporate in hot weather and re-condense in cooler weather, moving slowly northwards where it is too cold to evaporate. In this way, the Arctic accumulates POPs from around the world.

2. Air

Some pollution is produced close to home. For instance, most dioxins in Alaska come from people burning trash (especially plastics) in burn barrels in the backyard. Some pollution is "natural". Arctic soils are naturally high in many metals, some of which may affect health.

However, many chemicals arrive through "long range transport" from locations where they were accidentally produced or intentionally used. In general, winds move from the tropics northward to the Arctic or south to the Antarctic. In Europe and Asia, air movement to the Arctic is especially strong from November to May.[53]

Say a cornfield in Mexico is sprayed with DDT. Some DDT lands on the crop. Some is blown away on the wind. In the upper atmosphere, it becomes part of water droplets in clouds and eventually falls to earth as fog in San Diego. As the ground warms up, the chemical goes back up into the atmosphere, becomes part of water droplets again, moves with the wind and clouds, and falls to earth again, this time as rain in Seattle. It warms up in Seattle, the chemical rises, and eventually falls with snow in Koyukuk. It "hops" from place to place, evaporating and recondensing until it finally reaches a place where it never gets warm enough to evaporate. Some contaminants, like most heavy metals and benzo(a)pyrene, can only hop once. But most POPs, PAHs, and mercury, can hop many times. (AMAP 1998 p 27).

Contaminants also travel in dust. Huge dust storms from deserts sweep across the world. Storms from the Gobi desert in Asia gather air contaminants from eastern Russia, China, and Japan. Contaminants ride the storms across the Pacific to the western parts of the U.S., Canada, and Alaska. When one such storm hit Washington, the state issued an air advisory for two days[54]. No studies have been done to determine the contaminants in these storms.

Chemicals carried by clouds, air streams, and dust storms fall onto soil in Alaska. They move from soil into nunivagseghat. They land in rivers and lakes, where they get into tiny freshwater animals, fish, and ducks. They land on snow, and get into the soil when the snow melts.

They may also land in the ocean or on pack ice.

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[53] AMAP 1998

[54] Lecture by Michael Smolen of the World Wildlife Fund at the "Alaska Oceans and Watersheds Symposium" June 19, 2002. Anchorage, Alaska.

What are Persistent Organic Pollutants (POPs)?

"POPs" refers to any chemical that
- breaks down very slowly
- bioaccumulates in fats
- biomagnifies in the food chain
- is toxic

POPs are man-made chemicals; many have chlorine atoms. Sun, temperature, and bacteria don't break down very quickly, and they are usually able to evaporate in hot weather and re-condense in cooler weather. This allows them to travel long distances by wind and water, continually landing and evaporating, "hopping" slowly northwards. So a chemical used in South America may travel to the Arctic, where it is cold enough that the chemical never evaporates. In this way, the Arctic "gathers" POPs pollutants from around the world.

PCBs and many pesticides are POPs. PAHs and metals are not because they do not biomagnify.

Bioaccumulation and Biomagnification

"Bioaccumulation" means that a plant, animal, or person is able to build up some substance in their body. Many chemicals can be accumulated: metals, toxins, nutrients. Some chemicals cannot accumulate: most vitamins that the body cannot use immediately are flushed out of the system in urine.

"Biomagnification" refers to a situation where a chemical builds up more and more in higher trophic levels. Most chemicals that are able to do this are ones that are stored in fat cells, like POPs. It is the reason that POPs are so dangerous to people, who feed at a high trophic level. When a human eats a plant or another animal, the person is exposed to all the POPs in the animal, and the animal carries all the POPs of all the plants and animals it has eaten. Let's say that a rock represents a toxin in a tiny plant. A small fish eats seven of these plants, and now it has seven rocks inside it. A larger fish eats five small fish, and now the large fish has 7 x 5 = 35 rocks inside it. A seal eats 10 large fish and now it has 35 x 10 = 350 rocks inside it. Toxins degrade over time (this is like saying a rock will disintegrate) so animals do not keep ALL of the "rocks" or toxins from all of the plants and animals it has eaten, but they degrade slowly. Older animals have the most POPs because they have eaten the most food, and more "rocks" have been transferred to them.

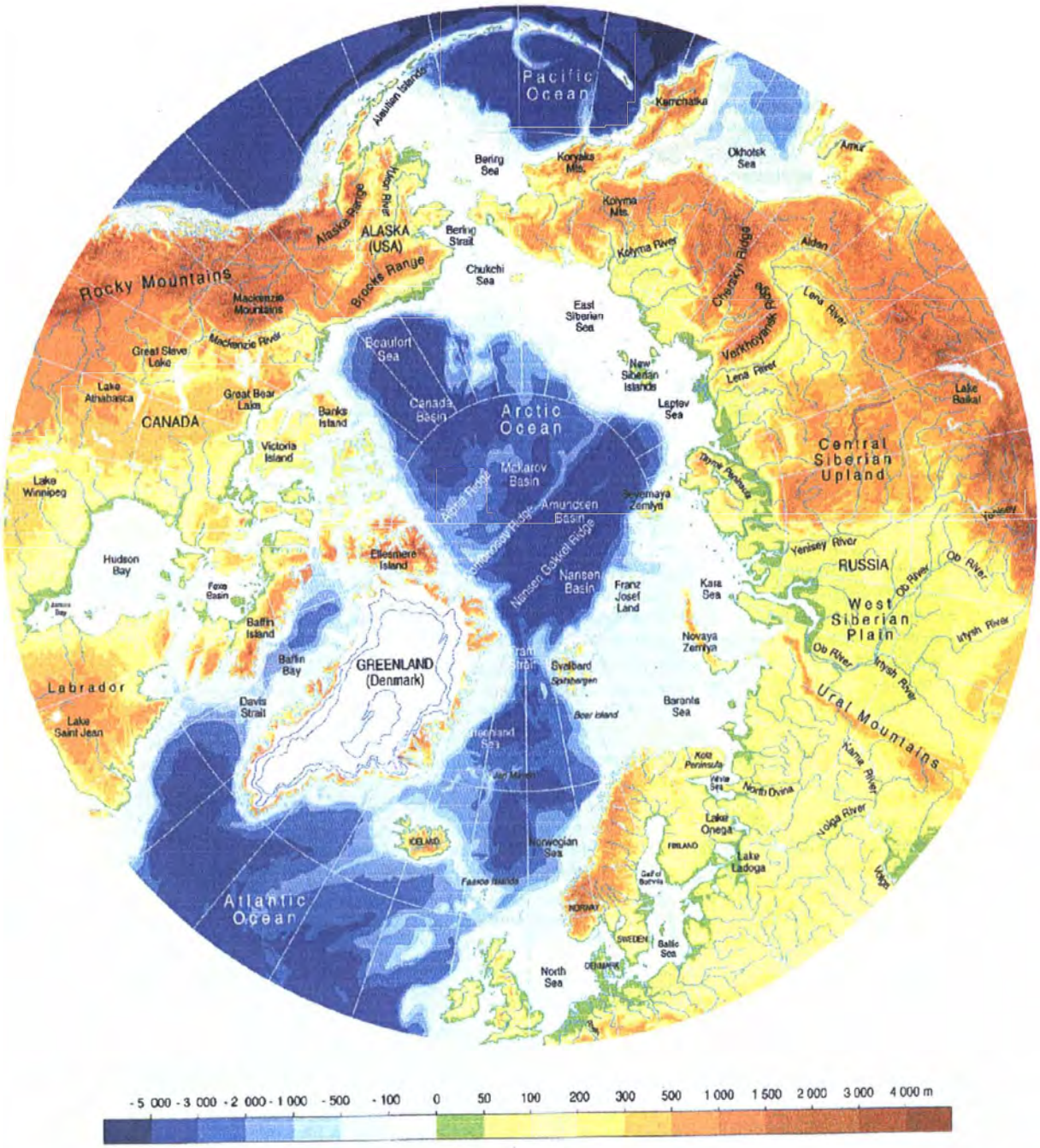
Not all toxic substances biomagnify. For instance, some metals can be toxic, and they will accumulate inside a plant or animal over their lifetime, but they do not biomagnify.

What is a Trophic Level?

Trophic level is a concept about who eats whom. Plants are considered the lowest trophic level, Level 1, because they don't eat anybody. Reindeer, plant eating fish, plant eating birds, and vegetarians would be trophic Level 2. A man who eats a reindeer, or who eats a plant-eating fish or plant-eating bird would be Trophic Level 3. If a fish or bird eats a plant-eating fish, then it is Trophic Level 3. If a seal or a man eats the carnivorous fish, then they are at Trophic Level 4. If a man, polar bear, or ayveq eats a seal, they are at Trophic Level 5. Here are some examples:

Algae is eaten by clams which are eaten by a ayveq. The ayveq is at Trophic Level 3.
Algae is eaten by a plant-eating fish, which is eaten by a murre (fish-eater), which is eaten by a ringed seal, eaten by a man. The man is at Trophic Level 5.
Lichen is eaten by a reindeer which is eaten by a man. The man is at Trophic Level 3.

The more "steps" in the food chain, the higher the trophic level, and the greater amount of POPs concentrate.



Topography and bathymetry of the Arctic (based on the ETOPO5 data set, NOAA 1988).

Map 5: Circumpolar Map
From AMAP 1998

3. Oceans and Ice

When farmers in Mexico spray corn with DDT, some DDT goes into the air and eventually falls into creeks, rivers, or oceans as fog, rain, or snow. Some may land directly in creeks near the cornfield, and eventually make it to an ocean.

Western Alaska is fortunate. Like air currents, water currents flow generally north from the equator to the arctic (or south to the Antarctic). However, most of the water that goes into the Arctic Ocean (80%) comes from the *Atlantic Ocean* and flows past Greenland. Only 17% comes from the Pacific, through the Bering Straits. The rest comes from rivers, mostly Russian rivers and the McKenzie River in Canada. Water that leaves the Arctic Ocean also mostly feeds out past the Canadian high arctic islands and Greenland.

What this means is that most of the contaminants that come down rivers into the ocean never go past western Alaska; and indeed, studies of marine mammals show western Alaskan mammals to be generally much less contaminated than those from eastern Canada, Greenland, Norway, or even Barrow.

Map 6: Ocean Currents

AMAP 1998 Figure 2-20

Once contaminants get into the Arctic Ocean (from the Atlantic, Pacific, or air), they can last a long time. Those in the surface waters of the Arctic Ocean circulate for about 12 years before flushing out. Those in deeper layers circulate about 30 years; and those at the bottom may stay for hundreds of years.

Pack ice is somewhat of an exception to the rule of contaminant movement. Ice "collects" contaminants that fall out of the atmosphere all winter; when it melts in the summer, the whole collection may realease quickly. Unfortunately, this happens during the most productive times in the Arctic, when phytoplankton are blooming, fish fry are feeding, and young animals are born. Scientists are just starting to study the affect this annual summer release may have.

B. What are the most Abundant Contaminants in the Arctic?

Again, we turn to Canadian studies, since the US has not looked into this.

The most commonly seen global POPs are the pesticides HCH, DDT, endosulfan, dieldrin, endrin, chlordanes, toxaphene, and mirex, and the industrial chemical PCBs. The most common PAHs are fluorene, fluoranthene, phenanthrene, and pyrene. The only metal that travels far is mercury, and to some degree lead. Most metals contamination is due to natural soils or a local pollution source; Canadian studies of recently active DEW radar sites showed extensive lead contamination up to 12 miles from the source, but no further[55].

Land: land in the Canadian arctic was found to be high in
PCBs (global and local military sources)
Cadmium (natural in the soil)
Lead (from military sources)

[55] CACAP 1997 page 225

Rivers, Lakes: High in
mercury (global and natural)
toxaphene (global)
PCBs (global)
Concerning fish, the larger the fish, the more of these contaminants they will have.

Oceans: High in
mercury (natural) in the western arctic
cadmium (natural) in the eastern arctic
toxaphene in the lower end of the food chain (global)
PCB and DDT over most areas (local and global sources).

Studies like these help Alaskans understand the contaminants that affect them and what to look for. They also help us track trends. For instance, as more countries ban PCB and DDT levels have been *decreasing* in soil, water, and animals over the last ten years or so. Although these contaminants break down slowly, they *do* break down. If no PCB or DDT is produced, used, or spilled, eventually our world will be free from these toxins.

Arctic studies also help us track contaminants that are *not* decreasing. For instance, the pesticide γ–HCH (lindane) is still in use in Russia, India, US, Canada, Japan, and Iceland. HCH is *not* decreasing in the Arctic yet.

We can also track new chemicals and contaminants, possibly before they become a serious problem.

Figure 9: Current Use of POPs

	US	Canada	Russia	Iceland	Norway	Sweden
Chlordanes	restricted 1988	not registered 1990	banned	banned 1996	not marketed since 1967	banned 1971
DDT	banned 1972	withdrawn 1985	banned	banned 1996	banned 1988	banned 1975
HCB	not registered 1984	not registered 1976	not known	Banned 1996	withdrawn 1987	withdrawn1980
α–HCH	restricted 1977	restricted 1977	probably in use	never registered	no information	banned 1989
γ–HCH (lindane)	restricted 1983	restricted	in use	restricted	banned 1991	banned 1989
Mirex	banned 1988	never registered	no information	never registered	never used	never used
Toxaphene	not used since 1986	withdrawn 1982	restricted 1992	banned 1996	never used	not since 1950s
Endosulfan	still used	restricted	no information	restricted	still used	withdrawn 1995
PCBs	closed use	closed use	still made	banned 1996	banned 1995	banned 1995

From CACAP p 18

Figure 10: Abundant POPs in Arctic Air and Water

Most POPs Produced Globally 1950 – 1992	Most abundant in arctic air (Canada, Russia)	Most abundant in fresh snow (Canada)	Most abundant in old snowpack (Canada)	Most abundant in seawater
HCH	HCH	HCH/PCB	PCB	α HCH
DDT	PCB	DDT/HCB/chlordane	HCH	HCB
Toxaphene	Toxaphene/chlordane/endosulfan		DDT/HCB/chlordane	γ HCH
PCB	pentachloroanisole			toxaphene
	Chloroveratroles			chlordane/PCB
	DDT/dieldrin			DDT
	Octachlorostyrene			
	Methoxychlor/endrin			
	Trifluralin/mirex			
	Fluorene/phenanthrene/flouranthen/pyrene			

From CACAP p3, listed in order of abundance

Figure 11: POPs in St. Lawrence Island Animals

Reindeer	Bearded Seal	Ayveq	Murre Eggs
DDT	PCB	HCH	DDE
Endrin	DDT	PCB	PCB
Endrin aldehyde	HCH	DDT	HCB
α–chlordane	HCB		mirex
endosulfan			
heptachlor			

IX. Marine Mammals, Marine Birds and Contamination

In this section, contaminants in alpa manik, bearded seal, and ayveq are presented. These animals move around and are affected by global contamination more than by pollutants left at Northeast Cape. At the end of this section, St. Lawrence Island animals are compared to similar ones in the arctic.

Animal samples were gathered just the way people eat them -- eggs from the cliffs, rendered seal and ayveq oil, seal and ayveq blubber, some dried meat, some meat stored in oil – in order to see what contaminants are in food the way it is eaten. All were gathered from in or around Savoonga.

This section only explores whether contaminants may be affecting the animals and birds themselves; whether contaminant levels are affecting people who eat them is discussed in Section XII "Human Health".

A. Bearded Seal (oogruk)

In 1998, Pam Miller (director of ACAT) received samples of oogruk from Savoonga and Deering. One other study has been done on oogruk: six samples from Bering Sea seals in 1993 – 1995[56]. Savoonga seal was examined for PCBs and the pesticides DDT and HCH.

1. Lipid Weight and Wet Weight

"Lipid" just means fat, specifically the fat tissue in an animal. **"Lipid weight"** is the weight of contaminants in fat. Many contaminants are attracted to the fatty part of a food, not muscle or skin. Analyzing contaminants by "lipid weight" is useful when comparing different kinds of tissues, like blood and meat.

"Wet weight" means the food as you would normally eat it. That is, the amount of contaminants in a piece of meat, rather than the level in just the *fat* of the meat. This is a more realistic way of determining what you are being exposed to when you eat the meat. Either can be used to determine if contaminants are affecting animal health. In this report, all levels are assumed to be wet weight (ww) unless specifically noted otherwise.

Lipid Weight in ppb (nanograms of contaminant per gram of fat in the food item)

	ΣPCB	ΣDDT	ΣHCH	HCB
blubber fat	225	120	62	44
the fat in dried seal meat	130	31	44	

Average Wet weight in ppb (nanograms of contaminant per gram of whole food eaten)

Oogruk	s-PCB	s-DDT	s-HCH	HCB
Entire blubber piece	128	70	37	35
piece of dried meat	2.6	0.6	0.9	
EPA guidelines protecting fish –eating wildlife (not species specific)	*160*	*39*		
General IJC[57] guidelines (not species specific)	*100*	*1,000*		

The lipid weight chart shows that PCBs concentrate at higher levels than pesticides in fat tissues. It does not tell us *why*. The animal may be exposed to more PCBs, or may metabolize and eliminate pesticides more easily.

The lipid weight chart also shows that blubber fat attracts more contaminants than meat fat does.

The higher the level of fat, the more similar lipid weight and wet weight levels will be. Notice that *all* of the lipid weights are higher than their wet weight counterparts. Most of the contaminants are in the fat (lipid) so if you just weight the amount of contaminants in fat you will get a high number. If you weigh the contaminants in the whole piece of meat—fat, muscle, and skin – the small weight of contaminants in the muscle and skin averaged with the contaminants in the fat make for an overall smaller number.

[56] Bering Sea samples from Krahn, 1997, quoted in Santillo unpublished. Different labs were used to analyze contaminants in seal in 1995 and in 1998.
[57] International Joint Commission

2. PCBs and Oogruk Health

What health problems could excessively high PCBs result in? PCBs affect liver, kidney, thyroid, reproductive, and immune systems. Often obvious problems, like population declines or deformities, are not seen. Subtle low level health problems, such as slightly lower activity levels, or fewer antibodies produced, are often the first signs of exposure. It is extremely difficult, outside of a lab, to tell what level of PCBs or other toxins affect an animals health to the point that it affects the life of the animal.

The amount of PCBs in any individual seal depends on the age and sex of the seal, whether it eats mostly fatty or mostly lean fish, whether it is going through a time of starvation, and so forth. It is not possible for us to say that any *one particular* seal is unsafe.

The average PCB level for Savoonga oogruk blubber was 128 ppb wet weight, with maximums of 318 ppb. No studies have been done on oogruk to see how much it takes to begin to affect health, but many studies have been done on ringed seals (neghsapik) and harbor seals. Levels of 25,000 – 77,000 ppb lipid weight (we can guess that this would be 15,000+ ppb wet weight) caused changes in the immune or reproductive system of seals in lab tests. Levels seen in arctic neghsapik ranged from 241 ppb – 5700 ppb wet weight and Savoonga seal blubber had 128 ppb; these are much lower than levels that harm seal health. Average oogruk PCB levels were also lower than guidelines the EPA sets for "protection of fish-eating wildlife[58]" (which is 160 ppb wet weight), although the maximums were higher than EPA guidelines, and averages were higher than IJC guidelines. Subtle memory problems were seen in humans at 500 ppb lipid weight, and some oogruk may approach this level.

It is important to remember that each species has different "tolerance levels" to a contaminant and mix of contaminants. If oogruk have similar tolerances as ringed and harbor seals, then PCB levels are too low to cause them any health effects, but whether tolerances are indeed similar has yet to be proven.

3. Pesticides and Oogruk Health

What about DDT? Of *pesticides* analyzed for, DDT was the highest at 70 ppb wet weight (120 ppb lipid weight). Again, the highest levels were found in blubber; meat was low. Bering Sea oogruk, studied in 1995 had similar levels, about 100 ppb. These are higher than EPA guidelines for "protection of fish-eating wildlife", which is set at 39 ppb, but lower than guidelines set by the IJC of 1000 ppb.

Studies on actual seals are more indicative of levels that will cause problems than general EPA or IJC guidelines are. Again, affects of DDT on oogruk have not been studied, but neghsapik have been. Neghsapik tend to have higher levels of DDT: 200 – 1600 ppb. Even these higher levels are lower than amounts that cause reproductive and immune system changes[59]. Levels of 3,000 ppb wet weight are needed before DDT affects gull eggs. The WHO[60] recommends human blood levels be below 200 ppb. We can guess that DDT in Savoonga oogruk is not causing them to have health problems.

What about HCH and chlordane? These pesticides were only seen at low levels.

HCB is also low at 35 ppb. While studies have not been done to see how much HCB it takes to affect marine mammals, levels of 190 ppb in sea eagle eggs (Norway) were enough to cause eggshells to be thinner than normal, but not thin enough to cause the eggshell to break or affect reproduction

4. Are Contaminants Affecting Oogruk?

PCBs:	lower than levels known to cause problems in neghsapik and harbor seals but possibly high enough to cause some very subtle effects
Pesticides:	DDT, HCH, chlordane, HCB levels are low.
Metals:	not tested

[58] AMAP 1998 page 296

[59] This was determined using TEQ equivalents; muscle contaminant levels not available.

[60] World Health Organization.

B. Ayveq (ayveq)

Ayveq has been studied more than oogruk. Ayveq from Savoonga were sampled in 1994 and 1998 for PCBs and pesticides. The wet weight contaminant levels are as follows:

Average Wet weight in ppb
(nanograms of contaminant per gram of whole food eaten)

Ayveq	s-PCB	s-DDT	s-HCH	HCB
Piece of blubber, 1998	61	9	110	Very low
1994	103	4	413	
EPA guidelines to protect fish eating wildlife	*160*	*39*		
General IJC[61] guidelines (not species specific)	*100*	*1,000*		

1. PCBs and Ayveq Health

The average levels of PCB in ayveq are lower than EPA guidelines protecting fish-eating animals, and lower than levels found in nearly all ayveq tested throughout the world, which range from 100 – 11,000 ppb. As discussed in the section on oogruk, no studies have been done on ayveq to see what amount of PCBs it takes to affect their health, but tests in seals showed that there were no affects on seal health until levels had reached 25,000 – 77,000 ppb lipid weight. Subtle short-term memory loss has been seen in human babies who have cord blood levels of 500 ppb lipid weight, and ayveq are still well below this level. It is unlikely that PCBs are affecting ayveq health.

2. Pesticides and Ayveq Health

The contaminant of most concern in ayveq is actually HCH (a pesticide), not PCB or DDT.

HCH levels in ayveq are fairly high, about 110 ppb in blubber in 1998, and up to 413 ppb in blubber tested in 1994. These levels are much higher than what is seen in fish, seals, or even other ayveq studied around the arctic, which is unusual, because most animals from St. Lawrence island have *lower* contaminants than ayveq throughout the arctic.

Levels of HCH needed to cause health problems in marine animals is not known. High levels of HCH can disrupt hormones, depress the immune system, and affect kidneys and thyroids. Ayveq may be affected in some of these ways.

3. Trace Metals and Ayveq Health

The studies done by ACAT on ayveq did not look at trace metals. Researchers from US Fish and Wildlife Service have been studying metals in ayveq in Gambell, Savoonga, and other arctic areas since 1981. They find that cadmium tends to be elevated in all ayveq. Ayveq absorb cadmium from the shellfish they eat. The EPA sets a recommendation of 10 ppm (10,000 ppb) for vertebrae kidney and liver tissues. Gambell ayveq livers averaged 11,000 ppb while Savoonga ayveq livers averaged 14,000 ppb. While it is not really known if these levels are affecting the ayveq, levels above 13,000 ppb are thought to interfere with organ function.[62] Other studies say if cadmium levels in the liver are 20,000 – 200,000 ppb, organ function in ayveq may be affected.[63] St. Lawrence Island ayveq generally range just below the level that could affect organ function, but should continue to be monitored.

Cadmium, while elevated, remained roughly the same from 1981-1989. So did mercury and zinc.

But arsenic levels significantly *increased*. Arsenic was not found in ayveq from Nome, Diomede, or Wales when analyzed in 1981-84, but *was* found in ayveq from Gambell, Savoonga, and Zakharovo Russia in those years Gambell and Savoonga ayveq analyzed again in 1986-89 were found to have greatly increased levels of arsenic in their livers.

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[61] International Joint Commission
[62] Warburton 1993
[63] AMAP 1998 p 437

This does not necessarily mean that arsenic is harming the ayveq. Arsenic is absorbed from food, then rapidly excreted in urine, so that high levels usually indicate that ayveq are continually being exposed to arsenic not that they are accumulating it. Also, arsenic is known to protect against selenium poisoning in some species, so it may in part be playing a protective role (note that selenium levels have decreased). Marine invertebrates are known to be safe with much higher levels of arsenic.

