Public Health Assessment for

Review of Sediment and Biota Samples:

PENOBSCOT RIVER
PENOBSCOT INDIAN NATION, MAINE

JANUARY 7, 2014

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

Comment Period Ends:

FEBRUARY 7, 2014

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i) (6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i) (11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR will utilize this document to determine if follow-up health actions are appropriate at this time.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. This revised document has now been released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

Additional copies of this report are available from:
National Technical Information Service, Springfield, Virginia
(703) 605-6000

You May Contact ATSDR Toll Free at
1-800-CDC-INFO
or
Visit our Home Page at: http://www.atsdr.cdc.gov

PUBLIC HEALTH ASSESSMENT

Review of Sediment and Biota Samples:

PENOBSCOT RIVER
PENOBSCOT INDIAN NATION, MAINE

Prepared by:

Western Branch
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry

Foreword

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the Superfund law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency (EPA) and the individual states regulate the investigation and cleanup of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and states with which ATSDR has cooperative agreements. The public health assessment process allows ATSDR scientists and cooperative agreement partners flexibility in document format when presenting findings about the public health impact of hazardous waste sites. The flexible format allows health assessors to convey to affected populations important public health messages in a clear and expeditious way.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data are needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high-risk groups within the community (such as the elderly, chronically ill, and highly exposed people) also receive special attention during the evaluation.

ATSDR uses existing scientific information to evaluate the possible health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available.

Community: ATSDR also needs to learn from the local community about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals, and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the public comments related to the document are addressed in the final version of the report.

Conclusions: The report presents conclusions about the public health threat posed by a site. Ways to stop or reduce exposure will then be recommended in the public health action plan. ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA or other regulatory agencies. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also recommend health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Manager, ATSDR Record Center, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (F-09), Atlanta, GA 30333.

Table of Contents

List of Tables and Figures

Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
CEL	cancer effect levels
CV	comparison value
DHHS	Department of Health and Human Services
EMEG	Environmental Media Evaluation Guide
EPA	U.S. Environmental Protection Agency
IARC	International Agency for Research on Cancer
LOAEL	lowest-observed-adverse-effect-level
mg/kg	milligrams per kilogram
mg/kg/day	milligrams per kilogram per day
MRL	minimal risk level
NOAEL	no-observed-adverse-effect-level
PCB	polychlorinated biphenyl
PIN	Penobscot Indian Nation
RCRA	Resource Conservation and Recovery Act
RfD	reference dose

I. Summary

INTRODUCTION

The Agency for Toxic Substances and Disease Registry (ATSDR) recognizes the Penobscot Indian Nation's (PIN) need for more information about potential exposures to mercury, dioxins/furans, and polychlorinated biphenyls (PCBs) in the Penobscot River area. Our primary objective in writing this health assessment is to provide the information needed to protect health.

In May 2004, The Chief of the Penobscot Indian Nation requested that ATSDR conduct an assessment of the health effects to PIN members from exposure to Penobscot River contaminants. In June 2006, ATSDR published a health consultation that reviewed fish sampling data from 1988-2003. In 2008-2009, U.S. EPA and the PIN Department of Natural Resources (DNR) collected additional fish samples, as well as sediment, turtle, duck, medicinal roots, and fiddlehead ferns. This Public Health Assessment (PHA) evaluates these additional samples, focusing on any contaminants of concern detected in them.

ATSDR determined early in the health assessment process that PIN members who ate fish and turtle were the main people potentially exposed to Penobscot River contaminants. ATSDR found that mercury in fish and turtle was at levels that could cause a health hazard. Dioxins/furans and dioxin-like PCBs were detected at levels that might pose an increased possible cancer risk.

CONCLUSIONS

ATSDR reached four important conclusions in this health assessment:

Conclusion 1

Penobscot Indian Nation (PIN) members who eat Penobscot River fish and turtle at the ingestion rates suggested in the Wabanaki Traditional Cultural Lifeways Exposure Scenario (Scenario), could be exposed to harmful mercury levels. The mercury levels in Penobscot River duck, fiddlehead fern, or medicinal roots, however, are not of health concern.