Although it is not necessarily harming ayveq, studies should continue to monitor arsenic levels and try to determine why there was such a great increase in just a few years. Studies also need to try to find out why lead levels increased so much in all ayveq tested. Could there have been an increase in dust storms between 1984 and 1989 that might have brought heavy metals from Asian air pollution to western Alaska? If so, why didn't mercury and zinc levels increase? Why are selenium levels consistently decreasing in ayveq but increasing in Spectacled Eiders from the same area?

Metals interactions are extremely complex, and are different for each species. It may be many years before these questions can be answered.

	Arsenic	Cadmium	Lead	Mercury	Selenium	Zinc
1981-84 Gambell	10	11,180	20	1,720	2,240	44,170
1981-84 Savoonga (females only)	20	14,410	50	900	2,320	47,250
1981 – 84 Diomede	0	7,000	40	700	2,380	Not tested
1986, Diomede	100	5,025	150	925	1,050	65,775
1988, Gambell and Savoonga	125	7,350	175	1,150	1,500	50,475
1989, Diomede	50	8,025	125	675	1,650	55,775
EPA recommendation, ppb		*2500*				
Levels known to affect marine mammals, ppb		*13,000*[64]		*60,000+*		
Toxic levels in domestic animals, ppb	*10,000*	*20,000*	*10,000*	*5,000*	*2,500*	*200,000*

Figure 12: Metals in Savoonga, Gambell, and Diomede Ayveq liver, 1986 – 89
(ppb wet weight[65]*)*

4. Are Contaminants Affecting Ayveq?

PCBs: levels are low

Pesticides: **HCH** levels are potentially a concern for ayveq. HCH is known to affect the immune system, kidney, thyroids, and hormones. DDT, HCB, and chlordane levels are low.

Metals: **cadmium** has been consistently elevated for the past ten years; **arsenic** and **lead** have recently increased. It is thought that liver levels of cadmium over 13,000 ppb may affect kidney and liver function; levels over 20,000 ppb are known to affect organ function in some animals. In birds, cadmium damages the heart, kidney and testicles; lead causes curved spines in fish and damages the nerves of birds and humans. Arsenic is probably in the non-toxic organic form.

C. Murre Eggs (alpa manik)

Wilfred Miklahouk and Douglas Gologergen gathered alpa manik in late June 2001 near Savoonga; 11 eggs were analyzed for PCBs and pesticides.

1. PCBs and Murre Health

Savoonga murres eat a lot of arctic cod[66], so we expect them to have higher PCB levels than cod, due to biomagnification. Cod at Savoonga have not been analyzed for contaminants, but blackfish, dolly varden, and pink salmon from Northeast Cape rivers have been[67]:

Fish, NEC:	20 – 160 ppb
Alpa manik, Savoonga:	47 - 142 ppb (average 82 ppb)

[64] Taylor et al 1989 consider 13,000 ppb wet weight to be a significant hazard. They consider 10,000 ppb in kidney or liver, or 2,000 ppb whole body to be considered cadmium contamination but health effects at this level are unknown.

[65] Levels were reported in Warburton 1993 as dry weight. For ayveq liver, they reported that 4.2 ppm dw = 1.1 ppm ww. Therefore approximate wet weights were derived by dividing dry weight by 4.

[66] Personal communication, Adrian Gall, Oregon State University

[67] Fish were analyzed in one lab, eggs in another; analyses from different labs are not always directly comparable.

Dollies and pink salmon from the Tapisaghak river average 20 – 30 ppb PCBs; we can guess that arctic cod have similar levels and alpa manik are slightly higher from concentrating the contaminant.

Most alpa manik in the arctic (Canada, Norway, Russia) average 300 – 500 ppb PCBs (See Section IX "Marine Mammals, Marine Birds, and Contamination"). Studies with herring gulls, bald eagles, and cormorants show that egg survival is not affected until levels reach 3500 – 5000 ppb[68]. Levels as high as 5000 ppb had no affect on peregrine falcon eggs.

It is unlikely that PCBs are affecting the survival rates of alpa manik.

2. Pesticides and Murre Health

Alpa manik were analyzed for the pesticides DDE, HCB, and mirex. DDE is the chemical that DDT breaks down into, and is toxic just like DDT. HCB was used as a fungicide until the 1980s and is a byproduct of incinerators. Mirex is a pesticide that was used in Alaska until 1988. Fish-eating birds tend to have higher mirex levels than other birds.

DDE levels were well below levels known to cause eggshell thinning in birds. The smallest amount of DDE that affects birds in any way is 290 ppb in chicken eggs, a level that causes deformities in chickens. Sea eagles were not affected until the DDE levels in eggs reached 3,000 – 5,000 ppb.

Although HCB was found at a lower level than DDE, HCB is more toxic. Nonetheless, HCB levels are probably too low to cause health problems in murres. Levels of 40 –100 were commonly seen in thick-billed alpa manik from arctic areas. Levels of 190 ppb in sea eagle eggs (Norway) did not affect eggs or survival rates. Except for sea eagles, the levels of HCB needed to cause health problems in arctic birds have not been studied, so we cannot say what level of HCB (or mix of DDE, HCB, and PCBs) will affect the birds.

Mirex levels are low. No studies have been done on arctic bird eggs to determine mirex levels, but in arctic falcons (Norway and Russia), eggs ranged from 2 – 150 ppb wet weight. Levels of 150 ppb did not appear to affect the eggs.

Lipid Weight: Pesticides in alpa manik, ppb (nanograms of pesticide per gram of tissue)

Contaminant	*Average level*	*Minimum*	*Maximum*
DDE	662	189	2099
HCB	334	184	482
Mirex	13	8	19

Wet Weight: PCBs and Pesticides in alpa manik, ppb (nanograms of pesticide per gram of tissue)

Contaminant	*Average level*	*Minimum*	*Maximum*	*Concern Level*
DDE	78	26	242	25,000
HCB	39	23	56	>190
mirex	2	1	2	>150
PCB	82	47	142	1,000 – 5000[69]

3. Are Contaminants Affecting Murres?

PCBs are lower than levels known to affect egg survival.
DDE is lower than levels known to affect egg survival.
HCB is lower than levels known to affect egg survival.
Mirex levels are low, but few studies have been done to see the effects of mirex.

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[68] AMAP 1998 p293

[69] Lowest PCB levels that caused egg mortality in cormorants, bald eagles, and herring gulls were 3500, 4000, and 5000 ppb wet weight respectively (AMAP 1998 p 293). Concern levels for white tailed sea eagles were 39,000 – 44,000 ppb wet weight. Unpublished research shows that as blood levels increased from 50 to 1,000 ppb, adult survival of glaucous gulls decreased (Bustnes 2002)

Figure 13: Summary of Contaminants Looked for and Found in St. Lawrence Island Plants and Animals

	PAHs										Metals					POPs				
	light aromatics				*heavy aromatics*												*Pesticides*			
	Ace	Ant	Flu	Nap	B(a)a	B(a)p	B(b)fla	B(k)fla	Chr	Fla	As	Hg	Cd	Pb	Zn	PCB	DDT, DDE	HCH	Chlordane	HCB
Nunivagseghat	x	x	x	x	x	x	x	x	x	X	x	x	x	x	x	x	nl	nl	nl	
Suqi Fish *stickleback*											nl	nl	nl	nl	nl		nl	nl	nl	
Blackfish	x		x	x						x	x	x	x	x	x	x	nl	nl	nl	
Dollies, 1999, whole	nl	nl	nl	nl	nl	nl	nl	nl	nl	NL	nl	nl	nl	nl	nl	x	nl	nl	nl	
Dolly varden eggs	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	nl	nl	nl	
Dolly varden fillet	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	nl	nl	nl	
Dolly varden heads	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	nl	nl	nl	
Dolly varden remains				x			x		x	x	x	x	x	x	x	x	nl	nl	nl	
Quang. Fish *stickleback*											nl	nl	nl	nl	nl		nl	nl	nl	
dolly varden											nl	nl	nl	nl	nl		nl	nl	nl	
Tapi Fish																				
Dolly, pink salmon eggs											x	x	x	x	x	x	nl	nl	nl	
Dolly, pink salmon fillet											x	x	x	x	x	x	nl	nl	nl	
Dolly, pink salmon heads											x	x	x	x	x	x	nl	nl	nl	
Dolly, pink salmon remains											x	x	x	x	x	x	nl	nl	nl	
Quyngiq (reindeer) *meat*	x	x	x	x	x	x	x	x	x	x	nl	nl	nl	nl	nl				x	
fat		x	x								nl	nl	nl	nl	nl					
blood											nl	nl	nl	nl	nl		x	x	x	
Alpa manik (murre eggs)	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	x	x	nl	nl	x
Oogruk (bearded seal) *blubber*	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	x	x	x	x	x
oil	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	x	x	x	x	x
dried meat	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	x	x	x	?	
dried meat stored in oil	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	x	x	x	?	
Ayveq (walrus) *blubber*	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	x	x	x	x	x
oil	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	nl	x	x	x	x	x

x = contaminant was found in low amounts

Yellow box = contaminant may be a concern to the health of the animal

blank square means the contaminant was not found

nl = contaminant was not looked for

X. Summary of Contaminants in Plants and Animals on St. Lawrence Island

Contaminant studies help us delineate contaminants coming from a local source, which has the potential to be cleaned up, with contaminants coming from global sources, which require international treaties to eliminate. They do *not* tell us whether *specific* health problems in animals are from contaminants, but provide one more piece of the puzzle to find patterns. PCBs and the vast majority of oil residue contaminants came from the military; metals originate from both natural and military sources. Overlaid on this is the effect of global pollution, which studies of marine mammals helps us determine.

Local contaminants at Northeast Cape include:

Soil: High DRO, PCB, metals Water: High DRO, PCB, metals; low PAH

Global pollutants that affect St. Lawrence Island include pesticides (DDT,HCH, HCB mirex, etc), a few PAHs (fluorene, fluoranthene, phenanthrene, pyrene), PCBs, mercury, and lead-- contaminants that travel to the arctic.

In the chart below, animals most likely affected by global contaminants are in light blue, those likely to be affected by local Northeast Cape contaminants are in purple. Contaminants high enough to be of concern *to the animal* (not to a person eating it) are highlighted; note that highlights for PAHs in fish refers to potential to harm fish eggs. Nunivagseghat are listed as "plants with dust"; further tests may show contaminants are in dust, not plants.

	PCBs (ppb)	DDT or DDE (ppb)	HCH	HCB	Chlordane	mirex	PAHs global	PAHs Non global	Metal
	Average	Average	Average	Average	Average	Average	Max	Max	
Oogruk						NA	NA	NA	NA
Blubber	128	70	37	~35	Very low				
Oil	159	50	39	~0.5	Very low				
Dried meat	3	0.6	1						
Dried meat in oil	19	9	4						
Ayveq (1998)						NA	NA	NA	NA
Blubber	61	9	110	Very low	Very low				Cd
Oil	68	7	109	Very low	Very low				
Alpa manik	82	78		39	NA	2	NA	NA	NA
Quyngiq	ND	5	NA/ND	NA/ND	NA/ND	NA	134	174	NA
Suqi blackfish, 1999	100	NA/ND	NA	NA	NA	NA	11	103	NA
Suqi blackfish, 2001	100	NA/ND	NA	NA	NA	NA	11	37	Hg
Suqi Dollies, 1999	ND - 160	NA/ND	NA	NA	NA	NA	ND	ND	NA
Suqi Dollies,2001	30	NA/ND	NA	NA	NA	NA	21	153	No concern
Tapi and Quang Rivers	20	NA/ND	NA	NA	NA	NA	ND	ND	No concern
Plants with Dust	10-9300	NA/ND	NA	NA	NA	NA	NA	NA	Pb, Hg

NA= not analyzed Contaminant levels of concern highlighted in yellow.

Figure 14: Contaminants in St. Lawrence Island Plants and Animals, 1998-2001*(wet weight, ppb)*

Global contaminants do not appear to be high enough to harm the health of marine mammals, except that Savoonga ayveq have high levels of HCH and cadmium. PAHs and metals dominate Northeast Cape foods.

HCH affects the kidney, thyroid, hormones, and immune systems.
PAHs may affect the growth and development of fish.
Hg is a nerve poison that affects memory, eyesight, and causes insanity.
Cd in birds it damages heart, kidneys, testicles, and slows growth.

A. Northeast Cape: Nunivagseghat, Fish (iqalluget/kayut), and Quyngiq

There is reason for concern about the levels of metals seen in nunivagseghat, and the levels of PCBs in Suqi blackfish. Other Suqi fish should be monitored for PCB levels, which appear to have fluctuated in the last couple of years. It is not known what level of PCBs will affect fish health. Quyngiq appear to have no contaminants of concern, but need to be tested for metals. Fish eggs may be affected by low levels of PAHs.

B. Marine animals: oogruk, ayveq, alpa manik

Contaminant levels in bearded seal (oogruk) were lower than levels known to cause problems in neghsapik.

Ayveq (ayveq) have HCH and metals levels of concern. Savoonga ayveq had some of the highest HCH levels seen in the arctic. They should continue to be tested to see if levels remain elevated HCH affects hormones, the immune system, kidneys, and thyroid. Cadmium in ayveq is consistently elevated. Arsenic and lead have recently increased in ayveq in Western Alaska; but arsenic may be the non-toxic organo-arsenic form. Lead is far below levels known to be toxic in domestic animals, but cadmium approaches levels known to affect organ function. Whether ayveq are actually being affected by metals is not known.

It is not surprising that ayveq have low levels of PCBs, because they eat low on the trophic level and do not have a chance to biomagnify contaminants. Only ayveq that eat seals have high contaminant loads. It is surprising that ayveq concentrate such high levels of HCH, and that needs to be further looked into.

Contaminants in alpa manik are all lower than levels known to cause problems in other birds.

These are general statements; we are missing much of the information that could give us a complete picture. While it appears that fish, quyngiq, and nunivagseghat do not have concerning levels of pesticides, this is because they have not been tested for most pesticides. Similarly, it appears that oogruk, ayveq, and alpa manik are not affected by PAHs and metals, but no one has analyzed them for PAHs and metals. In addition, no organ meat from any of the St. Lawrence Island animals has been tested.

No one has studied the affects of contaminants specifically on murres, oogruk, and ayveq; "safe" levels are determined by comparing levels in these animals to levels known to affect harbor seals and eagle eggs. In addition, while contaminant levels appear to be too low in most animals to affect them, no one has studied the effects of mixtures of contaminants on fetal and pregnant animals.

XI. Circumpolar Comparison of Plants and Animals

How do nunivagseghat and animals of St. Lawrence Island compare to others around the Arctic? The following pages compare contaminants in nunivagseghat, fish, quyngiq, oogruk, ayveq, and murres. Charts are organized with highest contaminant levels at the top.

A. Plants

Canadian studies found PCBs, lead, copper, and zinc elevated in soils and nunivagseghat around DEW radar sites. Cadmium and mercury were not elevated. In Northeast Cape soils, lead, zinc, cadmium, and chromium were elevated, with mercury and PCBs occasionally high. The Canadian study looked at PCBs in 525 nunivagseghat and associated soils, and looked for lead in 617. About 20 Northeast Cape nunivagseghat were sampled. Only nunivagseghat in the most polluted areas of Northeast Cape were sampled; no attempt was made to sample consistently further away to see the extent of comtamination. Nunivagseghat growing in the sewage outfall area were not tested, despite the fact contaminants are commonly dumped down drains, ending up at the sewage pipe outfall.

Despite the fact that the Northeast Cape site was closed over 30 years ago, we see that Northeast Cape soil remains more contaminated compared to Canadian counterparts. Nunivagseghat information is not directly comparable at this time, but ACAT will make comparisons when they receive full information on the nunivagseghat samples.

	Lead	*PCBs*
Suqi River Drainage, nunivagseghat[70], ppb dw	65 – 11,300	10 - 9300
Suqi River Drainage, soil, max, ppb	822,000	180,000
Canadian DEW sites, recently closed,max nunivagseghat, ppb ww	1,120,000	49,000
Canadian DEW sites, recently closed, soil, max ppb	2,780,000	320,000
Canadian DEW sites, closed 30 years ago, nunivagseghat, max ppb ww	70,000	3400
Canadian DEW sites, closed 30 years ago, soil, max ppb		1400
Canadian sites, soil background concentrations, ppb	72,000	
US Regulation limits for soil	*400 – 1,000*	*1,000 –10,000*

Figure 15 : Lead and PCBs in Canadian Arctic and Suqi River Plants (nunivagseghat) *(ppb)*

The Canadian study tested each nunivagseghat and the soil it was in. Nunivagseghat often had *less* PCBs than surrounding soil. Nunivagseghat were taking up PCBs, but not accumulating them. Either not all of the PCBs were bioavailable to the nunivagseghat, or the nunivagseghat lost some PCBs during normal growth.

B. Fish (iqalluget/kayut)

1) PAHs

Fish from the Suqi river are higher in PAHs than fish from Canada, while fish from the Tapisaghak river had no PAHs. This is a strong indication that PAH contamination is due to spills at the military site, and PAHs are being taken up by fish. PAHs may be affecting fish eggs, growth, and reproduction.

	Anthracene	Naphthalene	Phenanthrene	Benzo(a)pyrene	Fluoranthene
Smoked salmon, Prince William Sound	NA	1200	5600	20	1400
Plants, Suqitughneq Drainage	50	42	Nl	330	980
Quyngiq, St Lawrence Island	40	11	67	12	48
Dollies, Suqitughneq	18	12	NA	15	2
Mountain whitefish, Liard River, Northwest Terr	0.09	3.2	1.7	NA	0.14
Northern Pike, Liard River, Northwest Terr	0.05	2.2	0.3	NA	0.09
Arctic grayling, Ron Lake, Northwest Territories	0.04	2.5	0.3	NA	0.1
Lake trout, Ron Lake, Northwest Terr.	0.04	1.9	0.3	NA	0.02
Round Whitefish, Ron Lake, Northwest Terr.	0.04	2.1	0.2	NA	0.05
Blackfish, Suqitughneq	ND	68	NA	ND	4
Dollies, Tapisaghak	ND	ND	NA	ND	ND
Soil, US regulatory limit	*4,300,000*	*43,000*		*1,000*	*2,100,000*
Water, US regulatory limit	*11,000*	*1460*		*0.2*	*1460*

Figure 16: PAHs in Circumpolar Nunivagseghat, Fish (iqalluget/kayut), and Quyngiq *(ppb wet weight)*

2) PCBs and Metals[71]

Blackfish from the Suqi have higher PCB levels than all fish tested except for salmon from Lake Michigan, one of the most polluted lakes in the US. Some dollies reached high levels in 1999, but this was not seen in 2001. Fish should be tested when remediation is completed at Northeast Cape to ensure PCBs have not remobilized and increased fish levels again. Although levels are higher than what is seen in most fish around the arctic, they may not be high enough to affect survival or reproduction. No studies have looked at the levels affecting marine fish.

Overall metals levels in St. Lawrence Island fish were lower than levels in other fish. The highest levels (Northeast Cape blackfish) were higher than mercury in Norwegian fish livers. Arsenic levels have not been measured in fish from Europe and Greenland.

[70] Suqi plants are dry weight, Canadian plants are wet weight. Until we know moisture content of Suqi plants, we cannot compare them directly. Soil samples are directly comparable. Canadian information is from CACAP 1998page 225. Maximum levels listed for SLI, average levels listed for others.
[71] Dolly Varden, Pink Salmon, and Blackfish from the Suqitughneq, Tapisaghak, and Quanqi Rivers. Include whole fish, fillets, eggs, heads, "remains".

Map 7: PAH Map

0 500 1000 1500 Ft.

Substances found at Northeast Cape

ace = acenapthene
acn = acenaphthylene
ant = anthracene
flu = fluorene
2mn = 2-methylnaphthalene
nap = naphthalene
phe = phenanthrene
b(a)ant = benzo (a) anthracene
b(a)pyr = benzo (a) pyrene
b(b)fla = benzo (b) fluoranthene
b(b)pyr = benzo (b) pyrene
b(ghi) = benzo (g,h,i) perylene
b(k) fla = benzo (k) fluoranthene
chry = chrysene
d(a,h) = dibenzo (a,h) anthracene
fla = fluoranthene
indeno = indeno (1,2,3) perylene
pyrene = pyrene

Sed Tox = sediment toxicity

Sed Tox is a general measurement of how healthy an area is. The higher the number, the more toxic it is, as seen by depressed benthic plants and animals, and bacteria that reproduce slowly.

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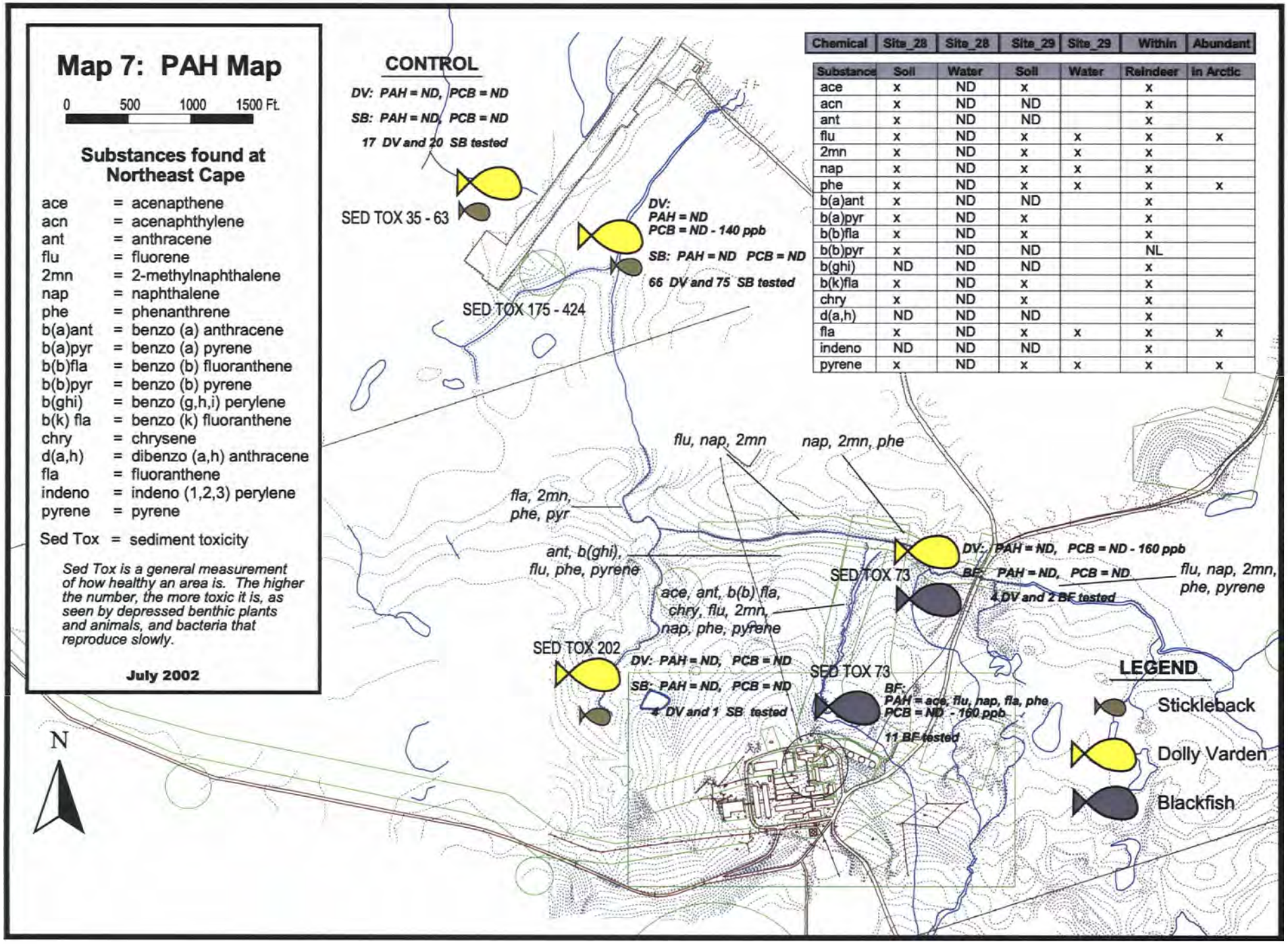

Chemical	Site_28	Site_28	Site_29	Site_29	Within	Abundant
Substance	Soil	Water	Soil	Water	Reindeer	in Arctic
ace	x	ND	x		x	
acn	x	ND	ND		x	
ant	x	ND	ND		x	
flu	x	ND	x	x	x	x
2mn	x	ND	x	x	x	
nap	x	ND	x	x	x	
phe	x	ND	x	x	x	x
b(a)ant	x	ND	ND		x	
b(a)pyr	x	ND	x		x	
b(b)fla	x	ND	x		x	
b(b)pyr	x	ND	ND		NL	
b(ghi)	ND	ND	ND		x	
b(k)fla	x	ND	x		x	
chry	x	ND	x		x	
d(a,h)	ND	ND	ND		x	
fla	x	ND	x	x	x	x
indeno	ND	ND	ND		x	
pyrene	x	ND	x	x	x	x

	Range of PCBs	Cd	Hg	Pb	Se
King Salmon fillet, Lake Michigan US	940				
Lake trout fillet, Northwest Territories and Yukon	12-898				
Northern Pike, Yukon and N. Quebec	<0.2-341				
Halibut, Canada	165-202				
Dolly Varden, 1999 Suqi	ND - 160				
Red salmon, Copper River Alaska, spawned out	79				
Blackfish, 1999 - 2001	60 - 140	10	100	30	10
Cod liver, Iceland	65				
Cod liver, Norway	16 – 97	1000	10-60	200	
Arctic char, Canada	11-53		10-570		
Red Salmon, Copper River Alaska, mature	54				
Dolly Varden, Pinks 2001 Tapisaghak	9-28	40	30	50	500
Dolly Varden 2001 Suqi	9-30				
Arctic cod, Pechora Sea, whole fish	22				
Arctic char, Northwest Territories Canada[72]	8				
Arctic cod, Norway, whole fish	6				
Cod fillet, Kodiak Alaska	5				
Chum Salmon, Port Graham Alaska	1				
Dolly Varden, Quangeghsak 1999	ND				
Herring liver, Greenland		30,600			
Cod fillet, Greenland			882		
Cod liver, Greenland			192		
Arctic char fillet, Sweden			100		
"fish muscle", Norway, Greenland, Russia, Sweden		1-50	10-1,000	2-50	200-1000

Figure 17: Circumpolar Metals and PCBs in Fish (iqalluget/kayut) *(ppb)*

C. Reindeer (quyngiq)

PCBs in St. Lawrence Island quyngiq are lower than in quyngiq from other northern countries. Pesticide levels are difficult to compare, since other quyngiq were not tested for the same pesticides, but overall all contaminant levels are low in St. Lawrence Island quyngiq.

	PCB	DDT	Endosulfan sulfate	Endrin	Heptachlor	Heptachlor Epoxide	Alpha Chlordane	Total chlordane
Russian quyngiq, livers	2 - 35	1-43				0 – 0.1		0.2 - 1
Norwegian quyngiq	<14	2-<10				0.4-1.2		
Northwest Terr. quyngiq	0.5 - 32	0-1.5				ND		0.2-8
SLI quyngiq[73]	ND	5.0	0.9	3.0	0.6	ND	1.0	

Figure 18: Pesticides and PCBs in Circumpolar Quyngiq ***(ppb)***

D. Seals (neghsat/maklaget)

Oogruk have not been studied in other countries, but neghsapik have. Below comparisons are made between oogruk and ringed seal (neghsapik).

Oogruk had lower contaminant levels than all of the neghsapik tested. This could mean that oogruk eat at a lower trophic level and contaminants are less biomagnified in them. In our previous assessment, we determined that oogruk probably do not have contaminant levels high enough to affect their health. HCB levels are approaching those seen in the Canadian high arctic, which is interesting, since the other contaminant levels in St. Lawrence Island oogruk are much lower than Canadian high arctic neghsapik.

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[72] Information from Northwest Territories Canada in this chart is from Cameron and Weiss, 1993

[73] Maximum levels are listed for St. Lawrence Island reindeer, average levels for others. DDT in SLI reindeer was found in blood, the others in muscle. Information on circumpolar reindeer is from AMAP 1998 page 340

	PCB	DDT	HCH	HCB
Neghsapik blubber, Hudson Bay, 1992, males	2066	1662	336	69
Neghsapik blubber, Hudson Bay, 1992, females	1115	840	335	63
Neghsapik blubber, Svalbard, 1986, male and female	991	1150		
Neghsapik blubber, Barrow, 1988, males	640	225		
Neghsapik blubber, Barrow	540	543	223+	
Neghsapik blubber, Baffin Island, 1994, female	467	359	179	38
Neghsapik blubber, Baffin Island, 1994, male	675	703	210	36
Neghsapik blubber, Greenland, 1994, male and female	441	546	129	
Neghsapik blubber, Nome, 1989, males	420	590		
Neghsapik blubber, Bering Sea, 1989 – 94, female	346	194		
Neghsapik blubber, Bering Sea, 1989 – 94, male	249	188		
Oogruk blubber, SLI 1993-95, female	199	96		
Oogruk blubber, SLI 1993 – 95, male	153	104		
Oogruk blubber, SLI 1998	128	70	37	35
Concern Level	*25,000 lw*[74]	*3,000*		

Figure 19: Circumpolar Comparison of Contaminants in Ringed Seal and Oogruk *(ppb)*

E. Ayveq

Savoonga ayveq are lower in PCBs and DDT than virtually any ayveq tested. HCH levels do approach levels in ayveq from North and Northeast Hudson Bay and Greenland. While PCBs and DDT are generally declining worldwide, HCH is a contaminant that is not decreasing. Cadmium in ayveq throughout the arctic is high.

	PCB	DDT	HCH	HCB	Cd
E Hudson Bay ayveq blubber, 1989, male[75]	11,500	4600	267	67	
E Hudson Bay ayveq blubber, 1989, female	4790	2164	214	62	2520
Baffin Island ayveq blubber, 1988	1643	605	156	54	
NE Hudson Bay ayveq blubber, 1989, male	1200	560	116	23	
Greenland ayveq blubber	144 – 288	40 – 72			
Greenland ayveq blubber, 1988, male	210	61	92		
N Hudson Bay ayveq blubber, 1988, male	199	33	100	23	10.500
NE Hudson Bay ayveq blubber, 1989, female	195	45	126	8	
N Hudson Bay ayveq blubber, 1988, female	90	21	63	15	
Savoonga ayveq blubber, 1994	103	4	413		
Savoonga ayveq blubber, 1998	40 – 88	9	110		
Savoonga ayveq bluuber, 1981-84					14,400
Gambell ayveq liver, 1981-83					11,200
Gambell and Savoonga ayveq liver, 1988					7,400
Diomede ayveq liver, 1989					8,025
Concern Level	*25,000 lw*	*3,000*			

Figure19 : Circumpolar Comparison of Contaminants in Ayveq *(ppb)*

F. Alpa manik

In the chart below, alpa manik gathered from Savoonga are compared to alpa manik, glaucous gull eggs, and murre chicks from other arctic areas.

Glaucous gull and herring gull eggs have by far the highest contaminants. Although polar bears, killer whales, and humans are generally considered to be at the top of the food chain, and therefore to have the highest

[74] Harbor seals show poor reproduction at 25,000 lipid wt PCBs; 3,000 ppb wet weight affects gull eggs (some studies put this at 25,000 ppb, sea eagles)
[75] East Hudson Bay ayveq prey on ringed seals; this increases contaminant levels dramatically.

contaminants, animals that *scavenge* on them give contaminants one more chance to biomagnify. Murres, fish-eaters, will not have levels as high as glaucous gulls, who scavenge on dead predators and bird eggs. Auklets, geese, and other plant-eating birds would have even lower levels than murres.

PCBs and DDT in Savoonga alpa manik are far less than the levels in Norwegian or Canadian alpa manik. This makes sense if we consider the global ocean currents, which travel primarily through channels around Greenland and the eastern Canadian arctic. Much less global water moves through the Bering Straits around Savoonga.

	PCB	DDT	HCH	HCB
Canadian high arctic, glaucous gull eggs, 1993	3330	2370	66	
Herring gull eggs, arctic areas	800 – 2600	220-1000	3-9	40-210
Norwegian alpa manik, 1992-93	530 – 920	340	4	100-110
Hudson Bay alpa manik, 1993	360-434	311-326	18 - 23	110
N Hudson Bay, guillemot eggs, 1993	300 –577	144-150	19	
Canadian western arctic, glaucous gull eggs, 1993	316-462	144-339	20-22	
Canadian high arctic, guillemot eggs, 1993	318	163	25	
Canadian high arctic, alpa manik, 1993	233 – 420	200-300	18-20	
Canadian high arctic, alpa manik, Coburg Island				70
Canadian high arctic, murre chicks, 1993	195	166	7	46
Canadian eastern arctic, murre chicks, 1993	192	192	6	62
Canadian high arctic, alpa manik, Leopold Isle				40
Savoonga alpa manik, 2001	82	78		39
Concern level	*1,000*[76]	*3,000*		

Figure 21: Circumpolar comparison of bird eggs (manik) *(ppb)*

G. Summary of Contaminant Comparison of Circumpolar Animals

What we see from these comparisons is that St. Lawrence Island foods are generally much less contaminated than foods from other areas of the arctic. Greenland, Hudson Bay, and northeastern Canada in particular seem to have much higher levels of contamination. Some wild food from St. Lawrence Island is less contaminated than fish caught in polluted areas of the US like the Great Lakes.

Some general comparisons we can make:

PAHs Quyngiq and fish from the Suqi had higher levels of PAHs than fish from Northwest Territories in Canada. Tapisaghak fish had none. This indicates a military source of PAHs at Northeast Cape.

PCBs Ayveq, oogruk, and alpa manik had much less contamination than those from other arctic areas. Dolly Varden from the Suqi that were tested in 2001 had less PCB contamination than any other fish tested, except for cod fillets from Kodiak. Military contamination continues to affect some Suqi fish.

DDT/DDE All St. Lawrence Island animals were lower in DDT/DDE than similar animals across the arctic.

HCH Ayveq blubber from St. Lawrence Island had some of the highest levels measured in the arctic, although ayveq oil and oogruk was low. Alpa manik, quyngiq, and fish from St. Lawrence Island were not analyzed for HCH. Bird eggs and fish throughout the arctic are low in HCH. Only marine mammals – ayveq, neghsapik, bowhead whales – were elevated. Lindane, a form of HCH, is still used and sold in the US, and levels are not declining in the arctic.

HCB St. Lawrence Island oogruk have similar levels to neghsapik at Baffin Island.

Mirex Alpa manik from St. Lawrence Island were lower in mirex than fish-eating birds in northern Canada, but higher than Canadian quyngiq fat and liver. This is probably due to biomagnification: quyngiq feed lower on the trophic level than murres do. Mirex levels have not been studied much yet.

[76] Unpublished study, Bustnes 2002, showed decreased adult survival rate at 1,000 ppb wet weight in blood

	PCBs	DDT or DDE	HCH	HCB	Chlordane	mirex	PAHs global	PAHs Non global	Metal
	Average	Average	Average	Average	Average	Average	Max	Max	
Oogruk, SLI, blubber	128	70	37	~35	Very low	NA	NA	NA	NA
Neghsapik, arctic, blubber	241-4200	25-2900	68 – 335	36 – 69	143 – 1600	4 - 26	NA	NA	Na
Concern level for marine mammals	25,000 lw	3,000							
Ayveq, SLI, blubber	61	9	110	Very low	Very low	NA	NA	NA	Cd
Ayveq, arctic, blubber	249 – 11,500	21 – 4600	62 – 336	8 – 67	99– 6200	3 – 216	NA	NA	Cd
Concern level for marine mammals	25,000 lw	3,000							
Alpa manik, SLI	82	78		39	NA	2	NA	NA	NA
Alpa manik, arctic	320 – 920	245 – 400 (DDE)	4 – 20	40 – 110	40 - 60	NA	NA	NA	NA
Herring gull eggs, arctic	800 – 2600	220 – 1000 (DDE)	3 – 9	40 – 210	70 - 260	NA	NA	NA	NA
Concern level for birds	1,000	3,000							
Quyngiq, SLI	ND	5	ND	NA	NA	NA	134	174	NA
Quyngiq, arctic	0.5 – 32	5.0	NA	NA	0.2-1	NA	NA	NA	NA
Concern level for quyngiq	9,000+?[77]								
Suqi fish	ND – 160	ND	NA	NA	NA	NA	11 – 21	ND – 153	Hg
Tapi and Quang Fish	20	NA/ND	NA	NA	NA	NA	ND	ND	No concern
Arctic fish	1 – 940	NA	NA	NA	NA	NA	NA	NA	Cd, Hg
Concern Level for fish									
Plants with Dust	10-9300	NA/ND	NA	NA	NA	NA	NA	NA	Pb, Hg
Plants, closed DEW sites	3400 dry wt								Pb
Concern level for plants									

Highlights refer to contaminant levels of concern to animal health.

Figure 22: Summary of Contaminants in Circumpolar Animals *(ppb)*

[77] 500 lipid weight is the level that affects short term memory in humans. Vertebrate studies have been done on mink, and no effect was seen as high as 9,000 lipid weight in muscle. (AMAP 1998 page 296)

PCBs

Oogruk	Bering Sea	SLI						
	150 - 200	125 - 150						
Ringed Seal	W. HUD	Hi Arctic	E. HUD	Barrow	Baffin	B. Strait	Nome	Bering Sea
(neghsapik)	1,000-2,000	1300	1200-1300	550-700	475-675	375-575	400	250-350
Ayveq	E. HUD	Baffin	NE HUD	W GNLD	N HUD	SLI		
	5,000-11,000	1650	200 - 1200	150 - 300	100-200	40 - 100		
Alpa manik	NWY	HUD	Hi Arctic	SLI				
	530 - 920	350 - 450	225 - 425	80				
Glaucous Gull Eggs	Hi Arctic	W. Arctic						
	3500	300-450						
Black Guillemot Eggs	N. HUD	Hi Arctic						
	300 - 575	300						
Bowhead Whale	Barrow							
	410							
Minke Whale	NWY							
	1000-3500							

Salmon	GRT LK	LK MI	CR	SLI	YUK	Cook Inlet
	1700	950	35-80	6-30	3-11	1-3
Greyling	CR					
	10 - 20					
Cod	KOD	CAN				
	5	5				
Cod Liver	NWY	ICE				
	15 - 100	65				
US Fast Food	Burger, Pizza, Chicken					
	1					

AYVEQ	GL. GULL	MINKE	K SALMON	AYVEQ	R. SEAL	R. SEAL	R. SEAL	K SALMON	MUR EGG	R. SEAL	R. SEAL	R. SEAL	GUIL. EGG	G. GULL EGG	MUR EGG	BOWHEAD
E. HUD	Hi Arctic	NWY	GRT LK	BAFFIN	W. HUD	Hi Arctic	E. HUD	LK MI	NWY	BARROW	BAFFIN	B. STRAIT	N. HUD	W. Arctic	HUD	BARROW
5,000-11,000	3500	1000-3500	1700	1650	1,000-2,000	1300	1250	950	530-920	550-700	475-675	375-575	300 - 575	300-450	350-450	410

R. SEAL	GUIL. EGG	MUR EGG	R. SEAL	B. SEAL	AYVEQ	AYVEQ	MUR EGG	COD LV	COD LV	R SALMON	GREYLING	P SALMON	R,C,K SALMON	COD	K,C SALMON	FAST FOOD
NOME	Hi Arctic	Hi Arctic	Bering Sea	SLI	N. HUD	SLI	SLI	NWY	ICE	CR	CR	SLI	YUK	KOD, CAN	Cook Inlet	US
400	300	225-425	150 - 200	125 - 150	100 - 200	40 - 100	80	15-100	65	35 - 80	10-20	6-30	3-11	4-7	2	1

DDT

Oogruk	Bering Sea	SLI				
	100	70				
Ringed Seal	Hi Arctic	W. HUD	E. HUD	BAFFIN	Barrow	Bering Sea
(neghsapik)	1650	850-1650	1000-1100	350-700	550	200
Ayveq	E. HUD	Baffin	NE HUD	W GNLD	N HUD	SLI
	2,000-4,500	600	45-550	40-75	20-35	5-10
Alpa manik	NWY	HUD	Hi Arctic	SLI		
	340	300 - 325	200 - 300	80		
Glaucous Gull Eggs	Hi Arctic	W. Arctic				
	2400	150-350				
Black Guillemot Eggs	Hi Arctic	N HUD				
	160	145-150				
Bowhead Whale	Barrow					
	330					
Minke Whale	NWY					
	1200-2400					
Fish *salmon*	CR	YUK	*cod*	CAN	*greyling*	CR
	20-50	2-13		5		1-5

Supermarket Foods, US

butter	26
spinach	16
dill pickles	8
Am. Cheese	7
winter squash	6
bacon	3
peanut butter	3
potato chips	3
2% milk	1
ice cream	1
carrots	1
grapes	1
french fries	1
fried eggs	1
fried chicken	1
mayonaisse	1
mustard	1

AYVEQ	G. GULL EGG	MINKE	R.SEAL	R. SEAL	R. SEAL	AYVEQ	R. SEAL	AYVEQ	MUR EGG	BOWHD	MUR EGG	MUR EGG	G. GULL EGG	R. SEAL
E HUD	Hi Arctic	NWY	Hi Arctic	W HUD	E HUD	Baffin	Barrow	NE HUD	NWY	Barrow	HUD	Hi Arctic	W. Arctic	Bering Sea
2000-4500	2400	1200-2400	1650	850-1650	1000-1100	600	550	45 - 550	340	330	300-325	200-300	150 - 350	200

B. GUILL EGG	MUR EGG	B. SEAL	AYVEQ	R. SALMON	BUTTER	AYVEQ	SPINACH	Dill Pickles	Am. Cheese	K SALMON	COD	GREYLING	R,C SALMON
N HUD	SLI	SLI	W. GNLD	CR	US Store	N HUD	US Store	US Store	US Store	YUK	CAN	CR	YUK
145 - 150	80	70	40 -75	20-50	25	20 - 35	15	8	7	9-13	5	1-5	2

HCH

Oogruk	SLI						
	38						
Ringed Seal	Hi Arctic	W HUD	E HUD	Barrow	Baffin		
(neghsapik)	425	335	275	225	175-200		
Ayveq	SLI 1994	E HUD	Baffin	NE HUD	SLI 1998	W GNLD	N HUD
	400	200-250	150	120	110	95	60-100
Alpa manik	HUD	Hi Arctic	NWY				
	20	20	4				
Glaucous Gull Eggs	Hi Arctic	W. Arctic					
	65	20					
Black Guillemot Eggs	Hi Arctic	N HUD					
	25	20					
Bowhead Whale	Barrow						
	200						
Fish *salmon*	CR	*cod*	CAN	*greyling*	CR		
	0.6		4		0.4		

R. SEAL	AYVEQ	R. SEAL	R. SEAL	R. SEAL	AYVEQ	BOWHEAD	R. SEAL	AYVEQ	AYVEQ	AYVEQ
Hi Arctic	SLI	W. HUD	E. HUD	Barrow	E. HUD	Barrow	Baffin	N. HUD	SLI	W GNLD
425	400	325	275	225	200-250	200	150	120	110	95

AYVEQ	G. GULL EGG	B. SEAL	B. GUILL EGG	G. GULL EGG	MUR EGG	MUR EGG	B. GUILL EGG	MUR EGG	COD	R. SALMN	GREYLING
N. HUD	High Arctic	SLI	High Arctic	W. Arctic	HUD	Hi Arctic	N. HUD	NWY	CAN	CR	CR
60 - 100	65	40	25	20	20	20	20	4	4	0.6	0.4

HCB

Oogruk		SLI				
		35				
Ringed Seal		W. HUD	E. HUD	Baffin		
(neghsapik)		65-70	55-60	35		
Ayveq		E. HUD	Baffin	NE HUD	N HUD	SLI
		60-65	55	20-80	15-20	very low
Alpa manik		NWY	SLI			
		100	40			
Bowhead Whale		Barrow				
		100				
Fish	*salmon*	CR		*greyling*	CR	
		4			0.5	

Supermarket Foods, US	
butter	1.5
winter squash	1
American cheese	0.5
bacon	0.5
canned tuna	0.5

MUR EGG	BOWHEAD	R. SEAL	AYVEQ	R. SEAL	AYVEQ	AYVEQ	MUR EGG	R. SEAL	B. SEAL
NWY	Barrow	W. HUD	E. HUD	E. HUD	Baffin	NE HUD	SLI	Baffin	SLI
100	100	65-70	60 - 65	55-60	55	20-80	40	35	35

AYVEQ	AYVEQ	R. SALMN	Butter	Squash	Am. Cheese	Bacon	Canned Tuna	GREYLING
N. HUD	SLI	CR	US Store	US Store	US Store	US Store	US Store	CR
15-20	very low	4	1.5	1	0.5	0.5	0.5	0.5

XII. Human Health

Up to this point, we have only considered contaminant levels that could affect wildlife. But contaminants in an animal that are too low to affect the animal may affect the person eating it because of biomagnification. Biomagnification is only a concern for POPs. Metals (except methylmercury) and PAHs do not biomagnify.

Humans are exposed to contaminants through the jobs they do (military, industrial work, oil cleanup), the food they eat, the water they drink, and the modern environment (vehicle exhaust, paint, cigarettes). In addition, a fetus and breastfeeding infants are exposed to contaminants in the mother, and are more susceptible than adults.

In this section, we look at potential health effects *on humans* of contaminants seen in arctic animals.

It is important to keep in mind, when reading through the Human Health section, that every individual is a constant interplay of nutrients, new contaminants, and old contaminants being built up, broken down, stored, and eliminated. Exposure to contaminants is also a mosaic of past contaminants underlying current daily contaminants such as cleaners, pesticides, pharmaceuticals, vehicles, paints, and plastics. While contaminants in wild foods, especially in marine mammals, are of concern, people are exposed at the same time to a small amount of POPs in store bought food, along with a variety of preservatives, sugars, and fats which also interact and affect an individual person's health. Because of this exposure to multitudes of contaminants and nutrients overlaid on each other, there is no possible way to predict how exposure to any one contaminant will affect the health of any one person. We can provide information on what contaminants are actually in you (through blood testing), health effects each contaminant may cause, and what the sources of contaminants may be.

When reading the upcoming charts, keep in mind that it is usually the fat or meat levels measured in animals, not blood. For direct comparisons of animals and human blood, we would need to review lipid weights (this may be a project we can do in the future). The animals are entered in the chart to give an idea of possible sources of exposure.

A. Humans and PAHs

PAHs are the ring shaped molecules that are part of petroleum products. There are several hundred different PAHs. They are found naturally in some nunivagseghat, can be made in labs, and are formed when wood, coal, and petroleum products are burned. As mentioned earlier, the PAHs with only one or two rings joined together tend to evaporate quickly; while they can be a significant health hazard if you breathe them they only stay in the air a very short time. Some of the small PAHs (which we call "volatile organics") are benzene, toluene, and xylenes. The main exposure would be while fueling a tank or vehicle (truck, snowmachine, ATV, outboard motor) or during cleanup of large volumes of spilled oil.

PAHs can have more than two rings. Extra rings increase toxicity. In addition, the larger, heavier molecules with several rings persist in the environment longer than small molecules. These larger molecules, like chrysene, are the ones most likely to be in "weathered oil", petroleum that was spilled decades ago. Exposure to large, heavy toxins are the reason fish eggs are susceptible to weathered oil.

Exposure to PAHs occurs through *breathing* of

- Tobacco smoke
- Vehicle exhaust
- Wood smoke, Coal fires
- Vapors from oil spills

Exposure occurs through "*ingestion*" (eating/drinking) of

- Smoked fish
- Barbecued foods
- Fried foods

Exposure occurs through *"dermal contact"* if petroleum products are splashed on the skin over time.

The primary route of PAH exposure is through cigarettes, for smokers, and through food for nonsmokers. Working at the military bases in the past would have exposed people to PAHs through vehicle emissions, oil spills, and the burning off of spilled oil. Contributions to air PAHs also come from ATVs, snowmachines, outboards, planes, and equipment.

PAHs can damage health because they attach to human chromosomes, promoting changes in the gene that can lead to cancer. Tumors occur when people breathe, eat, or have skin contact with PAHs over periods of time. Inhalation of oil vapors or mists causes immediate effects (dizziness, incoordination, headaches) and, if exposure is continues over years, chronic effects may show up (leukemia, nerve damage). Breathing PAHs in heavily polluted city air causes decreased birth weights, body length, and head size in babies.[78]

The PAH that has been most studied is benzo(a)pyrene, a toxic part of cigarette smoke which promotes lung cancer and chronic bronchitis. Exposure to PAHs from cigarettes is also known to reduce a person's ability to have children and cause low birth weights.[79] Smoking is estimated to be responsible for around 20% of the premature and low birthweight babies in Alaska Natives[80].

Other PAHs that have been known to promote cancer in lab animals include: benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3)pyrene[81]. All of these have been found in nunivagseghat, fish, and quyngiq at Northeast Cape, but at low levels. Nunivagseghat had the highest level of PAHs, but even these levels are far below what is expected to cause health problems (see next page).

The body eliminates PAHs, and does not store them in fats for long, so eating animals with low PAHs is not likely to harm health[82]. The highest levels in fish (300 – 400 ppb) can be compared to smoked salmon with 7800 – 23,000 ppb.

The amount of PAHs in the *air* at Northeast Cape and Gambell have not been measured. A chart is provided below that shows levels found in some Arctic women and in animals at Northeast Cape.