ATSDR recommends that PIN members eat only 1-2 Penobscot River freshwater fish meals per month. This ingestion rate is consistent with the State of Maine Safe Eating Guidelines. The State of Maine also recommends—and ATSDR concurs—that the most sensitive groups (e.g., pregnant and breastfeeding women and children under 8 years of age) not consume fish caught in Maine freshwater bodies. The only exception is one meal per month of brook trout or landlocked salmon.

ATSDR also recommends PIN members limit their turtle meals to 2-3 servings per month. Additionally, because PIN members have mercury exposures from their local foods, they should make sure that they do not consume other foods that have high levels of mercury, like store-bought swordfish and some tuna.

Basis for Conclusion

Exposure to mercury depends on the amount of fish and turtle that people eat. If a person eats as much fish and turtle as is suggested in the Scenario (i.e., 286 grams, or approximately 10 oz. of fish, turtle, or both per day), exposure could result in harmful health effects. The Scenario assumes PIN members eat one large serving of fish and turtle every *day*. ATSDR recommends that PIN members eat only 1-2 fish meals per *month* and limit turtle consumption to two to three 8 ounce servings per month.

Conclusion 2

Dioxins/furans and PCBs were found in Penobscot River fish and turtle at levels of possible cancer and non-cancer health concern for PIN members who eat those fish and turtle. But dioxins/furans and PCBs found in duck, fiddlehead ferns, or medicinal roots in the Penobscot River were not at levels of health concern.

Given the cancer risk, ATSDR recommends that PIN members limit their consumption of fish to 1-2 fish meals per month. This low number of fish meals will minimize lifetime cancer risk due to dioxins/furans and dioxin-like PCBs. ATSDR also recommends PIN members limit their turtle consumption to two to three 8 ounce servings per month. These recommendations protect human health from exposure to PCBs, dioxins/furans and dioxin-like PCBs, as well as from exposure to mercury.

Basis for Conclusion

A lifetime cancer risk was calculated for PIN members eating fish, turtle, duck, fiddlehead fern and medicinal roots from the Penobscot River. 1 in 10,000 is considered a moderate cancer risk. Fish and turtle resulted in a risk greater than 1 in 10,000; therefore, they might pose an increased possible cancer risk. Of all the fish species sampled, eel had the highest levels of dioxins/furans and dioxin-like PCBs. If eel were eliminated from the analysis, the remaining fish species would not pose an elevated cancer risk. Thus, to reduce cancer risk, PIN members might choose to eliminate eel from their diet. Eliminating eel from the diet would allow PIN members to eat the Scenario-suggested one serving of other species of fish per day without an elevated cancer risk. But keep in mind that all species of fish tested—not just eel—contained elevated mercury levels. Eating these fish as part of a daily diet is hazardous. ATSDR recommends that PIN members follow the State of Maine Safe Eating Guidelines.

State of Maine Safe Eating Guidelines

- **Pregnant and breastfeeding women and children under age 8** SHOULD NOT EAT ANY freshwater fish from Maine's inland waters. One meal per month of brook trout and landlocked salmon is safe.
- **All other adults and children older than 8** MAY EAT TWO freshwater fish meals per month. For brook trout and landlocked salmon, the recommended limit is one meal per week.

- Penobscot River below Lincoln: 1-2 fish meals a month

Conclusion 3

Exposure to Penobscot River sediment is not expected to result in harmful health effects.

Basis for Conclusion

Only three of the 21 sediment samples ATSDR evaluated were above health-protective Comparison Values (CVs). Average concentrations were below the CVs. Thus incidental ingestion of, and dermal exposure to, sediment in the Penobscot River is not expected to be a health hazard.

Conclusion 4

Duck, fiddlehead ferns and medicinal roots are safe to eat at the rates suggested in the Wabanaki Traditional Cultural Lifeways Exposure Scenario.

Basis for Conclusion

The Scenario assumes that PIN members eat 70 grams of duck per day and 133 grams of fiddlehead ferns per day. The fiddlehead fern ingestion rate was also assumed for medicinal roots. Samples were collected of Penobscot River duck, ferns and medicinal roots. The levels of mercury, PCBs, dioxin/furans and dioxin-like PCBs found in those samples were below human health exposure guidelines. Consuming Penobscot River duck, fiddlehead ferns and medicinal roots will not result in harmful health effects.

NEXT STEPS

To decrease mercury exposure, Penobscot Indian Nation members, especially children and women of childbearing age, should reduce their fish and turtle consumption. This will also reduce their exposure to dioxins/furans and dioxin-like PCBs. To be safe, ATSDR recommends that PIN members eat only 1-2 Penobscot River fish meals per month from the Penobscot River, and limit their consumption of Penobscot River turtle to 2-3 meals per month.

FOR MORE

If you have questions or comments, you can call ATSDR toll-free at 1-

INFORMATION	800-CDC-INFO and ask for information on the Penobscot River site. Detailed information about the toxicology of mercury is available in ATSDR's Toxicological Profile for mercury at http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=115&tid=24; the Toxicological Profile for dioxin is available at http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=366&tid=63; and the Toxicological Profile for PCBs is available at http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=142&tid=26.

II. Purpose and Health Issues

In this public health assessment, ATSDR evaluates whether people were exposed in the past, are currently being exposed, or will be exposed in the future to harmful levels of mercury, dioxins/furans, or PCBs found in the Penobscot River sediment, fish, turtle, duck or edible plants. ATSDR reviewed data collected in 2008-2009; these data are therefore most useful for determining exposures in the recent past and present.

What is Mercury?

Mercury exists naturally in the environment in several different forms: metallic mercury, inorganic mercury, and organic mercury. Microorganisms (bacteria and fungi) and natural processes can change mercury from one form to another (ATSDR 1999).

- Metallic mercury (also known as elemental mercury) is the pure form of mercury.
- Inorganic mercury is formed when metallic mercury combines with elements such as chlorine, sulfur, or oxygen.
- The most common organic mercury compound generated by microorganisms and natural processes is methyl mercury.

When ingested, the organic form of mercury is much more harmful than the metallic and inorganic forms (ATSDR 1999). In fish tissue, mercury is present predominantly as methyl mercury, the more toxic form (Bloom 1992; Grieb et al. 1990; Jones 1996).

III. Background

The Penobscot Indian Nation (PIN) reservation is located in central Maine. It comprises all the islands in the Penobscot River and its branches (see Figure 1). The PIN reservation extends from Indian Island at Old Town, Maine north along a series of islands in the middle of the Penobscot River, and east and west into tributaries near the high country around Mount Katahdin (ATSDR 2006). Indian Island, shown in Figure 2, is the PIN primary residence and the seat of tribal government.

In May 2004, the PIN Chief requested that ATSDR assess the public health effects of exposure to contaminants discharged by the Lincoln Pulp and Paper Mill at Lincoln, Maine. In June 2006, ATSDR published a Health Consultation on the Penobscot River Basin located near Lincoln, Maine. That consultation reviewed available fish sampling data from 1988-2003 and calculated fish consumption limits. The main contaminants of concern were dioxins/furans, polychlorinated biphenyls (PCBs), and methyl mercury. At that time, ATSDR recommended that anyone consuming fish from the Penobscot River follow the Penobscot Nation Department of Natural Resources fish consumption advisories.

ATSDR completed a public health consultation on the Penobscot River Basin in June 2006 (see http://www.atsdr.cdc.gov/hac/pha/index.asp).