	Anthracene	Naphthalene	Phenanthrene	Benzo(a)pyrene	Fluoranthene
Smoked salmon, Prince William Sound	NA	1200	5600	20	1400
Quyngiq, St Lawrence Island, muscle	40	11	67	12	48
Dollies, Suqitughneq muscle	18	12	NA	15	2
Blackfish, Suqitughneq , muscle	ND	68	NA	ND	4
Salekhard, Russian mothers, blood	0.3	10.7	9.8	0.2	1.1
Norilsk, Russian mothers[83], blood	0.4	9.5	6.6	0.2	1.6
Salekhard, Russian newborns, blood	0.3	5.8	7.6	NA	1.0
Norilsk, Russian newborns, blood	0.5	2.5	7.0	NA	1.2
Mountain whitefish, Liard River, Northwest Terr	0.09	3.2	1.7	NA	0.14
Northern Pike, Liard River, Northwest Terr	0.05	2.2	0.3	NA	0.09
Arctic grayling, Ron Lake, Northwest Territories	0.04	2.5	0.3	NA	0.1
Lake trout, Ron Lake, Northwest Terr.	0.04	1.9	0.3	NA	0.02
Round Whitefish, Ron Lake, Northwest Terr.	0.04	2.1	0.2	NA	0.05
Dollies, Tapisaghak , muscle	ND	ND	NA	ND	ND
Soil, regulatory limit	4,300,000	43,000		1000	2,100,000
Water, regulatory limit	11,000	1460		0.2	1460

For Northeast Cape animals, the maximum level found is listed. For Arctic people, the average level is given.

Figure 23: Circumpolar Comparison of PAHs in People and Animals *(ppb)*

[78] Perera et al 1999
[79] AMAP 1998 pg 781
[80] Personal Communication, Dr. James Berner of the Alaska Native Medical Center, June 2002.
[81] CACAP pg 433
[82] DeWailly et al 1994.
[83] Russian information from Klopov 1996.

B. Humans and Metals

Humans are exposed to metals in drinking water and foods. Arsenic in city drinking water is at safe levels, but arsenic has been found in high levels in the Suqi River.

Metals were found in fish and ayveq. Several metals were found in fish: arsenic, barium, cadmium, lead, nickel, vanadium, zinc, copper, mercury, and selenium. The levels found were not high. In ayveq, cadmium, arsenic, lead, mercury, selenium, and zinc were found. Only cadmium approached a level of concern.

Fish and ayveq absorb inorganic metals from sediments as they sift bottom sediment from food. Once inside the body, inorganic metal can interfere with necessary functions of cells. But sometimes the inorganic metal becomes "complexed" (binds with other molecules) inside the body to become "organic" forms. If the organic metal is strongly bound, like arsenic tends to be, it is not toxic. If it is loosely bound, like methylmercury, it can be toxic.

If a fish accumulates metal, it may pass the metal on to a seal or person who eats the fish, but the metal will be in the organic form. And unlike POPs, which biomagnify and increase at higher trophic levels, metal concentrations tend to decrease at higher trophic levels

The metals in fish and ayveq are not likely to be toxic to people eating them, but metals levels in ayveq should be monitored for the health of walrus.

C. Humans and PCBs

PCBs (polychlorinated biphenyls) is a term that refers to 209 similar compounds (congeners) that used to be produced commercially as mixtures called Aroclors. PCBs are one of the POPs, and biomagnify in higher trophic levels. This means that toxic effects will first be seen in people and animals at the top of the food chain. How toxic PCBs are depends on the individual congener and what other contaminants are present. In general, we can say that PCBs affect liver and kidney function, reproduction, thyroid, and the immune system. They cause low birth weights, neurobehavioral problems, chronic bronchitis, fatigue, jaundice, and stomach pain. It is suspected that they may increase risk of liver, skin, and intestinal cancers.

At St. Lawrence Island, people potentially have been exposed to both local (military) and global PCBs. People who worked at Northeast Cape or with the military in Gambell may have been directly exposed to PCBs, since PCBs were used in transformers, hydraulic fluid, and common lubricants. People who did not work with the military are most likely to be exposed through contaminated food.

The following food from Northeast Cape was tested for PCBs: nunivagseghat, fish (dolly varden, blackfish, pink salmon, sticklebacks), quyngiq (which roam through Northeast Cape). Levels of PCBs in these foods are discussed in Section II (Northeast Cape Foods and Pollutants). No PCBs were found in quyngiq, some were found in dolly varden and pink salmon, elevated levels were found consistently in blackfish. We cannot tell how much was in nunivagseghat because of the way the experiment was done.

1. How Much PCB is Safe?

In previous sections, we examined PCB levels in animals and whether animal health might be affected by those levels. Here we examine whether *people eating* those animals may be at risk for health problems. Before looking at specific nunivagseghat, we need to look at how the US and Canada decided how much PCB is safe to eat.

When a country decides how much of a toxin is safe, it uses a number called the "Allowable Daily Intake" (ADI). This figure is not amounts people have eaten and gotten sick from. No person is going to sit still while someone feeds him increasingly larger doses of PCBs until he develops a rash, or his immune system puts out fewer antibodies. Instead, lab animals are fed increasingly larger doses of PCBs until *they* develop a problem. The smallest dose that causes a problem is written down, and then an "uncertainty factor" is figured in.

Canada and the US came up with uncertainty factors in different ways. The US wanted a number they could use to decide when a contaminated area needed to be cleaned. Canada, knowing that PCBs were often found in traditional foods, took into account the benefits of traditional food when they looked at uncertainty factors.

US says it is safe for an average size person (150 lb) to eat 1400 nanograms (ng) of PCB each day.
Canada says it is safe for average size person (150 lb) to eat 70,000 nanograms (ng) of PCB each day.

Canada says it is safer to eat a lot more PCB than the US. The amount the EPA says it is safe for food to contain, if the food is to be eaten in unlimited amounts, is 50 parts per billion (ppb); same as 50 nanograms of PCB in one gram (one thousand nanograms) of fish meat.

How the US decided what amount of PCBs is safe

Adult monkeys were fed a certain amount of PCBs every day for 2 years and for 4 ½ years. The lowest amount that caused any harm (changes in the immune system) was 0.005 mg of PCB per kilogram of the monkey's body weight per day (abbreviated mg/kg/day)

The lab divided 0.005 mg/kg/day by an Uncertainty Factor of 300 to get the "safe" number of 0.000016 mg/kg/day, which rounds to 0.00002 mg/kg/day.

While these numbers are difficult to envision in the ounces and pounds we are used to, we are dealing with such small amounts that ounces and pounds cannot be used. We will later take these "safe" levels and use them to find out how much of certain foods it is safe for a person to eat.

The number picked for the Uncertainty Factor took into consideration the fact that humans might be more sensitive than monkeys, that humans vary in their sensitivity, and that they wanted a small enough amount that NO health effects would occur.

Nanograms are too small to imagine; smaller than even a grain of salt (see Appendix A: Understanding Very Small Numbers). It is useful to have these numbers, though, because they help determine what amount of food is safe to eat.

Using either figure will probably give you a "safe" amount of PCB that you can eat without health effects. Remember, your body metabolizes and removes toxins, even PCBs; it just takes a long time. However, there is so little known about long term ingestion of toxins, what happens to a fetus when a mother ingests toxins, what happens to our immune systems, what happens when we are exposed to lots of different toxins at the same time, and so forth, that it should be up to the villages themselves and their health care providers to discuss what they feel is "safe".

In this report, calculations determining "safe" amounts of food are done using both Canadian and US recommendations. The levels seen in nunivagseghat and animals are real, true levels. What amount of Allowable Daily Intake is safe is up to *you* to decide.

2. PCBs in Food

Long range transport and a marine food chain longer than the land food chain, gives contaminants like PCBs a chance to accumulate and biomagnify. What is a safe level for an animal to carry may not be a safe level for a person to eat. Low trophic level animals, like quyngiq, are expected to have low PCBs.

a) Nunivagseghat, PCBs, and Health

The level of PCBs in Northeast Cape plants with dust is so high in some that it would be **very unsafe** to eat them without washing them. The highest level seen was 9300 ppb. When you look at Figure5 "Metals and PCBs in and on Plants from the Suqi River Drainage", recall that a fish advisory was issued at the Suqi because some fish contained over 100 ppb of PCBs. While some nunivagseghat had low PCBs, many had over 100 ppb. If this is due to dust on the nunivagseghat, contamination can be removed by washing them.

There is much information we need to know before we can accurately assess safe amounts of nunivagseghat to eat. First, we need to know if PCBs are in the nunivagseghat themselves, or in dust that settled on the nunivagseghat, which can be washed off. Secondly, the lab dries the nunivagseghat to ashes before testing for contaminants. Even though we know how much PCB was found in a nunivagseghat, we cannot tell how much nunivagseghat is "safe" until we know how much water was in the nunivagseghat. For instance, if Plant A had 10 ppb PCB, but was half water, it would be much safer to eat than Plant B with 10 ppb PCB and only 10% water.

b) Fish (iqalluget/kayut), PCBs, and Health

The EPA recommends that fish should not have over 50 ppb of PCBs for "unlimited fish consumption". That is, at 50 ppb or less, people can eat as much fish as they want without increased risk of health concerns. This level does not, however, take into account effects on pregnant women and developing embryos.

Reviewing Figure 5 (seen again below), we see that blackfish in 1999 and 2001 had PCBs over 50 ppb, as did some dollies from the Suqi in 1999. Suqi fish had generally higher levels of PCBs than most arctic fish, indicating PCB pollution at the military site is affecting fish.

	Suqi River				River drainage	Control: Quang		Control: Tapisaghak			
1999	DV		SB	BF	BF	DV	SB				
PCB	<50 – 160		ND	ND	100	<50	<50	No fish tested			
2001	DV				BF	No fish tested		DV and PS			
	Egg	Fillet	Hd	rmn	Whole fish			Egg	Fillet	Hd	rmn
PCB	8-13	6-16	23-30	15-18	60 – 140			9-17	6-11	16-28	6-9

EPA concern level, PCBs in fish eaten by humans, unlimited fish consumption is 50 ppb
www.epa.gov/ust/fishadvice/volume2 (per Dr. David Carpenter)

**DV=dolly varden SB= stickleback BF = Blackfish ND = below detection limits*
***All fish in 1999 were whole fish samples 100 – yellow highlights are levels of concern to people eating fish*

Some fish from the Suqi had no PCBs detected in them: all sticklebacks, many dollies, and some blackfish. All Tapisaghak fish had low levels. These fish do not appear to be exposing people to high levels of PCBs.

While only Suqi blackfish continued to have high levels in 2001, fish need to be monitored during the remediation process at Northeast Cape. As remediation progresses, contaminants can remobilize, becoming more available to fish. In the long run, *sources* of toxins will be removed, but in the short run, *exposure* to toxins could be greater. And levels are already high enough to be of concern.

c) Quyngiq, PCBs, and Health

No PCBs were found in quyngiq. Quyngiq feed low on the trophic level and contaminants do not biomagnify in them to the extent they do in marine animals. People eating quyngiq should not be at increased risk.

d) Oogruk, PCBs, and Health

PCBs in oogruk, like those in fish, are probably not high enough to affect the animal, but may be a concern in people eating the animal.

Contaminants concentrate in the fat of animals. Contaminant levels in meat, skin, and lean blubber are much less than levels in fatty blubber or oil. If a person is eating just dried meat, they are receiving far fewer contaminants than if they are eating anything else. If dried meat is soaked in oil, some of the oil is absorbed into the meat, and so contaminants from oil also move into the meat.

Oogruk blubber and oil are above the EPA limit of allowable PCBs "for unlimited consumption". People eating a lot of oogruk may be at increased risk for the health problems caused by PCBs.

Average Wet weight in ppb (nanograms of contaminant per gram of whole food eaten)

Oogruk	s-PCB	s-DDT	s-HCH	HCB
Entire blubber piece	128	70	37	35
seal oil	159	50	39	0.5
piece of(lean) blubber stored in oil	36	17	11	
piece of dried meat	2.6	0.6	0.9	
piece of dried meat stored in oil	19	9	4	
lowest national regulatory limit, fish products	*50, US EPA*	*2000, Denmark*	*100, Canada*	
EPA regulatory limit for fish products	*50*	*5000*	*no limit set*	

Levels of concern are highlighted.

We can also examine the safety of oogruk blubber by using the MRls for PCBs to find a "safe" amount of blubber that can be eaten daily. The MRL for PCBs is 0.00002 mg/kg bw/day. For a person that weighs 70 kg (154 lbs), the safe amount of blubber or oil to eat (called the Allowable Daily Intake) is less than 1/3 of an ounce (US recommendation) or about a pound (Canadian recommendation) of oil or blubber each day[84].

e) Ayveq, PCBs, and Health

The average levels of PCB in ayveq are low, but still above EPA recommendations for unlimited consumption. Although meat was not tested, we assume it has lower contaminant levels than blubber.

Average Wet weight in ppb (nanograms of contaminant per gram of whole food eaten)

Ayveq	s-PCB	s-DDT	s-HCH	HCB
Piece of blubber, 1998	61	9	110	
1994	103	4	413	
ayveq oil, 1998	68	7	109	
Lowest national regulatory limit, fish products	*50 (US)*	*2000 (Denmark)*	*100 (Canada)*	
US regulatory limit(fish products)	*50*	*5000*	*No limit*	

Note, again, that if we compare the highest levels (about 100 ppb), we are in the range of the levels of PCBs in Suqi fish that caused a precautionary statement suggesting people not eat the fish. Again, the amount of PCBs that may be found in *one individual* ayveq will depend on many things—like age, sex, what it has been eating, etc. What level of PCBs will affect *one individual* human will also vary, depending on the individual's own health, and other factors.

f) Alpa manik, PCBs, and Health

Again, levels in alpa manik are above the EPA recommendation for unlimited fish consumption. They are, however, *lower* than the US recommendation for PCBs in eggs. The difference in the recommendations probably has to do with how much they expect a person will eat.

If recommendations give such different opinions, how do we know what is safe? We can calculate the ADI to tell us how much egg it is safe to consume daily. At the average amount of PCB seen in the eggs (82 ppb wet weight), Allowable Daily Intakes say it would be safe for an adult to eat between one ounce (US) or as much as a pound (Canada) of alpa manik every day, or for a child to eat 1/3 of an ounce (US) to about 1/3 of a pound (Canada) of eggs. If you eat more than these levels, you may increase your risk of PCB-related health problems.

[84] This calculation was done using the average level of PCBs in blubber and oil. Actual levels in individual seals varies, so safe amount to eat will vary.

Alpa manik *(wet weight, ppb)*	s-PCB	s-DDE	HCB	Mirex
Range	82	78	39	2
Average	47 - 142	26 – 242	23 – 56	1-2
US regulatory limit(fish products)	*50*	*5000*		
US regulatory limit, eggs	*300*			

g) PCBs in fast foods

One study found an average of 1 ppb in Big Macs, Kentucky Fried Chicken (3 piece meal), and pizza (See Appendix G "Contaminants in Fast Food"). This is less than in traditional foods.

Ring seal blubber, Baffin Island, male	675		
Ring Seal blubber, Barrow	540		
Alpa manik, Norway	530		
Glaucous Gull Eggs, Canadian west arctic	462		
Bowhead whale blubber, Barrow	410		
Ring seal blubber, Nome	400		
Alpa manik, Hudson Bay	360		
Alpa manik, high arctic	233		
Oogruk blubber, Bering Sea, female	199		
Murre chicks, Canadian high arctic	195		
Oogruk oil	159	39	306
Oogruk blubber, Bering Sea, male	153		
Ayveq blubber, Greenland	144		
Oogruk blubber	128	62	318
Dolly Varden, 1999 Suqi		ND	160
Alpa manik	82	47	142
Red salmon, Copper River Alaska, spawned out	79		
Blackfish, 1999 - 2001		60	140
Cod liver, Iceland	65		
Ayveq blubber	61	40	88
Cod liver, Norway		16	97
Red Salmon, Copper River Alaska, mature	54		
Ring seal liver, Barrow	23		
Dolly Varden 2001 Suqi		8	30
Bowhead whale liver, Barrow/Kaktovik	9		
Arctic charr, Northwest Territories Canada[85]	8		
Eider, Northwest Territories Canada	6		
Cod fillet, Kodiak Alaska	5		
Oogruk dried meat	3		
Crowberries, Northwest Territories Canada[86]	3		
Chum Salmon, Port Graham Alaska	1		
Pizza Hut US[87]	1.2		
Kentucky Fried Chicken, 3 pieces, US	1.2		
Big Mac, US	1.0		
Clams, Northwest Territories Canada	1.0		

Figure 24: Circumpolar Comparison of PCBs in Arctic Animals *(ppb)*

[85] Information from Northwest Territories Canada in this chart is from Cameron and Weiss, 1993
[86] Kuhnlein and Kinloch, 1988
[87] Fast food information is from Schecter and Li, 1997

3. PCB Levels in Human Blood

a) St. Lawrence Islanders

Potentially concerning levels of PCBs have been found in nunivagseghat, ayveq, Suqi river fish (but not fish from other rivers), bowhead whale, oogruk, and alpa manik. All these foods are contaminated by global PCBs, except for Suqi river fish and nunivagseghat, which have an additional load from military contamination.

But recall that people eating PCBs in food is only one way they may be exposed to them. Another way is through direct contact. People may have had direct contact if they spent time in the military at Northeast Cape or Gambell. Do people who worked with the military have higher PCB levels? Do people who have subsistence camps at Northeast Cape, where there is an extra exposure to PCBs in foods have higher PCB levels?

In 2001, sixty residents of St. Lawrence Island volunteered to have their blood tested for PCBs and pesticides. Twenty residents from Gambell, twenty resident of Savoonga who did not spend significant amounts of time at Northeast Cape, and twenty Savoonga residents who did spend time at Northeast Cape. ACAT staff in Anchorage were "controls", what PCB levels might be in the average Anchorage population.

Figure 25: PCBs in Human Blood, St. Lawrence Island, ppb

	Northeast Cape		Savoonga		Gambell		ACAT Staff	US
	Female	Male	Female	Male	Female	Male	female	
Average	9.3	8.7	4.5	7.6	4.5	7.2	3.2	1 ppb
Min	3.7	1.2	2.6	2.9	2.6	3.0	1.4	
Max	15.3	19.4	8.4	15.8	8.4	13.7	4.6	
Average, male and female	8.9		7.3		6.0		3.2	

We see a definite trend. People who spent time at Northeast Cape had higher levels of PCBs, followed by Savoonga, Gambell, and ACAT staff. In addition, we note that the ACAT staff is higher than the average US population, despite the fact that only one was born in Alaska. Gambell and Savoonga females had about the same levels as ACAT staff, but women who spent time at Northeast Cape had distinctly higher levels. Men from all areas had about the same levels, with men from Northeast Cape slightly higher. Maximum levels tended to be highest in men, which is expected since women transfer some contaminants when breastfeeding.

b) Circumpolar Comparison

How do we compare to other people from around the arctic? Levels in people from St. Lawrence Island are lower than PCBs in people exposed on the job or people from the lower 48 who ate fish from contaminated waters. They tend to be slightly higher than people from the Aleutians and Pribilofs. They are above the Canadian "concern level" for women of reproductive age, which is serious. Recall that PCBs can cause low birth weights and reproductive problems.

D. Humans and Pesticides

Pesticides were low in soil. They do not appear to be contaminating foods at Northeast Cape (nunivagseghat, quyngiq). However, some global pesticide contaminants have been seen in concerning levels in marine mammals and birds. Human blood levels of pesticides are discussed and compared with levels in other people. New research that looks at low level effects of pesticide mixtures on human cells is also discussed.

	Average	Minimum	Maximum
People Exposed on the Job			
Transformer repair, recent	43.7	4.3	253
Transformer repair, past	30.0	1.5	143
People Who Eat Fish from PCB contaminated water			
Sportfishermen, Lake Michigan US	72.7	25	366
Sportfishermen, Alabama US	22.2	3	158
Native American, Akwesasne New York,US, men	2.8	<0.1	31.7
Sportfishermen, Great Lakes US, women	2.1	0.5	12.1
Arctic People			
Action level for men and women over 18[88]	100+		
Northwest Territories, people 15 – 83 years old[89]	41		
Concern level for men, menopausal women	20+		
Greenland, mothers[90]	14.8		
Northwest Territories, women over 45 years old, 1985	11.7		
Nunavik mothers	10.0		
Northeast Cape, women	9.3	3.7	15.3
Northeast Cape men	8.7	1.2	19.4
Atka, Alaska [91]	8.0	ND	53.7
Savoonga men	7.6	2.9	15.8
Gambell men	7.2	3.0	13.7
Savoonga women	6.9	2.1	13.3
St. George, Pribilofs, Alaska	6.6	ND	29.6
Swedish mothers	6.1		
Akutan, Alaska	5.5	2.8	17.9
Action level for pregnant and nursing women	5		
Concern level for women of reproductive age	5		
Gambell women	4.5	2.6	8.4
Northwest Territories, Inuit mothers	4.3		
Norwegian mothers	3.6		
St. Paul, Pribilofs, Alaska	3.4	ND	42.3
ACAT Staff, women	3.2	1.4	4.6
Akutan, Atka, Nikolski, and Pribilofs, women	2.0	ND	14.9
Northwest Territories, Dene mothers	1.6		
Arctic Newborn Babies (cord blood)			
Nunavik newborns	1.9		
Northwest Territory Inuit newborns	1.0		
Northwest Territory Dene newborns	0.2		
Unexposed People			
Non-fish eaters Lake Michigan US	17.3	<5	41
Infrequently eat fish, Great Lakes area, US men	1.5	0.5	9.7
US population, average	1 – 1.5		
Infrequently eat fish, Great Lakes area, US women	0.9	0.5	3.3

Figure 26: Blood Levels of PCBs in Arctic Peoples and Unexposed Populations *(ppb)*

[88] Concern and Action levels are from Canadian guidelines, listed in Kinloch and Kuhnlein 1988
[89] Listings with ages are from DeWailly et al 1994
[90] For "mothers", maternal blood plasma of pregnant women was analyzed. Both the mother and the child has blood tested. For the baby, blood from the umbilical cord of her baby (cord blood) is tested.
[91] Aleutian Island and Pribilofs information from Middaugh et al 2000

1. Pesticides that affect Arctic People

a) HCB

HCB was used by some countries as a fungicide until the 1980s; it currently enters the atmosphere as a byproduct of incinerators. It is also used as a base for the making of chlorinated solvents and pesticides.

It has been found in high levels in snow and seawater in northern Canada, due to global atmospheric transport. Residents of St. Lawrence Island are most likely exposed through the food they eat: Alpa manik and oogruk blubber (not oogruk meat) had elevated HCB.

HCB may increase the risk of certain cancers. In lab animals, it is known to cause liver, kidney, and thyroid cancers, and to cause birth defects, behavior changes, reproductive problems, and depressed immune systems. In people, it causes skin lesions. The health effects caused by long term exposure is not known.

b) DDT and DDE

The pesticide DDT was banned by many Western nations in the mid-1970s, although it is still in use in some places, especially in Africa where it is effective in controlling mosquitoes that carry malaria. Like all POPs, our metabolism is able to slowly break down DDT. Unfortunately, it breaks down into DDE and DDD, which are also toxic. They are called "metabolites" of DDT because the body's metabolism makes them. All three are stored in fatty tissues. Altogether they are referred to as ΣDDT (Σ just means the sum of DDT+DDE+DDD).

DDT and its metabolites are found in Arctic air, snow, seawater, and in humans throughout the world. Most people in Alaska do not have any DDT, but nearly all have levels of DDE and DDD[92]. This is because people in Alaska are not directly exposed to the pesticide DDT, and it has been partly broken down by the time it reaches us. They all leave our body through feces, urine, and breastmilk, but we absorb them faster than they leave. If DDT is no longer used or manufactured in the world, it will eventually leave our bodies entirely; already there has been a dramatic decrease in the levels found in Arctic animals and people since the 1970s.[93]

DDT has not been linked to cancer in human studies yet, but is considered a "probable carcinogen" by the EPA because it has caused cancers in lab animals. In animals, it has been found to cause problems in reproductive and nervous systems and in the liver. It makes lab animals hyperactive, less coordinated, with less memory and stamina. It is suspected of causing developmental delays in children.

Recently studies have been done in the lab with human embryo cells in petri dishes (small containers), exposing the cells to the same levels of DDE that are found in Alaska Natives from Barrow. Human cells stopped multiplying (the cell cycle paused) for a while, but then resumed. Cells did not die[94].

When DDE was mixed with levels of HCB also commonly seen in Alaska Natives, the mixture caused a decrease in the number of cells expected to grow (cell cycle pause again), more DNA strand breaks than expected, and potential damage to cell membranes[95]. What this means is that a mix of DDE and HCB in levels seen in Alaskans may interfere with the normal cell function of a developing fetus.