In May 2008, a joint effort between the U.S. Environmental Protection Agency (EPA), US Geological Survey (USGS), ATSDR, PIN, and U.S. Fish and Wildlife Service finalized the Quality Assurance Project Plan (QAPP) for the EPA New England Indian Program, Regional Applied Research Effort (RARE). This project addressed a regional research need to determine the level of contaminant exposure faced by PIN members who wanted to continue to fish, hunt, trap and gather according to their culture and traditions (EPA 2008). Through this effort, in 2008-2009 additional samples of fish, turtle, duck, fiddlehead ferns, medicinal roots, and sediment were collected. These are the samples evaluated in this health assessment.

Finalized in July 2009, the Wabanaki Traditional Cultural Lifeways Exposure Scenario (the Scenario) was a coordinated effort between the U.S. EPA and five federally recognized Tribal Nations in Maine, including the PIN. The Scenario "provides a numerical representation of the environmental contact, diet, and exposure pathways of the traditional lifestyles in Maine" (Harper and Ranco 2009). The Scenario's dietary consumption rates might not represent the PIN members' current patterns. Still, if members use natural resources in a traditional manner, the consumption rates are realistic. ATSDR used the Scenario to estimate PIN members' ingestion rates of fish, duck, turtle, and fiddlehead fern.