DDT and/or DDE have been found in quyngiq, oogruk, ayveq, and alpa manik on St. Lawrence Island. Fish have not been tested for it. It is high enough in alpa manik and oogruk blubber to be a concern.

c) Mirex

Mirex is a pesticide that was used in Alaska until 1988, but has not been used in other circumpolar countries. Because of long range transport, it is found in humans throughout North America and Greenland. As with other

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[92] Simonetti et al 2001
[93] AMAP 1998
[94] This study compared the effects of DDE on human embryonic cells and mouse embryonic cells. Some mouse cells did die (Simonetti et al 2001).
[95] Salmon et al, 2002.

POPs, no one knows what harm long term low level exposure to mirex can do. It is considered a "possible carcinogen" because of studies in lab animals that show genetic damage, cancer, and damage to animal fetuses. Like most POPs, it damages kidneys, liver, reproductive system, and thyroid in animals. It also affects the eyes and causes weight loss.

Mirex accumulates in fats, biomagnifies through the food chain, and breaks down into "photomirex". It is eliminated from our bodies slowly, mostly through feces and breast milk. People in Alaska are mainly exposed to mirex through eating fish and bird eggs.

Of the studies on animals at St. Lawrence Island, only alpa manik were analyzed for mirex; levels were low.

2. Pesticides in Food

a) Oogruk, Pesticides, and Health

DDT does not appear to be high enough in oogruk to be of concern, but HCB might be. Few studies have been done on HCB, and none have been done on effects of HCB on marine mammals.

Again, we turn to determining what a safe daily intake level is. When calculating risk using MRLs for average levels of HCB[96] (35 ppb), we determine that eating as little as one ounce of blubber a day may increase chances of health risks. Oddly, seal oil has virtually no HCB in it, and should be safe in any amounts. HCB affects reproduction, the thyroid, the immune system, and cause cancers of the liver, kidney and thyroid in lab animal studies

As with PCB, Canada believes a higher intake of DDT is safer than the US guidelines say.

Blubber (DDT average 70 ppb):
US guidelines suggest that eating more than a pound of oogruk blubber a day could increase a person's risk of health problems. Canadian guidelines suggest 44 lbs of blubber a day is okay!

Oil (DDT average about 35 ppb):
Seal *oil* had about half as much DDT contamination, so a person could eat about twice as much (about 2 pounds per day US or 88 pounds per day Canada) without exceeding safety guidelines for DDT.

DDT in Oogruk: The Math

US:
MRL is 0.0005 mg/kg bw/day

An average sized person (70 kg, or 154 lbs) could eat about 0.035 mg (35,000 ng) a day before exceeding DDT guidelines.

Oogruk blubber has an average of 70 ng of DDT per gram of blubber.

35,000 ng DDT a day
70 ng DDT in a gram of blubber

= 500 grams of blubber a day can be eaten without exceeding DDT guidelines.

500 grams is about a pound.

Canada:
MRL is 0.02 mg/kg bw/day
Using the same math, Canada comes up with an amount of 44 lbs of blubber a day can be eaten without exceeding DDT guidelines.

b. Ayveq, Pesticides, and Health

In ayveq, DDT and HCB levels were both low, but HCH levels were elevated. HCH levels are about 110 ppb in blubber and oil tested in 1998, and up to 413 ppb in blubber tested in 1994. These levels are much higher than what is seen in fish and seals. Possibly ayveq are not able to break down HCH as well as other species. However, these levels are higher than what is seen in most other ayveq in the arctic as well.

If we look at the regulatory limits that countries put on the amount of HCH allowed in fish, we see that ayveq exceed the Canadian limit (of 100 ppb). Other countries have limits that range from 200 to 2000 ppb. The US does not have a regulatory limit for total HCH, although it does have recommended MRLs for the individual α–, β, and γ–HCH chemicals.

High levels of HCH can disrupt hormones, depress the immune system, and affect kidneys and thyroids. It is possible that ayveq may be affected in some of these ways. Using Canadian guidelines[97], we determine a safe daily intake about 6 ounces (at 100 ppb of HCH).

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[96] ATSDR MRL of 0.00002 mg/kg bw/day, chronic oral exposure, developmental effects
[97] 0.3 ug/kg bw/day for combined alpha, beta, delta, and gamma HCH (CACAP 1997, pg 343)

c. Alpa manik, Pesticides, and Health

Alpa manik were analyzed for DDE, HCB, and mirex. DDT is probably not a concern, except at the maximum levels of contamination found. HCB may be concerning for consumers. HCB is about the same as the level found in ayveq, and we determined that as little as about an ounce a day of bird eggs could exceed recommended levels.

Alpa manik *(wet weight, ppb)*	s-PCB	s-DDE	HCB	Mirex
Range	82	78	39	2
Average	47 - 142	26 – 242	23 – 56	1-2

Using US MRLs for DDT (see information box "DDT In Oogruk: The Math"), we determine that a pound of eggs a day (at 78 ppb of DDE, the average level of contamination), or 5 ounces a day (at the maximum contamination) could exceed recommended levels. Canadian guidelines suggest that 12 to 40 pounds a day of eggs would be within recommended levels.

d. Pesticides and Supermarket Foods

A study of DDT in supermarket foods found some supermarket foods had higher levels of DDT than were found in Alaskan fish. (see Appendix H "Contaminants in Fish"). Of supermarket foods, butter had the highest level, at 26 ppb. In comparison, oogruk and alpa manik from St. Lawrence Island ran 70 – 80 ppb. Bowhead whales (taken at Barrow) had the highest levels, at 330 ppb.

3. Human blood levels of Pesticides

Trends for HCB and mirex are the same as the trend for PCBs: Northeast Cape people highest, followed by Savoonga, Gambell, and the ACAT staff in Anchorage.

Levels of mirex in men from all three places were nearly identical, but levels in women followed the pattern. Mirex is known to be found in bird eggs, and may be the primary source. St. Lawrence Island residents have about the same levels as other arctic peoples; information for non-arctic peoples was not available.

HCB levels generally followed the pattern. HCB is found in bird eggs, and also in oogruk blubber (though not in the oil), and is not expected to be a contaminant left by the military. Levels in St. Lawrence Island residents were in the same range as for other arctic peoples; information was not available for non-arctic people.

Levels of DDE do not follow the pattern. Levels in all three places run about the same, from a low of 2.5 ppb (Savoonga men) to a high of 3.3 ppb (Gambell women). There is less than 1 ppb difference between everyone. The ACAT staff actually had the highest average levels, at 3.8 ppb. DDE was expected to come from global sources, and would affect all residents similarly. The levels are about the same as other arctic residents, and about the same as the average DDE+DDT for people from the lower 48. DDE was not found to be elevated in a animals from St. Lawrence Island, except at the highest levels of contamination in bird eggs.

Mirex is a pesticide that was used in Alaska until 1988, but has not been used in any other circumpolar countries. Because of long range transport, it is found in humans throughout North America and Greenland. As with other POPs, no one knows what harm long term low level exposure to mirex can do. It is considered a "possible carcinogen" because of studies in lab animals that show genetic damage, cancer, and damage to animal fetuses. Like most POPs, it damages kidneys, liver, reproductive system, and thyroid in animals. It also affects the eyes and causes weight loss.

Hexachlorbenzene

	Gambell		Northeast Cape		Savoonga		ACAT Staff
	Female	Male	Female	Male	Female	Male	Female
Average	0.47	0.55	0.87	0.63	0.68	0.75	0.13
Min	0.11	0.15	0.40	0.07	0.31	0.14	0.04
Max	0.93	0.99	1.41	1.61	1.39	2.64	0.25

DDE

	Gambell		Northeast Cape		Savoonga		ACAT Staff
	Female	Male	Female	Male	Female	Male	Female
Average	3.33	3.19	2.65	3.00	2.88	2.51	3.84
Min	0.70	1.21	1.36	0.69	0.96	0.48	0.85
Max	11.43	4.82	3.69	5.18	4.17	5.58	6.70

Mirex

	Gambell		Northeast Cape		Savoonga		ACAT Staff
	Female	Male	Female	Male	Female	Male	Female
Average	0.10	0.22	0.30	0.28	0.18	0.28	0.08
Min	0	0.08	0.08	0.03	0.04	0.09	0
Max	0.22	0.39	0.68	1.06	0.44	0.71	0.14

Figure 27: Blood levels of pesticides, St. Lawrence Island *(ppb)*

Mirex accumulates in fats, biomagnifies through the food chain, and breaks down into "photomirex". It is eliminated from our bodies slowly, mostly through feces and breast milk. People in Alaska are mainly exposed to mirex through eating fish and bird eggs. Of the studies on animals at St. Lawrence Island, only alpa manik were analyzed for mirex; levels were low.

	Average	Minimum	Maximum
Arctic Peoples			
Nunavik mothers, 1992[98]	1.4		
Greenland mothers	0.9		
Northeast Cape women	0.9	0.4	1.4
Nunavik mothers, 1995	0.7		
Savoonga men	0.7	0.1	2.6
Savoonga women	0.7	0.3	1.4
Northeast Cape men	0.6	0.08	1.6
Gambell men	0.5	0.2	1.0
Gambell women	0.5	0.1	0.9
Northwest Territories, Inuit mothers	0.5		
Norilsk, Russian mothers	0.4		
Icelandic mothers	0.3		
Norwegian mothers	0.2		
Northwest Territories, Dene mothers	0.2		
Swedish mothers	0.2		
ACAT staff	0.1	0.04	0.2
Arctic Newborn Babies (cord blood)			
Barrow Alaska newborns [99]	0.33	0.12	0.84
Nunavik Inuit newborns	0.14	0.02	1.2
Northwest Territory Inuit newborns	0.14		
Norilsk, Russian newborns	0.14		
Northwest Territory Dene newborns	0.06	0.01	0.32
Northwest Territory non-aboriginal newborns		0.01	0.12

Figure 28: HCB Blood Levels in Arctic Peoples *(ppb)*

[98] Klopov, 1996
[99] Simonetti et al, 2002

	Average	Minimum	Maximum
Non Arctic People			
Great Lakes, US fisheaters[100]	5.5		
Arkansas, US	2.8		
Arctic People			
Nunavik mothers, 1992	11.2		
Nikolski, Atka, and Akutan, Alaska[101]	7.8	0.5	33.5
Nunavik mothers, 1995	6.0		
Greenland mothers	5.2		
ACAT staff, women	3.8	0.9	6.7
Gambell women	3.3	0.7	11.4
Gambell men	3.2	1.2	4.8
Northeast Cape men	3.0	0.7	5.2
Savoonga women	2.9	1.0	4.2
Northeast Cape women	2.7	1.4	3.7
Savoonga men	2.5	0.5	5.6
Northwest Territories, Inuit mothers	1.9		
Barrow Alaska mothers	1.3	0.4	3.5
Northwest Territories, Dene/Metis mothers	1.3		
Icelandic mothers	1.1		
Swedish mothers	1.1		
Norwegian mothers	0.9		
Norilsk, Russian mothers	0.9		
Arctic Newborns			
Southern Quebec newborns		6.1	14.9
Nunavik Inuit newborns	1.3	0.1	14.0
Northwest Territories Non Aboriginal newborns		0.1	9.3
Northwest Territories Inuit newborns	1.3	0.1	1.6
Norilsk, Russian newborns	0.9		
Northwest Territories Dene newborns	0.3	0.1	1.1
Barrow Alaska newborns	0.3	0.1	0.8

Figure 29: DDE Levels in Blood of Arctic and NonArctic peoples ***(ppb)***

	Average	Minimum	Maximum
Nunavik mothers, 1992	0.35		
Northeast Cape women	0.30	0.08	0.68
Northeast Cape men	0.28	0.03	1.06
Nikolski, Atka, and Akutan, Alaska[102]		ND	0.8
Savoonga men	0.28	0.09	0.71
Norilsk, Russian mothers	0.27		
Gambell men	0.22	0.08	0.39
Savoonga women	0.18	0.04	0.44
Gambell women	0.10	0	0.22
ACAT staff	0.08	0	0.14
Arctic Children (cord blood, ug/l)[103]			
Northwest Territory Inuit		0.01	0.65
Nunavik Inuit		0.01	0.13
South Quebec people		0.01	0.03
Northwest Territory non –aboriginal people		0.01	0.02
Northwest Territory Dene	0.01		

Figure 30: Mirex Levels in Blood of Arctic People *(ppb)*

[100] Middaugh et al 2001
[101] Middaugh et al 2001
[102] From Middaugh et al 2001
[103] From Canadian Arctic Contaminants Assessment Program (CACAP) 1998 (Jensen J, ed)

E. Discussion of Results of Human Blood Tests

Every human has some level of PCBs and DDT/DDE in their blood. Blood tests are the only way to tell what level of contaminants is in your personal body. Interviews that accompany the blood draws help us learn how a person was exposed to contaminants. Blood was only tested for four kinds of contaminants: PCBs and the pesticides HCB, DDE, and mirex. People would likely be exposed to PCBs both through the food they eat and from direct contact with PCBs while working in the military, or living near spills left by the military. People would be exposed to pesticides (HCB, DDE, and mirex) through wild foods, especially marine animals. Researchers hoped to see whether the military presence at Northeast Cape and Gambell had affected people who spent time there.

Summary of human blood results is in the table below. As expected, the contaminant levels were usually slightly higher in men than in women, because women are able to pass some of their to children during pregnancy and breastfeeding.. Contaminants were also higher in older people.

	US	ACAT staff	Gambell		Savoonga		Northeast Cape	
	avg	Female	female	male	female	male	female	male
PCB average	1	3.20	4.53	7.23	6.96	7.60	9.34	8.71
HCB average		0.13	0.47	0.55	0.68	0.75	0.87	0.63
DDE average		3.84	3.33	3.19	2.88	2.51	1.36	0.69
Mirex average		0.08	0.10	0.22	0.18	0.28	0.30	0.28

Blood results for PCB and HCB show a distinct split between Anchorage staff and Northeast Cape people (with Gambell and Savoonga falling in between), while DDE and mirex levels remain fairly constant across all people. The murre eggs that were tested had some DDE and mirex, but levels were not high; ACAT staff in Anchorage actually had higher DDE levels, and only one of them has ever had alpa manik!

There is reason for concern about the levels of PCB and HCB. HCB exposure is apparently occurring through eating ayveq blubber and alpa manik. PCB exposure may have been through direct contact in the military. PCB is also found at over 50 ppb (the level at which it is safe to eat unlimited amounts of an animal) in all animals tested except quyngiq. How much of an animal is "safe" to eat daily is debatable, depending on whether you use US or Canadian guidelines, the overall health of the person, and whether the consumer is a girl or woman of reproductive age. It is critical that all women minimize their exposure to PCBs until they are past reproductive age, since it takes ten years for your body to get rid of half the PCBs in it; that is, if you are born with PCBs and have no exposure for the next ten years, your PCB level will be half of what it was when you were born. If you have no exposure for twenty years, you will have one-fourth of the level you had when you were born.

Although there was an increasing trend in blood levels of HCB from a low in Gambell, to Savoonga, to a high in Northeast Cape, generally people from the island had about the same levels as found in other northern, marine mammal eating people.

However, women from St. Lawrence Island had significantly higher PCB levels (7 – 9 ppb) than women from the Aleutians and Pribilof Islands (2 ppb). They were high enough to increase the risk of cancer. They were high enough to potentially increase risk of problems with the immune system, nerves, and endocrine system (hormones that regulate growth, metabolism, sexual cycles and development). They were high enough to increase risk of cancer and reproductive problems. This is a serious concern. Women may want to contact the Alaska Native Health Board about the "maternal blood-cord blood sampling program". The program checks mother and child blood levels for contaminants. Knowing this may or may not be helpful; it may only serve to increase fear. Once a child is born, there is little that can be done except minimize exposure to contaminants and give them as healthy a diet and lifestyle as possible, which all mothers will want to do anyhow. Having contaminants in your blood does not *necessarily* mean you will have health problems, but it is an added burden to the body.

Because PCBs are a global contaminant that has biomagnified to elevated levels in nearly all food consumed by northern people, it will take **global** efforts to eliminate it. Russia reportedly made and used PCBs until just a

few years ago. In the US and Canada, PCBs are not produced, but they do remain in old transformers and can be found leaking from landfills, including military landfills in Alaska. PCB use is completely banned in Scandinavia. Whether PCBs are used in Asia is not known, but if they are, they could impact St. Lawrence Island because of the way air currents drift.

HCB is not used by northern nations (possibly by Russia), and levels are expected to decrease worldwide with time. Pesticides *are* still heavily used by Asia, especially China, and St. Lawrence Island is particularly vulnerable to them.

What can you do?

Women of reproductive age may want to have PCB levels checked and learn what they can do to have healthy children. People who spent significant time at Northeast Cape may want to see how they can optimize their health, since a healthy body is more able to fight toxins. Some traditional foods, as outlined in this report, are much lower in contaminants than others. Animals that tend to have generally lower levels of POPs are reindeer. Because they eat low on the food chain, we would suspect that plant-eating birds may have lower contaminant levels. Lean meat from any animal tends to be lower in contaminants than fatty meat or blubber. Animals that tend to have higher levels of POPs are those at the "top" of the food chain. One food that was not mentioned previously, which tends to be very high in contaminants, is polar bear. Polar bear in the Alaskan arctic (like seal – eating walrus in other arctic areas), biomagnify contaminants from the seals they eat. Polar bear meat, fat, and organs tend to be particularly high in contaminants. More studies testing traditional food just the way it is eaten (dried meat, meat stored in oil, etc) will help us see which are most (and least) contaminated so communities can make decisions on how to maintain their traditional lifestyle while avoiding most exposure to contaminants.

It is unconscionable that people who have never made, used, or were in any way involved with these chemicals need to fear them and deal with them on a daily, personal level. It is horribly wrong that dangerous chemicals continue to be made and used. All northern peoples need to work together to eliminate the sources of POPs so no one has to fear traditional foods. Most countries banned DDT in the 1970s, and now, thirty years later, we see a significantly lower level of contamination in northern animals even though a few countries continue to use it. Stopping countries from making or using a chemical has *real* effects. A new global treaty, called the Stockholm Convention, is a vital part of eliminating POPs from the world. This international treaty would ban the production and use of the twelve worst POPs (including PCBs), and could potentially ban more chemicals later if they are found to be globally harmful. It is essential that Alaskans write to senators Ted Stevens and Frank Murkowski in support of this treaty, telling them that they need to sign it. President George Bush has signed it (through Christine Whitman), but now our Congress needs to approve (ratify) it. Fifty nations need to ratify the treaty (have their Congresses approve it) before it will become international law.

Northern people and animals will remain at risk of increasing health problems until all POPs are eliminated.

XIII. Future Work

ACAT will be on St. Lawrence Island in the summers of 2002 and 2003 to do contaminant testing in Gambell, Savoonga, and Northeast Cape, to help residents know what contaminants they or the nunivagseghat and animals on the island may be exposed to.

At Northeast Cape, sensitive equipment will be used to detect whether low level PCBs and PAHs are in Suqi River water or bottom sediments. If fish eggs can be found, eggs will be tested for PAHs. Greens and the soil they grow in will be gathered, in order to test washed and unwashed nunivagseghat for metals and PCB to determine whether high levels seen previously were in dust or in nunivagseghat. This study will help determine which species, if any, concentrate metals and PCBs. Soil, water, and nunivagseghat far from areas of human activity will be sampled in order to understand true background levels of metals and PAHs. Soil will be tested for explosives residue. Air sampling will be done at Northeast Cape, and, if people on the island are interested, local people will be trained in using the machine so they can take samples at several locations around the island.

Other ideas that may be pursued include:
Having residents gather gull eggs to test, since gulls tend to have high levels of contaminants.
Gather greens and associated soil at Gambell to test for metals and PCBs.
Test the "interstitial pore water" of the Suqi River. This is water right above the sediment, and water in between sediment and gravel. Inorganic metals tend to concentrate at this juncture.[104]
Testing the organs of fish in the Suqi and Troutman Lake for metals.
Testing fish from Troutman Lake for parasites, PAH, and PCB levels.
Collect sediment from the center of the estuary area where PAH and PCBs may settle out.
Determine what fish people use for subsistence, and what those fish eat.
Test soil for organophosphate pesticides.
If it is obvious that two types of dolly varden are in the Suqi – resident and anadromous—fish will be separated and sampled to determine levels of local versus background (global) PCB and PAH contamination.

ACAT welcomes ideas from residents of St. Lawrence island about what testing or actions ACAT can take that would benefit the communities.

[104] Personal communication, Heidi Zamzow, MS. July 2002.

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http://www.cas.org/CASFILES/chemlist.html (regulated chemicals listing database)

http://www.epa.gov/iris/ (EPA Integrated Risk Information System)

http://www.epa.gov/ost/fishadvice/volume2/ (Recommended PCB level in unlimited fish consumption)

http://www.foxriverwatch.com/monsanto2b_pcb_pcbs.html (history of PCBs, health issues)

http://risk.lsd.ornl.gov/tox/profiles/anthra_c.shtml (risk assessment information system, toxicity profiles)

http://www.state.ak.us/local/akpages/ENV.CONSERV/home.htm (ADEC home page)

*www.nativeknowledge.org

ACAT
Alaska Community Action on Toxics

505 W. Northern Lights
Suite 205
Anchorage, Alaska 99503

Phone 907-222-7714
Fax 907-222-7715
email: info@akaction.net
http://www.akaction.net

TAKE ACTION IN SUPPORT OF THE STOCKHOLM CONVENTION

International Treaty Would Eliminate Certain Persistent and Toxic Chemicals

A new global treaty, the Stockholm Convention, aims to eliminate a class of chemicals that the international community has agreed is extremely dangerous to human health and the environment. On May 23, 2001, ninety-one countries and the European Community formally signed the treaty. The treaty must now be ratified by at least 50 countries before it goes into effect. The United States Senate has not yet ratified the treaty. ***We are calling upon Alaska Senators Ted Stevens and Frank Murkowski to play a key role in the rapid ratification and implementation of the treaty.***

The chemicals in question are persistent organic pollutants ("POPs")—substances that are toxic, persist in the environment, accumulate in the body fat of humans and animals, concentrate up the food chain, and can be transported across the globe. Infants around the world are born with many POPs in their blood—developing children are particularly at risk from exposure in the womb. At low exposures, POPs can cause health problems such as certain cancers, birth defects, and lowered intelligence. The Arctic is a hemispheric sink for persistent pollutants. POPs continue to accumulate in northern environments, animals, and people, including those already banned in the United States such as the pesticide DDT. The treaty recognizes the special vulnerability of Alaska Native and other Northern Indigenous Peoples who are reliant on traditional foods such as fish and marine mammals.

The treaty identifies an initial list of 12 POPs slated for elimination. Nine of the 12 (aldrin, endrin, dieldrin, chlordane, DDT, heptachlor, hexachlorobenzene, mirex, and toxaphene) are pesticides. The other chemicals are: PCBs (industrial chemical used in electrical equipment and other applications); and dioxins and furans (by-products of chlorine-based industries and incineration). The pesticides named above and PCBs have already been banned in the U.S., but the chemicals are still in use in many other countries. Dioxins and furans are still produced as by-products of industrial processes in the U.S.

The treaty contains provisions and establishes scientific criteria to add new chemicals beyond the initial list of the 12 "dirty dozen." The treaty establishes that the addition of new chemicals will be informed by the precautionary principle, directing the international community to take protective action based on available knowledge. Some of the chemicals likely to be considered for addition, such as the pesticides lindane and endosulfan, are currently in widespread use in the U.S. and other industrialized nations. Elimination of these and other additional chemicals is likely to be more controversial than an agreement to eliminate those that have already been banned domestically.

Please contact Senator Ted Stevens and Senator Frank Murkowski and urge them to take a leadership role in the ratification and implementation of the Stockholm Convention in the United States Senate. The Senate is discussing the treaty NOW, so it is urgent that you let them know why this is important for Alaskans. Ask them to:

- **Ratify the Stockholm Convention in the U.S. Senate immediately.**
- **Implement the treaty by requiring the EPA to focus on the elimination of dioxin emissions.**
- **Implement the treaty by requiring the phase-out and elimination of additional persistent pesticides and other industrial chemicals that qualify as persistent pollutants under the Stockholm Convention (examples include the pesticides lindane and endosulfan).**

Senator Ted Stevens
United States Senate
522 Hart Building
Washington DC 20510-0201
Phone: (202) 224-3004
Fax: (202) 224-2354
Senator_Stevens@stevens.senate.gov
http://www.senate.gov/~stevens/webform.htm

Senator Frank Murkowski
United States Senate
332 Hart Building
Washington DC 20510-0202
Phone: (202) 224-6665
Fax: (202) 224-4349
http://murkowski.senate.gov/webmail.html

For more information, please contact Alaska Community Action on Toxics at 222-7714. Thank you!

Appendix A

Understanding Very Small Numbers

Throughout this report, we look at very very small numbers. We can easily visualize amounts like "pounds", "ounces", or "tons"; but the contaminant levels in meat, blood, soil, and water are much smaller.