Figure 1. Penobscot Indian Nation Reservation

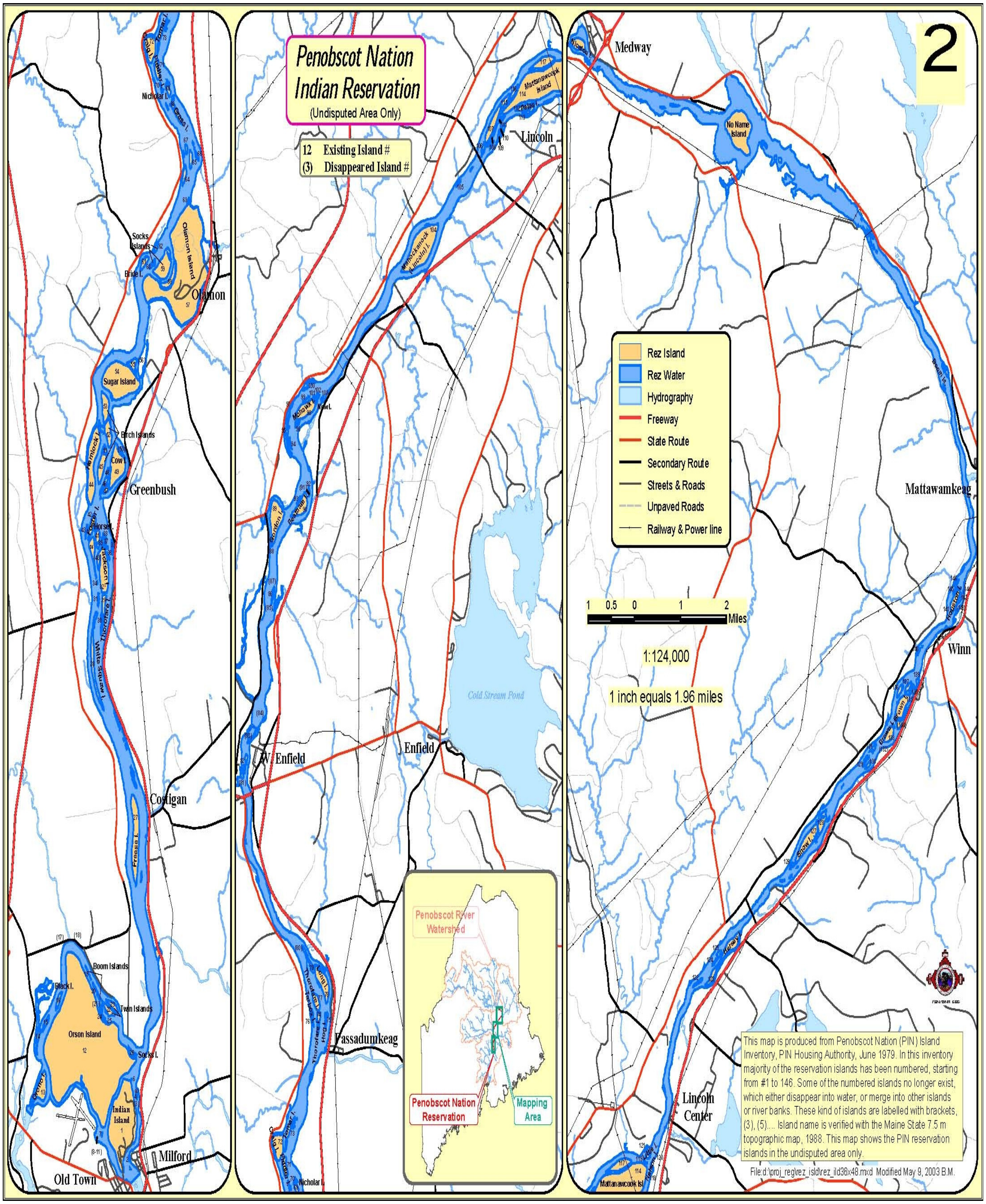
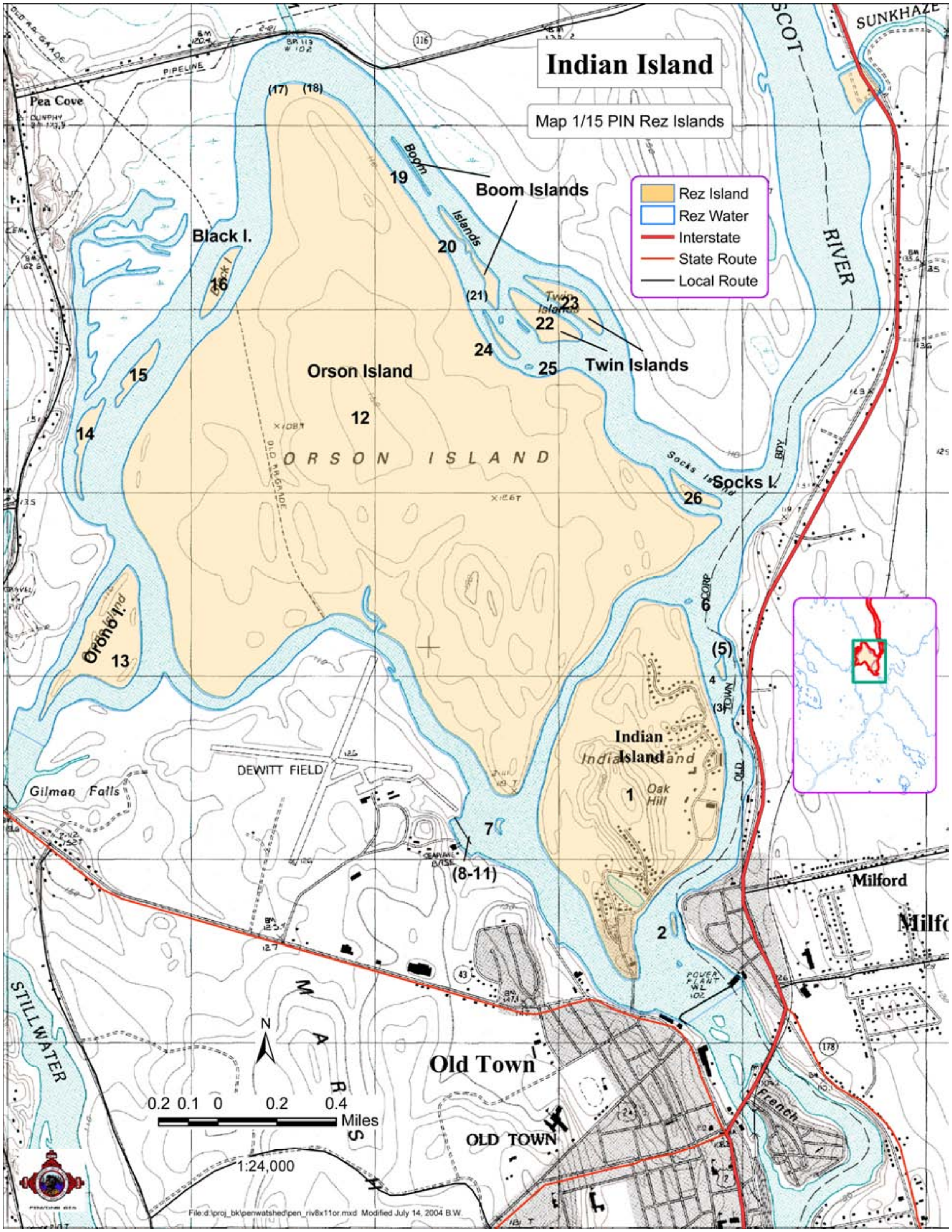


Figure 2. Location of Indian Island



IV. Discussion

Sediment, fish, turtle, duck, fiddlehead fern, and medicinal roots were collected following the methods described in the Quality Assurance Project Plan (QAPP) for the U.S. EPA New England Indian Program's Regional Applied Research Effort (RARE). The samples were analyzed for dioxins/furans, PCBs, total mercury and methyl mercury.

ATSDR calculated contaminant exposure doses for fish, duck, turtle, fiddlehead fern, and medicinal roots (See Appendix B for calculations). A person's contaminant dose from biota is dependent upon how much he or she eats, the contaminant concentration, and other factors such as body weight, exposure frequency and duration. ATSDR used the Scenario report ingestion rates to calculate exposure doses for fish, turtle, duck, fiddlehead fern, and medicinal roots (Harper and Ranco 2009). See Appendix B for exposure dose calculations.

$$\textbf{Exposure Dose} = \frac{\textbf{conc x IR x EF x ED}}{\textbf{BW x AT}}$$

conc=concentration (mg/kg)
IR=ingestion rate (kg/day)
EF=exposure frequency (365 days/yr)
ED=exposure duration (30 yrs adult, 6 yrs child)
BW=body weight (70 kg adult, 16 kg child)
AT=averaging time (ED x EF)

IV.A. Mercury in biota

Mercury was below health guideline values in duck, fiddlehead fern, and medicinal roots (See Appendix B). In fish and turtle, however, mercury was detected at levels above health guidelines. Note, in this regard, that mercury is not considered a carcinogen.

IV.A.1. Fish

During July through October 2008, researchers collected 228 fish from six reaches along the Penobscot River. Fish species included chain pickerel (*Esox niger*), white (*Morone americana*) and yellow perch (*Perca flavescens*) (depending on which species were available in the reach), small-mouth bass (*Micropterus dolomieu*), brown bullhead (*Ameiurus nebulosus*) and American eel (*Anguilla rostrata*). For each reach, tissue from 3-5 fish of each species was composited into one sample (≥ 2kg of tissue). Each composite contained a single species; white and yellow perch were composited separately. A total of 37 composite samples, including duplicates, were analyzed for total mercury.

All species of fish sampled contained elevated mercury levels. The maximum concentration of total mercury in fish was 0.9789 milligram per kilogram (mg/kg); the average was 0.5366 mg/kg. Total mercury in fish is comprised mostly of methyl mercury [ATSDR 1999; EPA 2001]. Both the maximum and the average exposure doses exceeded the chronic minimal risk level (MRL).[1] The mercury MRL is based on the no-observed-adverse-effect-level (NOAEL). The NOAEL is the highest tested dose of a substance reported to have no harmful (adverse) health effects on people. Because the maximum and average doses exceed the NOAEL, ATSDR considered mercury levels in fish taken from the six Penobscot River reaches to be a health hazard.