In science, the metric system is used:

Grams or kilograms	instead of ounces or pounds
Liters	instead of quarts or gallons

We commonly see kilograms and liters on packages in the store now. A five pound bag of rice weighs about two kilograms. A one quart bottle of soda is about a liter.

When we look at very small amounts of something, we need names for extremely small numbers. Grams and liters can be divided into much smaller units:

one liter (1 l) is the same as
one thousand milliliters (1,000 ml) which is the same as
one million microliters (1,000,000 ul).

one gram (1 g) is the same as
one thousand milligrams (1,000 mg) which is the same as
one million micrograms (1,000,000 ug) which is the same as
one billion nanograms (1,000,000,000 ng)

You often see "kilograms" used, also. A kilogram is much bigger than a gram.
one kilogram (1 kg) = one thousand grams

Sometimes it is easier to imagine a number if we use the terms "parts per million" or "parts per billion". If you had a million Snickers candy bars and one Hersheys, the Hersheys bar would be one in a million, the same as one part per million (1 ppm). If you had a billion orange basketballs, and one was green, the green one would be one in a billion, the same as one part per billion (1 ppb).

In this report, we might say "The amount of PCBs found in dolly varden eggs is 10 ng/g." That would mean that out of one gram of eggs, ten nanograms of PCBs were found.

Remember that it takes one *billion* nanograms to make one gram. It takes a billion nanograms of water to make a gram of water. It takes a billion nanograms of chocolate to make a gram of chocolate. It takes a billion nanograms of PCB to make one gram of PCB. It takes a billion nanograms of *anything* to make one gram of anything. We can use metric terms, like "nanogram" or "gram" to come up with ppm or ppb.

1 ppm	= 1 mg/kg	1 ppb	= 1 ug/kg
	= 1 ug/g		= 1 ng/g
	= 1 mg/l		= 1 ug/l

Appendix B

Regulatory Levels of Contaminants

PCB Information

Soil

Soil, Alaska state regulations:	1,000 – 10,000 ppb
Soil, US federal regulations:	25,000 ppb

Water

Bottled water, FDA	0.5 ppb
Drinking water, EPA	0.5 ppb
Human health consumption of water,EPA	0.00017 ppb
Human health consumption of organisms in water, EPA	0.00017 ppb

Food[1]

US concern level, PCBs in commercial fish	2,000 ppb
US concern level, PCBs in eggs	300 ppb
US concern level, PCBs in milk	2,000 ppb
US action level, PCBs in red meat	3,000 ppb
US concern level, PCBs in infant food	200 ppb
US concern level, PCBs in fish for unlimited consumption	50 ppb

Allowable Daily Intakes:

US EPA Minimum Risk Level, PCB 1016:	0.07 μg/kg bw/day
US EPA Minimum Risk Level, PCB 1254	
Intermediate oral exposure:	0.03 μg/kg bw/day
Chronic oral exposure:	0.02 μg/kg bw/day
Canadian ADI:	1 μg/kg bw/day

Human Blood Levels, Canadian Guidelines

Concern level for women of reproductive age:	5 – 100 ppb
Action level for women of reproductive age:	100+ ppb
Concern level for men and postmenopausal women:	20 – 100 ppb
Action level for men and postmenopausal women:	100+ ppb

[1] From "Contaminated Catch" pg 43

Contaminant	Soil (ng/g) Inhale	Soil (ng/g) Ingest	Soil (ng/g) *Migration to* Groundwater	Water (µg/l) Water	Food *MRLs*[2] *(mg/kg bw/day)*	Food *Safe amount of contaminant for 150 lb person to eat every day*
OIL RESIDUES						
DRO	12,500,000	10,250,000	250,000	1500		
GRO	1,400,000	1,400,000	300,000	1300		
RRO	22,000,000	10,000,000	11,000,000	1100		
PAHs						
Acenaphthene	--	6,100,000	210,000	2200		
Anthracene	--	30,000,000	4,300,000	11,000	US[3]: 10	700,000,000 ng
Benzo(a)anthracene	--	11,000	6,000	1		
Benzo(a) pyrene	--	1,000	3,000	0.2		
Benzo(b)flouranthene	--	11,000	20,000	1		
Benzo(k)flouranthene	--	110,000	200,000	10		
Chrysene	--	1,100,000	620,000	100		
Dibenzo(a)anthracene	--	--	--	0.1		
Flouranthene	--	4,100,000	2,100,000	1460	US[1]: 0.4	28,000,000 ng
Flourene	--	4,100,000	270,000	1460	US[1]: 0.4	28,000,000 ng
Indeno(1,2,3)	--	11,000	54,000	1		
Naphthalene	--	4,100,000	43,000	1460	US1: 0.02	1,400,000 ng
Pyrene	--	3,000,000	1,500,000	1100		
2-methylnaphthalene	--	---	--	--		
phenanthrene	--	---	--	--		
BTEX						
Benzene	9,000	290,000	20	5		
Toluene	180,000	20,300,000	5400	1000	US,[4]: 0.02	1,400,000 ng
Ethylbenzene	89,000	10,000,000	5500	700		
Xylene	81,000	20,300,000	78,000	10,000	US[5]: 0.2	14,000,000 ng

[2] Minimum risk levels, from Agency for Toxic Substances and Disease Registry
[3] From ATSDR, using oral intermediate exposure, with the observed effect of liver damage.
[4] From ATSDR, using oral intermediate exposure with the observed effect: of neurological damage
[5] From ATSDR, using oral intermediate exposure with the effect: of kidney damage.

Contaminant	Soil (ng/g) Inhale	Ingest	*Migration to* Groundwater	Water (μg/l) Water	Food *MRLs (mg/kg bw/day)*	*Safe amount of contaminant for 150 lb person to eat every day*
PESTICIDES						
Aldrin	24,000	500	1600	0.05	US[6]: 0.00003	2100 ng
Chlordane	140,000	6000	3000	2	US6: 0.0006	42,000 ng
DDE	--	24,000	150,000	2.5		
DDT	5,300,000	24,000	88,000	2.5	US[7]: 0.0005	35,000 ng
					CA[8]: 0.02	1,400,000 ng
Dieldrin	8,000	500	15	0.05	US6: 0.00005	3500 ng
Endrin	--	30,000	300	2	US[9]: 0.0003	21,000 ng
Endosulfan	--	610,000	7000	200	US6: 0.002	140,000 ng
α HCH	5500	1300	2.6	0.10	US6: 0.008	560,000 ng
β HCH	43,000	4600	9	0.47	US[10]: 0.0006	42,000 ng
γ HCH	--	6400	3	2	US[11]: 0.00001	700 ng
heptachlor	800	2000	8000	0.4		
heptachlor epoxide	33,000	900	200	0.2	US[12]: 0.000013	910 ng
hexachlorobenzene (HCB)	7,000	5,000	730	1	US[13]: 0.0008	56,000 ng
METALS						
Arsenic	--	5500	2000	50	US[14]: 0.0003	21,000 ng
Lead	(residential 400, commercial 1000)			15	CA8: 0.0035	245,000 ng
Mercury	18,000	--	1400	2	Ca[15]: 0.0001	7000 ng
					Ca[16]: 0.0004	28,000 n

[6] From ATSDR using oral chronic exposure with the effect of liver damage.
[7] From ATSDR using oral intermediate exposure with the effects of developmental and liver damage.
[8] Canadian recommended level.
[9] From ATSDR using oral chronic exposure with the effect of neurological damage.
[10] From ATSDR using oral intermediate exposure with the effect of liver damage.
[11] From ATSDR using oral intermediate exposure with the effect of immunological damage.
[12] EPA reference dose for non – cancer effects concerning fish consumption, p37 "Contaminated Catch"
[13] EPA reference dose for non – cancer effects concerning fish consumption, p37 "Contaminated Catch"
[14] From ATSDR using chronic oral exposure with the effect of skin changes.
[15] California recommendations for women who are pregnant or thinking of becoming pregnant (Contaminated Catch)
[16] California recommendations for adults other than pregnant women.

Appendix C

PAH in Plants and Animals at Northeast Cape

Assessing PAH risk in foods

ATSDR lists minimal risk levels (MRLs) for acenaphthene, anthracene, fluorene, fluoranthene and naphthalene. Using the MRLs, we can find out how much food we can eat safely. Below, this is detailed for three of the PAHs.

Acenaphthene: ATSDR recommends not eating more than 0.6 mg of acenaphthene per kilogram of body weight per day[17].

If you weigh 70 kg (154 lbs), you should not eat more than

0.6 mg/kg x 70 kg = 42 mg (= 42,000,000 ng) of acenaphthene per day

The highest level in plants is: 75 ng/g
The highest level in reindeer is: 14 ng/g
The highest level in fish is: 26 ng/g
The highest level in smoked fish: 280 ng/g
(from Prince William Sound)

Since plants have the highest level of acenaphthene found in food from the island that was tested, we will look at how much of that plant can safely be eaten.

Safe amount of plant to eat =
(42 mg of acenaphthene per day is safe) / (75 ng of acenaphthene found per gram of plant)
= 42 mg per day/.000075 mg per gram
= 560,000 grams per day
= 1235 pounds of plant per day can be eaten safely

Using the same technique, we can see that we can eat 150,000 pounds of smoked salmon every day and not get too much acenaphthene.

Anthracene: ATSDR says people should not eat more than 10 mg of anthracene per kilogram of body weight per day[36]. If you weigh 70 kg, you should not eat more than 700 mg (=700,000,000 ng) of anthracene a day.

The highest level in plants is: 50 ng/g
The highest level in reindeer is: 40 ng/g
The highest level in fish is: 11 ng/g (fish eggs)

Using the math techniques above, and using plants at 50 ng/g, we can safely eat 1,400,000 pounds a day of the most contaminated plant.

Naphthalene: ATSDR says people should not eat more than 0.02 mg of naphthalene per kilogram of body weight per day[36]. If you weigh 70 kg, you should not eat more than 1.4 mg (=1,400,000 ng) of naphthalene each day.

The highest level in plants is: 42 ng/g
The highest level in reindeer is: 11 ng/g
The highest level in fish is: 68 ng/g
The highest level in smoked fish (*from Prince William Sound*): 1200 ng/g

Using the math techniques above, and taking fish at 68 ng/g of contamination, we can safely eat over 20,500 pounds of fish a day (or 1,000 pounds of smoked fish from Prince William Sound).

---

[17] MRL for intermediate oral exposure with the result of liver problems.

PAHs in Foods from Northeast Cape (ppb)

	Light Aromatics						*Heavy Aromatics*									
	Acenaphthene	Anthracene	Fluorene[18]	2 – mehtyl naphthalene	Naphthalene	Phenanthrene[37]	Benzo(a)anthroacene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(b)pyrene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenzo(a,h)anthracene	Fluoranthene[37]	Indeno(1,2,3)pyrene
Soil, Regulatory limit	210,000	4,300,000	270,000	?	43,000	?	6,000	1,000	11,000	?	?	110,000	620,000	0	2,100,000	11,000
Water, Regulatory limit	2200	11,000	1460	?	1460	?	1	0.2	1	?	?	10	100	0.1	1460	1
Plants, Minimum	0	0	0	nl	0	nl	0	0	0	?	?	0	0	0	0	0
Maximum	75	50	78		42		240	330	290			340	420	62	980	360
Suqi Fish																
stickleback	0	0	0		0		0	0	0			0	0	0	0	0
Blackfish minimum	6	0	11		0	0	0	0	0			0	0	0	0	0
maximum	26	0	67		68	9	0	0	0			0	0	0	4	0
Dolly minimum	0	0	0		0		0	0	0			0	0	0	0	0
maximum	9	18	19		12		20	15	11			30	20	11	2	7
Tapi Fish dolly, pinks	0	0	0		0		0	0	0			0	0	0	0	0
salmon[19], smoked	75-280		410-2100	?	450-1200	1800-5600	13-45	6-20	6-16	?	?	6-21	23-41	0.2-0.6	280-1400	3-9
Reindeer, Maximum	14	40	19	4.8	11	67	22	12	16	?	7.4	12	19	6.8	48	8.7
US food[20] Cigarettes								170 ng/cig								
Cooked beef								24 ppb								
Leaf vegetable								48 ppb								

[18] One of the abundant global PAHs found in the Canadian high arctic.
[19] From Prince William Sound, AK
[20] Cigarettes, for second hand smoke, information from British Columbia Ministry of Health; Beef, EPA 1980; leafy vegetables EPA 1985.

	light aromatics						heavy aromatics											
Site	acenaphthylene	anthracene	fluorene	2-methylnaphthalene	naphthalene	phenanthrene	benzo(a)anthracene	benzo(a)pyrene	benzo(b)fluoranthene	benzo(b)pyrene	benzo(ghi)perylene	benzo(k)fluoranthene	chrysene	dibenzo(a,h)anthracene	dibenzofuran	flouranthene	indeno(1,2,3-cd)pyrene	pyrene	DRO
SOIL																			
Site 1,3, 4, 5, 8, 12,13,14, 15, 18,19, 20, 26, 27: did not look for PAHs in soil																			
Site 2																			
SS 801								4											8200
Site 6 *BH6-3,MW6-1to6-2,SS112-117,SD100,SD115: none detected*																			
Site 7 (Cargo Beach Rd Landfill)																			
SD 104 (2001)								14			14	35					26		1,400,000
SS 127 (2001)			47	27	14		82					13					13		720,000
BH7-1 to 7-3, MW7-4, SS119 - 126, SD101 - 103: none detected																			
Site 9 (Housing Landfill)																			
SD 109 (2001)					24	21	86	39		88	57	64			23	18	41		510,000
MW9-1 - 9-3, SS 138 - 141, SS 801, SD104 - 108, 113, 114, 213: none detected																			
Site 10 (Buried Drum Field) *SS125 -128,SS134,SD116: none detected*																			
Site 11 *SS133-136: none detected*																			
Site 16 *MW16-1-16-3, SS156-164: none detected*																			
Site 17 *SS165: none detected*																			
Site 21																			
MW 21-1				19															482,000
MW 21-2				8															
MW 21-3, SS166-168, SD112: none detected																			
Site 22																			
SS170							349	423				772							2,640,000
Site 23 *SS171: none detected*																			
Site 24 *MW24-1 - 24-3, SS172 - 175, SD113: none detected*																			
Site 25 *SS176 - 177, SD114: none detected*																			

	light aromatics							heavy aromatics												
Site	acenaphthene	acenaphthylene	anthracene	fluorene	2-methylnaphthalene	naphthalene	phenanthrene	benzo(a)anthracene	benzo(a)pyrene	benzo(b)fluoranthene	benzo(b)pyrene	benzo(ghi)perylene	benzo(k)fluoranthene	chrysene	dibenzo(a,h)anthracene	dibenzofuran	flouranthene	indeno(1,2,3-cd)pyrene	pyrene	DRO
Site 28 (Suqi Drainage)																				
1994 - 1999 soil data																				
SS802			*16*				*16*										*35*		*25*	*95,000*
SD801	*670*				*6500*		*710*													*14,000,000*
SD802														*150*			*14,0*			
	2700		*1600*	*3100*	*13,000*	*2000*	*7500*	*1300*		*830*				*0*			*00*		*9500*	*18,000,000*
SD803				*2100*	*11,000*	*3400*	*1300*													*18,000,000*
BH10-2 to 10-3, MW10-1, MW10-4, SS129-137, SS801, SD109-117: none detected																				
28SD 111		*40*				*210*								*44*			*160*		*180*	
28SD 112				*39*		*15*														
28SD 113			*63*	*160*															*63*	
28SD114	*74*		*140*	*1400*	*330*	*18*									*33*					
28SD 115	*320*		*615*	*8*	*1800*										*75*					
and lots more 28 data																				
Site 29 1994-1999																				
SD801				*9*	*5*	*13*											*4*		*9*	*36,000*
SD802				*6*	*4*	*3*														*11,000*
SD803			*18*	*230*	*110*															*310,000*
SD804				*730*	*200*															*2,200,000*
SD806				*34*		*22*											*22*		*20*	*120,00*
SD805: none detected																				*53,000*
Site 29, 2001																				
	x		x	x	x	x			x				x		x		x		x	
	x		x	x	x	x														
		x				x											x			
	x		x			x														
1994-2001																				
Site 30: no PAHs seen in MW, SS, or SD																				

	light aromatics							heavy aromatics												
Site	acenaphthene	acenaphthylene	anthracene	fluorene	2-methylnaphthalene	naphthalene	phenanthrene	benzo(a)anthracene	benzo(a)pyrene	benzo(b)fluoranthene	benzo(b)pyrene	benzo(ghi)perylene	benzo(k)fluoranthene	chrysene	dibenzo(a,h)anthracene	dibenzofuran	flouranthene	indeno(1,2,3-cd)pyrene	pyrene	DRO
Water (ug/l = ppb)																				
Sites 1-5,8,12-15,17-20,22-23,26: did not take water samples, or did not look for PAHs in water																				
Site 6,7,9,10,25,26,28, 30: none detected																				
Site 11																				
MW11-3					390															
MW 11-2: none detected																				
Site 16																				
MW 16-1 (1994)					4															
MW 16-3 (1998)					20															
MW 16-4 (1994)					61															
16GW103 (2001)	0.05		0.08		1.5															
4 other samples: not detected																				
Site 21																				
MW21-1					5															
MW 21-3					6															
MW 21-2, SW111,SW112: not detected																				
Site 24																				
MW 24-2					3															
MW 24-3					5															
SW113: not detected																				
Site 29																				
SW801				9	5	13										4		9		
SW802				6	4	3														
SW803			18	230	110															
SW804				730	200															
SW806				34		22										22		20		
SW805: not detected																				

	light aromatics							heavy aromatics											
Site	acenaphthene	acenaphthylene	anthracene	fluorene	2-methylnaphthalene	naphthalene	phenanthrene	benzo(a)anthracene	benzo(a)pyrene	benzo(b)fluoranthene	benzo(b)pyrene	benzo(ghi)perylene	benzo(k)fluoranthene	chrysene	dibenzo(a,h)anthracene	dibenzofuran	flouranthene	indeno(1,2,3-cd)pyrene	pyrene	DRO
Plants (ng/g)																				
Site 28																				
plant site #1	x		x	x	x	x	x	x	x	x		x	x	x	x		x	x	x	
28PT1101	6			9		4	56							6			26		17	
28PT1102	11		6	15	10	11	250	11	9	17		5	14	39	2		190	6	120	
plant site #2	x		x	x	x	x	x	x	x	x		x	x	x			x	x	x	
28PT2101	6		3	9	5	6	87	3	2	9		2	6	20			86	3	50	
28PT2102	4		5	6	5	5	46	5		4				5			33	3	19	
plant site #3	x		x	x	x	x	x	x	x	x		x	x	x			x	x	x	
28PT3101	2		2	5	5	4	62			3			3	7			49	1	26	
28PT3102				11			91										56		29	
28PT3103	9		4	11	8	10	97			8			40	19			95	4	56	
28PT3104	6		3	8	8	9	83	4	4	8		3	8	18			79	3	48	
plant site #4	x		x	x	x		x	x	x	x		x	x	x	x		x	x	x	
28PT4101			4	6			76	7	9	24		10	17	31	4		91	12	64	
28PT4102	5			9	7		24	10	12	14		9	15	24			14	11	60	
plant site #5	x		x	x	x	x	x	x	x	x		x	x	x	x		x	x	x	
28PT5101	75		50	77	26	42	100	240	300	240		150	340	420	43		100	210	930	
28PT5102	23			14	9	8	58	6	7	11		4	110	11	4		25	9	21	
28PT5103				2	3	3	14			2				2			7		5	
28PT5104	2		3	3		2	29	10	13	15		8	11	18	4		29	13	31	
28PT5105	52		11	32	14	13	280	69	89	53		59	110	110	23		450	100	270	
28PT5106	4		8	7		4	64	6		5		3		7	4		42	5	69	
28PT5107							3													
28PT5204	75		29	78	23	41	1100	210	330	290		190	300	410	62		980	360	920	
plant site #6	x		x	x	x	x	x	x	x	x		x	x	x	x		x	x	x	
28PT6101	2			5	4	2	28			2			2	2			11		6	
28PT6102	13		49	22	8	6	290	75	21	53		13	46	87	13		380	24	280	
28PT6103	4			3		2	13	3	3	5		2	5	4	2		8	4	7	

Site	light aromatics							heavy aromatics											
	acenaphthene	acenaphthylene	anthracene	fluorene	2-methylnaphthalene	naphthalene	phenanthrene	benzo(a)anthracene	benzo(a)pyrene	benzo(b)fluoranthene	benzo(b)pyrene	benzo(ghi)perylene	benzo(k)fluoranthene	chrysene	dibenzo(a,h)anthracene	dibenzofuran	flouranthene	indeno(1,2,3-cd)pyrene	pyrene
Fish 1999, 2001(ng/g)																			
Site 28 *(Suqi Drainage)*																			
1999blackfish, whole body	7			11	71	16	9												
28 FT101 (bkfish, whole)	26			67	190	68	16										4		2
28 FT102 (bkfish, whole)	6			36	5		9					4							
28 FT103 (bkfish, whole)	14			42	89	25	6										2		2
Site 29 *(Suqi River)*																			
1999 dolly varden							no PAHs												
1999 stickleback							no PAHs												
29FT101 eggs	9.2		11	11	9	7	12	12	9	7		9	16	12	7		13	4	14
29FT102 eggs	2		3	3	3	2	3	3		2		3	4	3			3	1	3
29FT108 eggs							no PAHs												
29FT101 fillet	7		7	8	7	5	9	8	6	4		6	12	8	4		9	3	10
29FT102 fillet							no PAHs												
29FT103 fillet							no PAHs												
29FT104 fillet	1		2	2		2	2	1	2	1		4	4	3			2	1	3
29FT105 fillet				1			2					3	2				2	1	3
29FT106 fillet						2													
29FT107 fillet							no PAHs												
29FT108 fillet							2												
29FT101 head							1												
29FT102 head	3		3	3	3	2	5	2	2	2		3	4	4	2		4	1	4
29FT103 remains							no PAHs												
29FT107 remains						2	2	2		2				2				1	3

	light aromatics							heavy aromatics											
Site	acenaphthene	acenaphthylene	anthracene	fluorene	2-methylnaphthalene	naphthalene	phenanthrene	benzo(a)anthracene	benzo(a)pyrene	benzo(b)fluoranthene	benzo(b)pyrene	benzo(ghi)perylene	benzo(k)fluoranthene	chrysene	dibenzo(a,h)anthracene	dibenzofuran	flouranthene	indeno(1,2,3-cd)pyrene	pyrene
Site 30 (Background)																			
1999 char, stickleback	*no PAHs*																		
30FT101 eggs	*no PAHs*																		
30FT105 eggs	*no PAHs*																		
30FT101 fillet	*no PAHs*																		
30FT102 fillet	*no PAHs*																		
30FT103 fillet	*no PAHs*																		
30FT105 fillet																	*x*		
30FT106 fillet	*no PAHs*																		
30FT101 head	*no PAHs*																		
30FT104 head	*no PAHs*																		
30FT102 remains	*no PAHs*																		
30FT104 remains	*no PAHs*																		
30FT105 remains	*no PAHs*																		
Lincoln Loehr study of two smoked fish fillets (type of fish not mentioned) NEJAC 12/4/01																			
sample 1 (ng/g wet)	75	580		410		450	1800	13	7	6		3	6	23	0.2		280	3	200
sample 2 (ng/g wet)	280	###		1800		1200	5100	45	20	16		8	21	41	nd		1400	9	1000
Reindeer (1999)																			
muscle (of 8 animals)	4	1	6	4	1	6	8	6	5	5		3	5	5	3		7	4	7
highest level (ng/g wet):	*14*	*4*	*40*	*19*	*5*	*11*	*67*	*22*	*12*	*16*		*7*	*12*	*19*	*7*		*48*	*9*	*40*
fat (of 8 animals)			1														1		1
highest level (ng/g wet):			*4*														*6*		*6*
serum - no PAHs																			

Appendix D

Contaminant Testing in Soil at Northeast Cape

Contaminants Looked For in Soil, 1994 - 2001

Site		Oil Residues													High Levels
		GRO	DRO	RRO	VOC/SVOC	PAH	BTEX	dioxins	PCB	Pest	metals	Pb	Zn	As	
1 *burn site SE of landing strip*		none													
2 *airport*	SS109	x	x				x				x	30	108		hi Cr
	SS110	x	x				x								
	SS111								x						
	SS801		x	x	x		x								
	SS802		x				x								
	WI 110								x						
3 *fuel line corridor*	SS101	x	x				x		x		x	98	118		hi DRO
	SS102	x	x				x		x		x	27	35		hi GRO
	SS103	x	x				x								
	SS104											119			
	SS105				x		x								
4 *Subsistence camp*	SS106	x	x				x								
	SS107	x	x				x					160			
	SS108	x	x				x					7.4			hi DRO
5 *Cargo Beach*	SS100	x	x				x		x		x	18	553	4.8	hi As