Exceeding a NOAEL does not mean that an effect is anticipated, but in the case of methyl mercury exposure, we have several studies that do find effects at exposures not too much higher than the NOAEL. Several studies conducted in two fish eating populations (Seychelles and Faroe) are very useful for evaluating PIN exposures. The NOAEL referenced in ATSDR's Toxicological Profile for mercury comes from a study in the Seychelles Islands of children exposed in utero by mothers who were chronically exposed to methylmercury through ingestion of fish. The study did not find neurological effects. From this study ATSDR designated the median maternal hair concentration from the highest exposure group as a NOAEL. However, at the time of ATSDR's Toxicological Profile publication, the tests were not thought to be as sensitive as those used for the Faroe Islands children. Since the publication of ATSDR's toxicological profile, the same sensitive tests used on the Faroes have been repeated in Seychelles with negative or inconclusive results.

A study of Faroe Islands children exposed in utero by mothers who were chronically exposed to methylmercury through ingestion of fish and pilot whale meat found a slight increase in neuropsychological impairments in infants. Maternal daily dietary intake levels were used as the dose for the observed developmental effects in the children exposed in utero. The daily dietary intake levels were calculated from blood concentrations measured in the mothers with supporting additional values based on their hair concentrations (US EPA, 2001). A major difference in the studies is that the Faroe Islanders ate fish and whale, while the Seychelles Islanders ate primarily fish. For this reason, we would consider that the Seychelles population is a useful comparison group for PIN.

PIN members need to be aware of ways to control this health hazard. Of course, the best way for PIN members to decrease their exposure to mercury is to eat less fish. The Scenario report suggests that in a traditional lifestyle, PIN members eat one large serving of fish per day (286 g/day). The State of Maine, however, recommends people eat only 1-2 servings per month of fish taken from the Penobscot River. In fact, Maine recommends that the most sensitive groups (e.g., pregnant and breastfeeding women and children under 8 years of age) consume no fish caught in Maine freshwater bodies, with the exception of up to one meal per month of brook trout or landlocked salmon. Additionally, because PIN members have mercury exposures from their local foods, they should make sure that they do not consume other foods that have high levels of mercury, like store-bought swordfish and some tuna.

The PIN Department of Natural Resources (DNR) and Health Department has an even more specific fish advisory. The PIN DNR recommends that children under 8 years of age, women who are breastfeeding, who are pregnant or who may become pregnant eat no Penobscot River fish. For those who do not fall into those sensitive subpopulations, the PIN DNR recommends

[1] An MRL is an ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncarcinogenic effects.

eating no more than one meal per month of fish taken from Penobscot River below Mattaseunk Dam. For anywhere else on the river, PIN DNR recommends no more than one meal of brook trout or landlocked salmon per week or no more than two meals of any other species per month.

These fish advisories are especially important for children, for women who are pregnant or who may become pregnant, and for breastfeeding mothers. ATSDR recognizes that the PIN is a subsistence community and that many members of the community would like to resume their traditional practices. But due to regional and global increases of mercury in the environment, mercury levels in freshwater and marine fish have risen. Mercury levels in New England fish have risen along with those in the rest of the world's fish.

IV.A.1. Snapping Turtles

From July 2008 through September 2009, researchers collected seven individual snapping turtle (*Chelydra serpentine*) samples from the six reaches of the Penobscot River. These samples were analyzed for methyl mercury and total mercury. As expected, the data indicated that the majority of the mercury found in the turtles was methyl mercury. The maximum level of methyl mercury in the turtle samples was 0.938 milligram per kilogram (mg/kg); the average was 0.4836 mg/kg. The maximum level of total mercury found in the turtle samples was 1.046 milligram per kilogram (mg/kg); the average was 0.546 mg/kg. Both the maximum and the average exposure doses exceeded the chronic MRL. The maximum and average mercury dose exceeded the NOAEL. ATSDR thus considered mercury levels in the turtles taken from the six Penobscot River reaches to be a health hazard.