Contaminants Looked For in Soil, 1994 - 2001

Site		Oil Residues													High Levels
		GRO	DRO	RRO	VOC/SVOC	PAH	BTEX	dioxins	PCB	Pest	metals	Pb	Zn	As	
6 *Cargo Beach Rd Drum Field*	SS 112	x	x		x		x		x	x	x	68	75		hi DRO
	SS113	x	x		x		x		x	x	x				hi DRO
	SS114	x	x		x		x		x	x	x				hi DRO
	SS115	x	x		x		x		x	x	x				hi DRO
	SS116	x	x		x		x		x	x	x				hi DRO
	SS117	x	x		x		x		x	x	x				hi DRO
	SS801		x	x			x								
	SS802		x	x											hi DRO, RRO
	SD 100	x	x		x		x		x	x	x				
	SD 115	x	x		x		x		x	x	x				hi DRO
	SD116	x	x	x			x		x		x	lo	lo	nd	*As (4,20)
	SD117	x	x	x			x		x		x	lo	lo	nd	*As (1,6)
	BH 6 - 3	x	x		x		x		x	x	x				
	MW 6 - 1	x	x		x		x		x	x	x				
	MW 6 - 2	x	x		x		x		x	x	x				hi DRO
	TP101,102,201		x	x											hi DRO, RRO in all

Contaminants Looked For in Soil, 1994 - 2001

Site		Oil Residues													High Levels
		GRO	DRO	RRO	VOC/SVOC	PAH	BTEX	dioxins	PCB	Pest	metals	Pb	Zn	As	
7 *Cargo Beach Rd Landfill*	SS 118											86			
	SS119	x	x		x		x		x	x	x	48	181		hi DRO
	SS120	x	x	?	x	?	x	x	x	x	x	14	30	6.3	hi As
	SS121	x	x	?	x	?	x	x	x	x	x	19	30	3.7	hi As
	SS122	x	x	?	x	?	x	x	x	x	x	21	100	2	
	SS123	x	x	?	x	?	x	x	x	x	x	30	39	3.5	hi DRO, As
	SS124	x	x	?	x	?	x	x	x	x	x	46.5	26	5.1	hi As
	SD 101	x	x	?	x	?	x	x	x	x	x	924	47	14	hi DRO, As, Cd
	SD 102	x	x	?	x	?	x	x	x	x	x	76	89	4	hi As
	SD 103	x	x	?	x	?	x	x	x	x	x	210	440	10	hi As, Cr, Ni
	SD 104		x	x	x	x	x		x		x	lo	lo	nd	hi DRO *As (4,20)
	SD 105		x	x	x	x	x		x		x	lo	lo	nd	hi DRO *As (4,20)
	SS125		x	x	x	x	x		x		x	lo	lo	50	*As (7, 30)
	SS 126		x	x	x	x	x		x		x	lo	lo	nd	hi Cr *As (6,30)
	SS127		x	x	x	x	x		x		x	lo	lo	30	hi DRO, Cr *As(4,20)
	BH 7-1	x	x	?	x	?	x	x	x	x	x	20	55	3.9	hi As
	BH 7-2	x	x	?	x	?	x	x	x	x	x	24	35	3.9	hi DRO, Be, As
	BH 7-3	x	x	?	x	?	x	x	x	x	x	13	34	2.7	hi As
	MW 7-4	x	x	?	x	?	x	x	x	x	x	10	37	3.6	
8 *POL Spill Site*		none													

Contaminants Looked For in Soil, 1994 - 2001

Site		Oil Residues													High Levels
		GRO	DRO	RRO	VOC/SVOC	PAH	BTEX	dioxins	PCB	Pest	metals	Pb	Zn	As	
9 *Housing and Operations Landfill*	SS 138	x	x	?	X	?	x	x	x	x	x	33	68	6.3	hi DRO, As
	SS139	x	x	?	X	?	x	x	x	x	x	190	150	7.3	hi As
	SS140	x	x	?	X	?	x	x	x	x	x	31	52	5.8	hi As
	SS141	x	x	?	X	?	x	x	x	x	x	181	904	30	hi As, Cr, Sb
	SS801		x	x	X		x					nl	nl	nl	
	SD 104	x	x	?	X	?	x	x	x	x	x	48	130	5	hi As
	SD 105	x	x	?	X	?	x	x	x	x	x	26	71	6.8	hi As
	SD 106	x	x	?	X	?	x	x	x	x	x	79	89	11	hi As
	SD 107		x	x	X	x	x		x		x	nd	lo	nd	hi DRO *As (7,30)
	SD 108		x	x	X	x	x		x		x	lo	lo	nd	*As (5,20)
	SD 109		x	x	X	x			x		x	lo	lo	nd	hi DRO, Cr *As (10,60)
	SD113	x	x	x	X	x	x		x		x	lo	lo	nd	hi DRO *As (6,30)
	SD114,213		x	x	X	x	x		x		x	lo	lo	nd	*As (7,30)
	MW 9-1	x	x	?	X	?	x	x	x	x	x	38	45	8.5	hi As
	MW 9-2	x	x	?	X	?	x	x	x	x	x	28	40	3.6	hi DRO, As, Be
	MW 9-3	x	x	?	X	?	x	x	x	x	x	20	31	6.4	hi As
10 *Buried Drum Field*	SS101 - SS106		x												hi DRO
	SS125	x	x		X		x		x	x	x	40	84		hi DRO
	SS126	x	x		X		x		x	x	x	72	94		hi DRO
	SS127	x	x		X		x		x	x	x	84	183		hi DRO
	SS128	x	x		X		x		x	x	x	40	63	65	hi DRO
	SS134	x	x		X		x		x	x	x	32	54		hi DRO
	SS801		x	x			x								hi DRO
	SW/SD116	x	x		X		x		x	x	x	3.2	14		

Contaminants Looked For in Soil, 1994-2001

Site		Oil Residues													High Levels
	GRO	DRO	RRO	VOC/SVOC		PAH	BTEX	dioxins	PCB	Pest	metals	Pb	Zn	As	
11 *Fuel Storage Tank Area*		SS 133	x	x	?	x	?	x	x	x	x	67	53		hi DRO
		SS 135	x	x	?	x	?	x	x	x	x	67	53		hi DRO
		SS 136	x	x	?	x	?	x	x	x	x	67	53		
		MW11-1 to 11-3	x	x				x							hi DRO
12 *Gasoline Tank Area*		no samples taken													
13 *Heat and Electrical Power Bldg*		SS107 to 109							x						
		SS142 to 144	x	x				x							hi DRO
		SS149	x	x				x							hi DRO
		SS801 to 803							180						hi PCB
		BH 13-3	x	x				x							hi DRO
		MW 13-1		x											
		MW 13-2	x	x				x							hi DRO
		WI 103 to 105							x						
14 *Emergency Power Bldg*		SS801							x						
		SS802		x	x			x							
		SS 101-103,203							lo						
		WI 100							x						
15 *Buried Fuel Line Site*		SS 146 to 148	x	x				x							hi DRO
		MW 15-1	x	x				x							hi DRO
16 *Paint and Dope Storage Bldg*		SS 156				x		x	x	x	x	125	385	4.5	hi As, Cr
		SS 157				x		x	x	x	x	69	442	4.6	hi As
		SS 158				x		x	x	x	x	18	152	5	hi As
		SS 159				x		x	x	x	x	586	12100	4.2	hi As, Pb, Zn, Cd, Cr, Sb

Contaminants Looked For in Soil, 1994 - 2001

Site		Oil Residues													
		GRO	DRO	RRO	VOC/SVOC	PAH	BTEX	dioxins	PCB	Pest	metals	Pb	Zn	As	High Levels
16, cont															
	SS 160				x		x		x	x	x	224	112	7	hi As
	SS 161				x		x		x	x	x	822	127	6	hi As, Pb, Cr
	SS 163				x		x		x	x	x	204	460	12	hi As, Cr
	SS 164				x		x		x	x	x	34	50	4.8	hi As
	SS 165, 166								lo			lo			
	SS 167, 168									x					
	SS 265											lo			
	MW 16-1				x		x		x	x	x	23	54	5.6	hi As, Cr
	MW 16-2				x		x		x	x	x	18	45	5.6	hi As
	MW 16-3				x		x		x	x	x	157	49	4.2	hi As, Sb
17 *Supply and Mess Hall Warehouses*	SS 145								x						hi PCB
	SS 165				x		x			x					
	WI 101				x				x	x					
18 *Housing and Squad Headquarters*		no samples taken													
19 *Auto Maintenance Bldg*	SS 150	x	x				x				x	329	282		hi DRO, Cr
	SS 151	x	x				x				x	76	110		hi DRO
	SS 152	x	x				x				x	51	73		hi DRO
	SS 153	x	x				x				x	28	106		hi Cr
	MW 19-1	x	x				x				x	90	82	4.4	hi GRO, DRO, As, benzene
	MW 19-2	x	x								x	28	50		
	WI 106										x	170	220	5.2	hi As
	WI 107	x													
	WI 108										x	24	280	nd	
	WI 109	x													

Contaminants Looked For in Soil, 1994 - 2001

Site		Oil Residues													
		GRO	DRO	RRO	VOC/SVOC	PAH	BTEX	dioxins	PCB	Pest	metals	Pb	Zn	As	High Levels
20 *Aircraft Control and Warning Bldg*		no samples taken													
	SS 166	x	x	?	x	?	x	?	x	x	x	58	200	39	hi As, Cr
	SS 167	x	x	?	x	?	x	?	x	x	x	10	230	170	hi As, Cd, Sb
	SS 168	x	x	?	x	?	x	?	x	x	x	96	1300	18	hi DRO, As, Hg, 4 - chloroaniline
	SS169	x	x	x			x		x		x	nd	lo	nd	hi DRO *As (7,30)
21 *Waste-water Treatment Plant*	SS 170	x	x	x			x		x		x	lo	lo	nd	*As (3,10)
	SS 171		x	x			x		x		x	lo	lo	nd	*As (2,10)
	SS 172	x	x	x			x		x		x	lo	lo	nd	*As (6,20)
	SS 173	x	x	x			x		x		x	lo	lo	nd	hi DRO *As (2,8)
	SS 269	x	x	x			x		x		x	nd	lo	nd	*As (6,30)
	SW/SD 111														
	SW/SD 112	x	x	?	x	?	x	?	x	x	x	41	554	21	hi DRO, As, Cr
	SD 113	x	x	x			x		x		x	lo	lo	nd	*As (3,10)
	SD 114	x	x	x			x		x		x	lo	lo	nd	hi DRO, Cr *As (4, 20)
	SB 169,170	x	x	x			x		x		x	lo	lo	nd	hi DRO *As (2,8)
	SB 171	x	x	x			x		x		x	lo	lo	nd	hi Cr *As (2,6)
	MW 21 - 1	x	x	?	x	?	x	?	x	x	x	6.1	24	7.9	hi DRO, As
	MW 21 - 2	x	x	?	x	?	x	?	x	x	x	18	93	5.9	hi DRO, As, Cr
	MW 21 - 3	x	x	?	x	?	x	?	x	x	x	17	110	3.2	hi As
22 *Water Supply Wells*	SS 169	x	x				x								
	SS 170	x	x	?	x	?	x	?	x	x	x	497	169		hi DRO, Pb, Sb
	MW 22-1	x	x												
23 *Power Line Corridor*	SS 162								x						
	SS 171				x					x	x				

Contaminants Looked For in Soil, 1994 - 2001

Site		Oil Residues													
		GRO	DRO	RRO	VOC/SVOC	PAH	BTEX	dioxins	PCB	Pest	metals	Pb	Zn	As	High Levels
24 *Receiver Bldg*	SS 172	x	x	?	x	?	x	?	x	x	x	604	170		hi Pb
	SS 173	x	x	?	x	?	x	?	x	x	x	16	30		
	SS 174	x	x	?	x	?	x	?	x	x	x	280	2300		hi Cr
	SS 175	x	x	?	x	?	x	?	x	x	x	65	195		
	SW/SD 113	x	x	?	x	?	x	?	x	x	x	18	470		
	SD 114	x	x	x			x		x		x	lo	lo	nd	hi DRO *As (10,50)
	SD 115	x	x	x			x		x		x	lo	lo	nd	*As (2,7)
	SD 214	x					x								
	MW 24-1	x	x	?	x	?	x	?	x	x	x	24	67		hi DRO
	MW 24-2	x	x	?	x	?	x	?	x	x	x				hi Cr
	MW 24-3	x	x	?	x	?	x	?	x	x	x	22	55		hi Cr
25 *Direction Finder Area*	SS 176	x	x	?	x	?	x	?	x	x	x	8.5	35		hi DRO
	SS 177	x	x	?	x	?	x	?	x	x	x	65	160		
	SS 178								x						
	SS 801							x							
	SW/SD 114	x	x	?	x	?	x	?	x	x	x	36	430		
26 *Former Construction Camp*	no samples collected														
27 *Diesel Fuel Pump Island*	SS 101-105		x												hi DRO
	SS 154	x	x				x				x	52	72		hi DRO
	SS 155	x	x				x				x	68	78		hi DRO
	SS 179 -182	x	x				x								hi GRO, DRO, benzene
	SW/SD 801	x	x	x	x		x								
	BH 27 - 2	x	x				x								hi DRO
	MW 27 - 1	x	x				x				x	17	54	5.7	hi GRO, DRO, As, Cr, benzene

Contaminants Looked For in Soil, 1994 - 2001

Site		Oil Residues													
		GRO	DRO	RRO	VOC/SVOC	PAH	BTEX	dioxins	PCB	Pest	metals	Pb	Zn	As	High Levels
28 *Main (North)* *Suqi Drainage*	SS 101 -103								x						
	SS 107		x						x						hi DRO
	SS 108		x												hi DRO
	SS 129 - 137	x	x		x		x	?	x	x	x	lo	lo		hi DRO
	SS 801		x	x		x	x		x						hi DRO
	SS 802		x	x		x	x		x						
	SS 806 -809		x	x											
	SW/SD 101 to 106		x						x						hi DRO
	SD109,110, 117	x	x		x		x	?	x	x	x	lo	lo		hi DRO
	SD 801 - 803		x	x		x	x								hi DRO, RRO
	BH 10 - 2, 10-3	x	x		x		x	?	x	x	x	lo	lo		hi DRO, Cr
	MW10 - 1, 10-4	x	x		x		x	?	x	x	x	lo	lo		hi DRO
	SD 111 - 112		x	x		x			x		x	lo	lo		hi DRO
	SD 113		x	x		x			x		x	lo	lo		
	SD 114 - 137		x	x		x			x		x	lo	lo		hi DRO
	SD 138 - 182?														
	SD 183 - 187, 191									x					
	SD 188 - 190									x					
	SD 211		x	x		x					x	nd	lo		hi DRO
	SD 225,239,251									x					
	SD 253,257,263									x					
	SD 271,275									x					
	SD 285, 292									x					

Contaminants Looked For in Soil, 1994 - 2001

Site		Oil Residues													
		GRO	DRO	RRO	VOC/SVOC	PAH	BTEX	dioxins	PCB	Pest	metals	Pb	Zn	As	High Levels
29 *Suqi River*	SW/SD 107 to 108		x						x						
	SW/SD 111 to 113		x						x						hi DRO
	SD 114		x	x		x			x		x	lo	lo		hi DRO
	SD 115 - 117		x	x		x			x		x	lo	lo		
	SD 118		x	x		x			x		x	lo	lo		
	SD 119 - 123, 125		x	x		x			x		x	lo	lo		
	SD 124		x	x		x			x		x	lo	lo		hi DRO
	SD 126	x	x	x		x	x		x		x	lo	lo	nd	*As (2,10)
	SW/SD 801 to 806		x	x		x	x		x						hi DRO
30 *Background Samples*	SS 00	x	x	?	x	?	x	x	x	x	x	11	24	2	
	SS 801		x	x			x								hi DRO
	SS 902	x	x				x				x	4.8	12	nd	
	SD 903	x	x				x				x	4	15	nd	
	SW/SD 00	x	x	?	x	?	x	?	x	x	x	4.6	13	1	
	SD 101		x	x		x					x	lo	lo	nd	*As (5,20)
	SS 101		x	x		x					x	lo	lo	nd	hi DRO *As (3,10)
	SS 102		x	x		x					x	lo	lo	nd	*As (1,6)
	SS 103		x	x		x					x	lo	lo	nd	*As (8,30)
	SS 201										x	lo	lo	nd	*As (2,9)
	SW/SD 801 to 802		x	x		x	x								
	MWOO soil	x	x		x		x		x	x	x	92	84	2.5	hi As
	SS901 soil	x	x				x				x	25	77	3.6	hi As

Appendix E

Contaminant Testing in Water at Northeast Cape

Contaminants Looked For in Water, 1994 - 2001

Site		Oil Residues													High Levels
		GRO	DRO	RRO	VOC/SVOC	PAH	BTEX	dioxins	PCB	Pest	metals	Pb	Zn	As	
1 *burn site SE of landing strip*		none													
2 *airport*		none													
3 *fuel line corridor*	WP3 - 1		x			x	x								hi DRO
	WP 102 - 104		x	x											hi DRO, RRO
4 *subsistence camp*	WP4 - 1		x			x	x								hi DRO
	WP 102		x	x											hi RRO
	WP 103,104		x	x											hi DRO, RRO
5 *Cargo Beach*		none													
6 *Cargo Beach Rd Drum Field*	SW 100	x	x		x		x		x	x	x	nd	nd		
	SW 115	x	x		x		x		x	x	x	0.005	0.1		hi DRO, Pb, dPb
	SW 116		x	x											
	MW 6 - 1	x	x		x		x		x	x	x	0.23	0.8		hi Pb, Zn, Be, Cr, Ni
	MW 6 - 2	x	x		x		x								hi DRO
	WP 102		x	x											
	WP 103	x	x	x	x		x		x		x	0.16	17.7	0.02	hi Zn, Pb, Ni, As

Contaminants Looked For in Water, 1994 - 2001

Site		Oil Residues													High Levels
		GRO	DRO	RRO	VOC/SVOC	PAH	BTEX	dioxins	PCB	Pest	metals	Pb	Zn	As	
7 *Cargo Beach Rd Landfill*	SW 101	x	x	?	x	?	x	x	x	x	x	0.04	0.52	0.02	hi DRO, Pb, Zn, Ni, Thal, Hg, dHg, As
	SW 102	x	x	?	x	?	x	x	x	x	x	0.005	0.06	nd	hi Zn
	SW 103	x	x				x	x			x	0.005	0.1	nd	hi Zn, dZn
	SW 104,105	x	x	x	x	x	x		x		x	lo	lo	nd	
	WP 101	x	x	x	x	x	x		x		x	.04	2.47	.01	hi RRO, Pb, Zn, As
	WP 102	x	x	x	x	x	x		x		x	0.017	lo	0.004	hi Pb
	WP 103	x	x	x	x	x	x		x		x	lo	lo	lo	
	WP 202				x	x	x								
	MW 7-4	x	x	?	x	?	x	x	x	x	x	0.005	nd	nd	
8 *POL Spill Site*		none													
9 *Housing and Operations Landfill*	SW 104	x	x	?	x	?	x	x	x	x	x	nd	nd	nd	
	SW 105	x	x	?	x	?	x	x	x	x	x	nd	0.06	nd	hi Zn
	SW 106	x	x	?	x	?	x	x	x	x	x	0.01	nd	nd	
	SW 107,108,110	x	x	x	x	x	x		x		x	nd	nd	nd	
	SW 109	x	x	x	x	x	x		x		x	lo	lo	nd	
	SW 111, 112, 207	x	x	x	x	x	x		x		x	nd	nd	nd	
	MW 9-1	x	x		x		x			x	x	0.02	nd	0.01	hi DRO, Pb, As
	MW 9-2	x	x	?	x	?	x	x	x	x	x	0.045	0.12	0.03	hi Pb, Zn, As
	MW 9-3		x			x	x	x			x	0.04	0.1	0.006	hi DRO, Pb, Zn
	MW 103	x	x	x	x	x	x				x	0.3	0.5	nd	hi Pb, Zn, Be, Ni, Hg
	WP 102	x	x	x	x	x	x		x		x	lo	0.5	lo	hi RRO, Zn
10 *Buried Drum Field*	SW/SD 116	x	x		x		x		x	x	x	nd	nd		hi dAg

Contaminants Looked For in Water, 1994 - 2001

Site		Oil Residues													
		GRO	DRO	RRO	VOC/SVOC	PAH	BTEX	dioxins	PCB	Pest	metals	Pb	Zn	As	High Levels
11 *Fuel Storage Tank Area*	MW 11-1 to 11-3	x	x	x	x		x								hi DRO, benzene
12 *Gasoline Tank Area*		none													
13 *Heat and Electrical Power Bldg*	MW 13-1	x	x	x			x				x	0.45	0.66	0.07	hi GRO, DRO, As, dAs, Pb, Zn, Cr, Ni
	MW 13-2	x	x	x			x				x	0.33	0.49	0.04	hi GRO, DRO, Pb, Ni, Cr, As
14 *Emergency Power Bldg*		none													
15 *Buried Fuel Line Site*	MW 15-1	x	x	x			x				x	0.68	1	0.11	hi DRO, RRO, As, Pb, Zn, Be, Ni
16 *Paint and Dope Storage Bldg*	MW 16-1				x		x		x	x	x	0.28	1		hi Pb, Zn, Be, Cr, Ni
	MW 16-2				x		x		x	x	x	0.67	1.5		hi Pb, Zn, Be, Cd, Cr, Ni
	MW 16-3				x		x		x	x	x	0.21	0.54		hi Pb, Zn, Cr, Ni
	GW 101,102				x	X									
	GW 103				x	X									
17 *Supply and Mess Hall Warehouses*		none													
18 *Housing and Squad Headquarters*		none													

Contaminants Looked For in Water, 1994 - 2001

Site		Oil Residues													
		GRO	DRO	RRO	VOC/SVOC	PAH	BTEX	dioxins	PCB	Pest	metals	Pb	Zn	As	High Levels
19 *Auto Maintenance Bldg*	MW 19-1	x	x	x			x				x	0.42	0.42		hi GRO, DRO, Pb, Zn, benzene
	MW 19-2	x	x				x				x	0.14	0.18	0.006	hi DRO, Pb, Zn
20 *Aircraft Control and Warning Bldg*		none													
21 *Wastewater Treatment Plant*	SW/SD 111	x	x	?	x	?	x	?	x	x	x	0.002	0.49	nd	hi Zn, dZn
	SW/SD 112	x	x	?	x	?	x	?	x	x	x	0.004	0.21	nd	hi Zn
	SW 113, 114	x	x	x					x		x	lo	lo	lo	
	SW 213	x	x	x											
	MW 21-1	x	x	?	x	?	x	?	x	x	x	0.26	0.65	0.07	hi As, Pb, Zn, Cr, Hg, Ni
	MW 21-3	x	x	?	x	?	x	?	x	x	x	0.1	5.1	0.041	hi Pb, Zn, Ni, As
22 *Water Supply Wells*	MW 22-1	x	x				x								
23 *Power Line Corridor*		none													
24 *Receiver Bldg*	SW/SD 113	x	x	?	x	?	x	?	x	x	x	0.002	?		
	SW 114		x	x			x		x		x	nd	0.06	nd	
	SW 214		x	x					x		x	lo	0.05	nd	
	MW 24-2	x	x	?	x	?	x	?	x	x	x	0.04	0.2		hi Pb, Zn, Ni
	MW 24-3	x	x	?	x	?	x	?	x	x	x	0.006	?		
25 *Direction Finder Area*	SW/SD 114	x	x	?	x	?	x	?	x	x	x	0.002	0.5		hi Zn, dZn

Contaminants Looked For in Water, 1994 - 2001

Site		Oil Residues													
		GRO	DRO	RRO	VOC/SVOC	PAH	BTEX	dioxins	PCB	Pest	metals	Pb	Zn	As	High Levels
26 *Former Construction Camp*		none													
27 *Diesel Fuel Pump Island*	MW 27-1	x	x	x			x				x	0.023	0.28	0.03	hi GRO, DRO, Pb, Zn, Ni, As
28 *Main (North) Suqi Drainage*	SW/SD 101 to 106		x						x						hi DRO, PCB
	SW/SD 109	x	x		x		x	?	x	x	x	nd	nd		
	SW/SD 110	x	x		x		x	?	x	x	x	0.11	0.72		hi DRO, Pb, dPb, Zn, dZn, PCB
	SW 111 - 113		x	x					x						
	SW 114		x	x					x						
	SW 115,116, 211		x	x					x						
	SW/SD 117	x	x		x		x	?	x	x	x	68	?		
	MW 10-1	x	x		x		x	?	x	x	x	0.2	0.6	0.04	hi Pb, Zn, Cr, Ni, As
	MW 10 - 4	x	x		x		x	?	x	x	x	0.008	?		hi DRO
29 *Suqi River*	SW/SD 107 to 108		x						x						
	SW 114 - 117, 217	x	x	x	x	x	x		x		x	nd	nd	nd	
	SWSD 801 to 806		x	x		x	x		x						
30 *Background Samples*	SW/SD 00		x		x		x		x	x	x	nd	nd	nd	
	SW/SD 801 to 802		x	x		x	x								
	MWOO water	x	x	x	x		x	x		x	x	0.05	0.2	0.002	hi DRO, RRO, Pb, Zn
	WP 101	x	x	x	x	x	x				x	lo	lo	lo	hi DRO, RRO
	WP 102	x	x	x	x	x	x				x	lo	nd	lo	

Appendix F

Comparison of Contaminants in Reindeer and Marine Mammals from the Circumpolar Area

Reindeer and Caribou	% lipid	s-PCB	118	138	153	180	s-DDT	Trace Metals metal	level	s-HCH	s-chlordane	Other Contaminants	N	Study or reference
Alaska														
Savoonga, (1999?)														
blood		0					5							USDHSS 2001
Muscle		0									1			
Canada														
Canada, NWT														
Fat, female reindeer		11					2			13	5	Mirex 0.1	1	
Fat, male reindeer		40					2			26	3	Mirex 0.2	2	
Fat	~70%	1-32					0-2			3-40	0-5			
Liver, male reindeer		8					1			8	8	Mirex 0.7	1	
Liver	5%	1					0			2	4	Mirex 0.2	20	AMAP 1998 page 340
Muscle, male reindeer		2					2			42	5	Mirex 0.1	1	
Russia														
Russia, 1994														
Liver		18-41					5-43			4-12	0-1	Mirex=0	5	
Norway														
Norway, Svalbard														
fat	86%	0-35					0			6	0		35	AMAP 1998 p342
Liver	2%	0-1					0			2	0-1			

Reindeer and Caribou Contaminant Levels, ppb

Bearded Seal *Contaminant Levels, ppb*

earded Sea blubber and oil	% lipid	s-PCB	118	138	153	180	s-DDT	Trace Metals metal	level	s-HCH	s-chlordane	Other Contaminants	N	Study or reference
Alaska														
Savoonga, 1998														Santillo unpub.
piece of blubber	60%	128					70			37			8	
		(72 – 318)	*13.6*	*25.1*	*30.1*	*5*								
drink of oil	94%	159					50			39			7	
		(39 – 320)	*~18*	*~34*	*~44*									
piece of lean blubber stored in oil		36					17			11			1	
Bering Sea, 1993 -95														
piece of blubber, female seal		199					96						1	
piece of blubber, male seals		153					104						5	AMAP 1998

Bearded Seal muscle	% lipid	s-PCB	118	138	153	180	s-DDT	Trace Metals metal	Level	s-HCH	s-chlordane	Other Contaminants	N	
Alaska														
Savoonga, 1998														
Piece of dried meat		3					0.5			1			1	Santillo unpub
Dried meat stored in oil		19					9			4			3	
Alaska, 1989-93														
Liver								Cd	1,030				3	Egeland p76
Canada														
Canada, 1973														
Liver								Hg	143,000				6	Ponce 1997
								MeHg	300					
Muscle								Hg	530				3	
Canada, 1974														
Liver								Hg	26,200				56	Egeland p49
								MeHg	120					
Muscle								Hg	90				55	

Ringed Seal Contaminant Levels, ppb

Ringed Seal blubber, oil	% lipid	s-PCB	*118*	*138*	*153*	*180*	s-DDT	Trace Metals *Metal*	*Level*	s-HCH	s-chlordane	Other Contaminants	N	Study or reference
Alaska														
Bering Sea 1989-94														
Piece of blubber, female seals		346					194						2	AMAP 1998
Bering Sea 1993 - 1995														
piece of blubber, male seals		249					188						6	
Barrow blubber		540					543			223+			4	Egeland p118
Barrow, 1988 blubber		686											2	
Nome , 1989 blubber		~400											2	
Canada														
Belcher Island, NWT														Cameron and Weis, 1993
blubber	87.2%	1283.4		*217.3*	*311.8*	*217.3*	~1651.5			434.5	214.4		3	
Barrow Strait, 1984														Egeland p 119
Blubber, male seal		568											19	
Blubber, female seal		375											14	
W. Hudson Bay, 1992														
Blubber, male seal	92%	2066					1662			336	1596	HCB=69/Tox=661	30	
Blubber, female seal	91%	1,115					840			335	806	HCB=63/Tox=297	24	
E. Hudson Bay, 1989-92														
Blubber, male seal	95%	1,234					1143			275	708	HCB=62/Tox 221	4	CACAP p237
Blubber, female seal	93%	1300					1000			276	1000	HCB=55/Tox=307	7	
Baffin Island, 1994														
Blubber, male seal	95%	675					703			210	470	HCB=36/Tox = 180	10	
Blubber, female seal	95%	467					359			179	322	HCB=38/Tox=175	10	

s-PCB includes congeners 99, 101, 118, 138, 170/190, 180, 182/187, 183, 201, 203 for the Cameron - Weis data

Ringed Seal ***Contaminant Levels, ppb***

Ringed Seal meat,organs		s-DDT	118	138	153	180	Trace Metals	Metal	Level	s-HCH	chlordane	Other Contaminants	N	Study or reference
Alaska														
Alaska 1989-93														Egeland p 49,76
Kidney/liver								Cd	5100/2300				2/14	
Liver								Hg/MeHg	1970/410				9/4	
Barrow, 1988														
Liver		23											2	
Kidney		13											2	Egeland p118
Nome, 1989														
Liver		8											2	
Canada														
Belcher Island, NWT														
meat	1.83%	42.5	8.7	4.6	8.7	41				3.3	12.8		4	
kidney	2.43%	15.4	2.5	3.3	2.5	14				4.4	3.9		2	Cameron and Weis 1993
liver	3.25%	73.9	7.9	11	7.9	39				7.6	1.9		3	
Canada, 1975-77 Liver								Hg/MeHg	25,500/850					Ponce 1996
Liver								Hg	3760-16,100				60	Egeland 1999 p49
Liver								MeHg	500-890				18	
Liver/Kidney								Hg	32,700/2320				5/1/7	Egeland 1999
Liver/kidney/muscle								Cd	5,550/2790/50				5/1/7	Egeland p51,76
Western Arctic, 1987-93														
Liver/kidney/muscle								Cd	6/21/0				~145	CACAP p 241
								Hg	33/2/0					
								Zn	42/39/27					
Barrow Strait, 1984														
Liver		14-19											10	Egeland p119
Greenland, 1979														
Kidney								Cd	37,400				29	Egeland p 76
liver								Cd	7,320				29	

Walrus ***Contaminant Levels, ppb***

Walrus blubber and oil	% lipid	s-PCB	118	138	153	180	s-DDT	Trace Metals Metal level	s-HCH	s-chlordane	Other Contaminants of Concern	N	Study or Reference
Alaska	-												
Savoonga, 1998													Santillo 1998
blubber	80%	40-88	*5.8*	*8*	*33.2*	*1.4*	9		110			4	
oil	94%	49-94	*~8.5*	*~10.3*	*~29.1*		7		109			3	
Savoonga, 1994													Wiig, 2000
blubber	82%	103	*14.5*	*10.7*	*62*	*4*	4		~413			10	
Greenland													
Western (Thule)													Born, 1981
blubber		144 - 288					40 - 72		-			28	
Western, 1988													Muir and Born, 98
blubber, male walrus		210					61		92			11	
Canada													
N. Hudson Bay 1988													CACAP p237
blubber, male walrus	80%	199					33		100	312	HCB=23/tox= 451	12	
blubber, female walrus	81%	90					21		63	166	HCB=15/tox=201	12	
NE Hudson Bay, 1989													
blubber, male walrus	83%	1200					560		116	1169	HCB=23/tox=420	8	
Blubber, female walrus	87%	195					45		126	238	HCB=87/tox=606	2	
E. Hudson Bay, 1989													
Blubber, male walrus	85%	11,500*					4600		267	6293	HCB=67/tox=3493	4	
Blubber, female walrus	82%	4790*					2164		214	2753	HCB=62/tox1451	9	
Baffin Island, 1988													
blubber, male and female	82%	1643					605		156	2083	HCB=54/tox=359	6	

**PCBs may be high due to walrus predation on ringed seals in this area*

Walrus ***Contaminant Levels, ppb***

	% lipid	s-PCB	118	138	153	180	s-DDT	Trace Metals		s-HCH	s-chlordane	Other	N	study
Walrus skin and organs								*Metal level*				Contaminants		
Alaska	-													
Savoonga, 1994														Wiig, 2000
piece of skin	4%	6					0.2+			~11			10	
			0.7	*0.7*	*3.7*	*0.3*				*α=1*				
										β=10				
Gambell/Savoonga 1981-84														
Liver								Cd	6,000 (1400-50,000)				65	Egeland p 78
Alaska, 1981-84														
Kidney								Cd	46,500				42	Egeland p76
Liver								Cd	9,470				65	
								Hg	1,500				62	
Alaska														
Kidney								Cd	51,600					Egeland p 76
Liver								Cd	27,900					
Liver								Hg	490					Ponce 1997
muscle								Hg	20					Egeland p50
Canada														
E. Hudson Bay, 1992														
Liver/kidney/muscle								Cd	11/58/0.2				~100	CACAP p 241
								Hg	1/0.3/0.1					
Norway														
Svalbard, 1991 - 93														Skaare, 1996
ece of skin, male and female		21					78			-			26	
piece of skin	~4%	346**	*22.4*	*72.7*	*164.4*	*46.8*	60+			~9			25	Wiig, 2000
Franz Josef Land, 1993														Wiig, 2000
piece of skin	~4%	49**	*6.7*	*9.7*	*21.6*	*4.5*	7+			~3			28	

*** High local sources of contamination in these areas*

Birds and Bird Eggs *Contaminant Levels, ppb*

	% lipid	s-PCB	118	138	153	180	s-DDT	Trace Metals		s-HCH	s-chlordane	Other	N	Study or reference
Seabird Eggs and Chicks								*Metal*	*level*			Contaminants		
Murre Eggs														
Canada, Hudson Bay 1993	15%	360					326			23	58		15	CACAP p248
	13%	434					311			18	63		15	
Canada, high arctic 1993	14%	420					309			18	39		15	
	12%	233					201	Hg	0.3	20	42		15	
Alaska, Savoonga, 2001		82					78					HCB=39	11	Pagano, unpub
Norway, 1992-93	11%	530					340			4	50	HCB=110	5	AMAP 1998p361
	11%	920					340			4	40	HCB=100	5	
Murre Chicks														
Canada, high arctic, 1993	8%	195					166	Hg	0.3	7	22	HCB=46	16	CACAP p250
Canada, eastern arctic, 1993	10%	192					192			6	38	HCB=62	10	
Black Guillemot Egs														
Canada, N Hudson Bay 1993	9%	577					150			19	141		12	CACAP p 248
	12%	300					144			18	110		15	
Canada, high arctic, 1993	10%	318					163	Hg	0.6	25	68		12	
Black Guillemot Chicks														
Canada, high arctic, 1993								Hg	0.5				10	
Glaucous Gull Eggs														
Canada, high arctic, 1993	9%	3330					2370	Hg	1.1	66	388		10	CACAP p 248
Canada, western arctic, 1993	9%	462					339			20	78		15	
Canada, western arctic 1993	8%	316					144			22	48		14	
Glaucous Gull Chicks														
Canada, high arctic, 1993								Hg	1.4				4	

Whales ***Contaminant Levels, ppb***

	% lipid	s-PCB	118	138	153	180	s-DDT	Trace Metals Metal	level	s-HCH	s-chlordane	Other Contaminants	N	Study or Reference
Whales, blubber and oil														
Bowhead Whales														
Alaska														
Alaska, 1979-80														
blubber								Hg	7				7	Egeland 50
								Cd	30				7	
Alaska, 1986													6	
blubber								Hg	3					Egeland p50
								Cd	30				6	
Barrow/Kaktovik 1997-2000														
blubber	76%	410	14	12	13	4	331			203	152	HCB=100	72	Hoekstra 2001
Minke Whales														
Norway														
Norway, 1988-89														
Blubber, male whale		2700					2300						17	AMAP 1998
Blubber, male whale		1100					1200						20	P367
Norway, 1992														
Blubber, male whale		3700					2400						31	
		2000					1400						30	

Whales ***Contaminant Levels, ppb***

	% lipid	s-PCB	118	138	153	180	s-DDT	Trace Metals		s-HCH	s-chlordane	Other	N	Study or reference
Whales, meat, organs								*Metal level*				Contaminants		
Bowhead Whales														
Alaska														
Alaska, 1979-80														
Kidney/Liver/Muscle								Hg	6/5/1				2	Egeland p50
								Cd	1,420/1,500/20				2	
Alaska, 1986														
Kidney/Liver/Muscle								Hg	5/8/3				6	Egeland p50
								Cd	6,560/7,210/70				6	
Alaska 1992-93														
Liver								Hg	170				3	Egeland p50
								Cd	12,900					
Barrow/Kaktovik 1997-2000														
liver	7%	9	0.2	0.1	0.3	0.1	4			10	5	HCB=3	23	Hoekstra 2001

Appendix G

Contaminants in Fast Foods and Supermarket Foods

	Supermarket Foods				Contaminant Levels in ppb						
	s-PCB	s-DDT	s-HCH	s-chlordane	HCB	Toxaphene	Dieldrin	endrin	Hep.epoxy	N	study
U.S. Fast Food											
Big Mac	0.957										Schecter, 1995
Pizza Hut, personal pan pizza	1.18										
Kentucky Fried chicken (3 pc)	1.17										
U.S. Supermarket Food											
Butter	-	26	-	13	1.4	-	3	-	0.7		Schafer 2001
2% milk	-	1	-	-	-	-	0.1	-	-		
Vanilla ice cream	-	1	-	-	0.1	-	0.3	-	-		
American cheese		7			0.6		0.8		0.6		
Cantaloupe	-	1	-	-	-	28	1.2	-	0.5		
Grapes		1					0.8				
Raisins		2									
Cucumber	-	3	-	26	-	24.4	6.3	1	2.8		
Dill Pickles	-	8	-	15	-	25.1	6.2	-	2		
Onion	-	-	-	-	-	-	0.3	-	-		
Carrots		1					0.3				
Spinach	-	16	-	-	-	5.3	2.5	-	2		
Winter squash	-	6	-	25	0.9	23	11.4	-	1.1		
Summer squash	-	3	-	15	0.5	-	15.3	1.2	1.5		
Potatoes, boiled	-	0	-	-	-	-	0.5	-	-		
Potato chips	-	3	-	0.4	-	-	1.3	-	0.4		
French fries		1					0.4				
Peanut Butter		3			0.2	33.9	1.2				
Eggs, fried	-	1	-	-	-	-	0.4	-	-		
Chicken, fried		1					0.2				
Salmon, baked		14			0.8		2.6		0.3		
Ham		1			0.3						
Bacon		3			0.5		0.5				
Tuna, canned in oil		1			0.5		0.5				
Mayonnaise		1					1.1				
Mustard		1									

Appendix H

Contaminants in Fish from Alaska and the Lower 48

Marine and River Fish ***Contaminant Levels in ppb***

Fish	% lipid	s-PCB	*118*	*138*	*153*	s-DDT	Trace Metals *metal*	*level*	s-HCH	s - chlordane	Other contaminants	N	study
Salmon													
Alaska, Tapisaghak River 2001		**6-30**					As	200-900[21]				**3**	
Alaska, Copper River,													
Beginning migration	6%	37				18						20	Ewald 98
Mature	2%	54				**27**			**0.6**		**HCB =4**	20	
Spent	1%	79				49						10	
Alaska, Polaris High, 2002	3%	0.2+			0.2							1	Mark Lyke, unpub
Alaska, Port Graham, 1997-98													
King salmon		1					MeHg	37			s-Pest 17 ppb		EPA unpublished
Red salmon											s-pest 12 ppb		
Chum Salmon		3									s-pest 6 ppb		
US, Great Lakes, 1990													
King Salmon, whole		1700										5	Egeland p122
US, Lake Michigan, 1988													
King Salmon fillet		940										81	Egeland p122
Sweden	4%	17+			17							1	Mark Lyke unpub
Canada, Yukon, 1990-93													
King salmon	1%	11				11				3	Tox=40	6	AMAP 1998
Red salmon		3				3				1	Tox=9	3	p348
Chum salmon	1%	2				2				1	Tox=21	3	

[21] 3 Dolly Varden and 3 Pink Salmon from the Tapisaghak were analyzed for PCBs and metals in 2001. Information on which samples were dollies and which were pinks has not been published yet.

Marine and River Fish *Contaminant Levels, ppb*

Fish	% lipid	s-PCB	*118*	*138*	*153*	s-DDT	Trace Metals *metal*	*level*	s-HCH	s - chlordane	Other contaminants	N	study
Dolly Varden													
Alaska, Suqi 1999	5%	0-160										90	US DHSS 2000
Suqi 2001		8-30					As	200-800				8	MW Nov 2001
Quangeghsaq 1999		0										17	US DHSS 2000
Tapisaghak 2001		6-30					As	200-900				3	
Greyling													
grayling in a salmon-free lake	~2%	11				0.9			0.3		HCB=0.6	23	Ewald 1989
grayling in a salmon lake	~2%	~20				5.3			0.5		HCB=0.4	23	
Blackfish													
Alaska, Suqi drainage 1999		100										11	US DHSS00
Suqi drainage 2001		60-140					Hg	80				3	MW Nov 2001
Suqi River, 1999		0										3	
Cod													
Alaska, Kodiak 2002													
Fillet	24%	5										2	Mark Lyke, unpub
Alaska, Pt Graham 1997-98							MeHg	38					EPA 1998 unpub
Norway, 2002													
Liver	40%	16-97										3	Mark Lyke, unpub
Iceland, 2002													
Liver	38%	65										2	Mark Lyke, unpub
Canada, Lancaster Sound		4-7				5-6			3–4	4-8	Tox=23-47		CACAP p232

Appendix I

Siberian Yupik, English, and Latin Names for Plants and Animals

(courtesy of Linda Gologergan and June Martin)

Yupik Name	English Name	*Latin Name*
nunivagseghat	**Land Plants/Greens**	
ququngaq	willow leaves	*Salix spp.*
ammlluqiiraq	saxifrage	*Saxifraga spp.*
qugelngiq	sou grass	
nunivak	roseroot	*Sedum rosea*
angukaq	dwarf fireweed	*Epilobium latifolium*
alqegkaq	sour dock	*Rumex spp.*
kaamwaaq	coltsfoot	*Petasites nivalis*
sevnaawraq	tea leaves	
napaziiq	main stem	
unatat	ross avens	*Geum spp.*
akut	**Roots**	
saqlak	roseroot's root	*Geum spp.*
qakeqaaq	Parry's wallflower	
uqfiigaq	willow leaves root	*Salix spp.*
qullikaq	glacier avens	*Geum spp.*
pekneq	mouse nuts	
tepluk	wild celery, cow parsnip	*Heracleum maximum*
uulqiq	wild potato	
inghukat	**Berries**	
pagunghaq	blackberry	
aqavzik	salmonberry	*Rubus spectabilis*
kaavlak	bearberry	*Actostaphylos spp.*
kiitmik	lowbush cranberry	*Oxycoccus microcarpus*
sughat	blueberry	*Vaccinium ovalifolium*
tepat	**Sea Plants**	
kemagluk	sea pear	
tukughnak	sea cherries	
aghnaghuq	sea apple	
mamaghwaaq	sea radish	
uupa	sea peach	
kemkeghnak	sea carrot	
kingupak	sand mason's tube	
elqwaaq	**Kelp**	
elqwaapik	palmated kelp	
estegtaq	laver	*Porphyra spp.*
aqeftaghuk	dulse	*Rhodymenia palmata*

Yupik Name	English Name	*Latin Name*
imanat	**Clams**	
tamumeq	cockle	*Clinocardium nuttali*
nuvulqugnak	soft shell clam	*Mya arenaria*
uglumrek	oyster	*Pododesmus macroschisma*
qengesqut	limpet	
neghnat	**Crabs**	
neghnapik	king crab	*Paralithodes spp.*
neghnavregaq	rock crab	
kemegtungiq	shrimp	*Pandalus spp.*
iqalluget/kayut	**Fish**	
satuvak	arctic grayling	*Thymallus thymallus*
qupneg	whitefish	*Coregonus lavaretus*
kiiwhtaq	arctic char	*Salvelinus alpinus*
igallupik	dolly varden	*Salvelinus malma*
tunguuya	chum salmon	*Oncorhynchus keta*
amaghtu	pink salmon	*Oncorhyncus gorbusha*
qitaaqa	silver salmon	*Oncorhynchus kisutsh*
awisu	king salmon	*Oncorhynchus tshawytscha*
	red salmon	*Oncorhynchus nerka*
teptaakrak	hooligan (eulachon)	*Thaleichthys pacificas*
sikaaq	grunion	
kegarangiq	surf smelt	*Hypomesus pretiosus*
ivisa	halibut/flounder	*Hippoglossus stenolepis*
		(Pacific halibut)
uukaq	cod	
taqiiq	Pacific cod	*Gadus macrocephalus*
iqalluwaq	arctic cod	*Boreogadus saida (polar cod)*
nunangiik	ling cod	*Ophiodon elongatus*
kayupik	bullhead	
	blackfish	*Gadopsis marmoratus*
	nine-spined stickleback	*Pungitius pungitius*

Yupik Name	English Name	*Latin Name*
aghveghet	**Whales**	
sastegheslak	right whale	*Eubalaena glacialis*
aghvesak	large bowhead	*Balaena mysticetus*
aghvepik	bowhead	↓
aghveghaq	bowhead calf	
ingutuq	young bowhead	
angtughlaq	gray whale	*Eschrichtius robustus*
		↓
aghveghlluwaq	gray whale calf	
qungvughaq	minke whale	*Balaenoptera acutorostrata*
aghvesiiq	humpback whale	*Megaptera novaeangliae*
puugzaq	beluga whale	*Delphinapterus leucas*
mesungesak	killer whale	*Orcinus orca*
aghveqengertaq	Dahl porpoise	*Phocoenoides dalli*
Yupik Name	**English Name**	**Latin Name**
ayveq/ayveghet	**Walrus**	*Odobenus rosmarus*
angtughpak	very large bull	↓
miksagaghpak	large bull	
unkuvak	year or older	
qasiqaq	calf	
aghnasalek	cow	
neghsat/maklaget	**Seals**	
teghigluk	calf	
qazigyapak	large spotted seal	↓*Phoca largha*
qazigyaghaq	young	
neghsapik	ringed seal adult	*Phoca hispida*
nazisungaq	short winter seal	
nazighaq	hair seal	
kukupak	ribbon seal	*Histriophoca fasciata*
oogruk	bearded seal	*Erignathus barbatus*
nanuq	**Polar Bear**	*Ursus maritimus*

Yupik Name	English Name	Latin Name
	Land Animals	
quyngiq	reindeer	*Rangifer tarandus*
tungtu	caribou (Nome)	*Rangifer tarandus*
tuntuvak	moose	*Alces alces*
	arctic fox	*Alopex lagopus*
	red fox	*Vulpes vulpes*
	tundra shrew	*Sorex tundrensis*
	arctic ground squirrel	*Spermophilus parryii*
	collared lemming	*Dicrostonyx groenlandicus*
	northern red-backed vole	*Clethrionomys rutilus*
	tundra vole	*Microtus oeconomus*
qawaaget	**birds**	
metghapik/qatepak/tagrapak	common eider	*Somateria mollissima*
qengalek	king eider	*Somateria spectabilis*
	spectacled eider	*Somateria fischeri*
	Steller's eider	*Polysticta stelleri*
qagingiiq	harlequin duck	
quuk	whistling swan	*Olor spp.*
leghlleq	emperor goose	
kaangu	snow goose	*Anser caerulescens*
teghquilkak	brant	*Branta spp.*
nangqwalek	yellow billed loon	*Gavia spp.*
yuwayu	common loon	*Gavia spp.*
eghqaaq	red throated loon	*Gavia spp.*
satelgaq	sandhill crane	*Grus spp.*
ngelqaq	black cormorant	*Phalocrocorax spp.*
pagruwaq	tufted puffin	
quprughaq	horned puffin	
alpa	common murre	*Uria aalge*
samseghhaghaq	black guillemot	*Cepphus grylle*
sipelaaghaq	pigeon guillemot	*Family Alcidae*
sukilpaq	crested auklet	
akmaliighaq	least auklet	*Alle alle*
kaputaghaq	shearwater gull	*Family Laridae*
naghuyapik	glaucous gull	*Larus hyperboreus*
apergiiq	willow ptarmigan (Nome)	*Lagopus lagopus*
	black legged kittiwake	*Rissa tridactyla*