The Scenario states that in a traditional diet, PIN members would eat 286 g/day of turtle. This is roughly 10 oz.—or one large serving, per day. ATSDR calculated an ingestion rate that would be below health based guidelines—PIN members should only eat 22.3 g/day. This is roughly 5.6 oz per week, or 2-3 servings per month.

IV.A.2. Duck, Fiddlehead Fern and Medicinal Roots

In September – October 2008, researchers collected five wood duck (*Aix sponsa*) samples from four river reaches and analyzed the samples for methyl and total mercury. In ducks, the maximum level of methyl mercury was 0.0479 mg/kg; the average was 0.0291 mg/kg. The maximum level of total mercury in duck was 0.04875 mg/kg; the average was 0.03121 mg/kg.

In May 2008, researchers collected 7 fiddlehead fern (*Matteuccia struthiopteris*) composite samples from 5 Penobscot River reaches and analyzed the samples for methyl and total mercury. The maximum level of methyl mercury in fiddlehead fern was 0.0063 mg/kg; the average was 0.00174 mg/kg. The maximum level of total mercury in one fiddlehead fern was 0.00744 mg/kg; in the other six samples total mercury was not detected.

In 2009, researchers collected 5 medicinal root composite samples collected from four Penobscot River reaches and analyzed the samples for methyl and total mercury. Methyl mercury was not detected in any of the medicinal root samples. The maximum level of total mercury in medicinal root was 0.00861 mg/kg; the average was 0.005974 mg/kg.

None of the exposure doses exceeded health guidelines for methyl mercury. That means PIN members can safely eat duck, fiddlehead ferns and medicinal roots at the ingestion rates suggested in the Scenario (70 g/day for duck and 133 g/day for fiddlehead fern/medicinal roots).

IV.B. PCBs and dioxins/furans in biota

Researchers analyzed 34 composite fish samples for dioxins/furans and dioxin-like PCBs and analyzed seven smallmouth bass composite samples for total PCB congeners. Seven turtle samples were analyzed for dioxins/furans and dioxin-like PCBs; two of the samples were analyzed for total PCB congeners. Five duck samples were analyzed for total PCB congeners, dioxins/furans and dioxin-like PCBs. Seven fiddlehead fern samples were analyzed for total PCB congeners; six of those were analyzed for dioxins/furans and dioxin-like PCBs. Five medicinal root samples were analyzed for dioxin/furans and dioxin-like PCBs.

Fiddlehead fern and medicinal roots from the Penobscot River were all below the non-cancer health guidelines known as MRLs and EPA's Reference Dose (RfD)[2] for total PCB congeners, dioxins/furans and dioxin-like PCBs. Fish and turtle from the Penobscot River exceeded the MRL and RfD for maximum and average levels of dioxins/furans and dioxin-like PCBs. Duck from the Penobscot River had an average level of dioxins/furans and dioxin-like PCBs that exceeded the RfD, but not the MRL, for children only. These estimates are intended to serve as screening levels to identify contaminants and potential health effects that may be of concern. They are more conservative than the no observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL) on which they are based. But despite the fact that several of the exposure doses exceeded certain MRLs and RfDs, they were ten or more times lower than the NOAEL or LOAEL. ATSDR does not therefore consider dioxins/furans and dioxin-like PCBs in Penobscot River duck, fiddlehead fern or medicinal roots a non-cancer health hazard, however fish and turtle may pose a non-cancer health hazard.

IV.B.1. Cancer Risk

PIN members should not eat Penobscot River fish, turtle, duck, fiddlehead fern, or medicinal roots indiscriminately. In fact, if PIN members eat fish and turtle over a lifetime, the dioxins/furans and dioxin-like PCBs in those fish and turtle could cause an elevated possible cancer risk. Table 3 shows the maximum and average concentrations, calculated exposure doses, and cancer risk for total PCB congeners, dioxins/furans and dioxin-like PCBs in fish, turtle, duck, fiddlehead fern, and medicinal roots. Although cancer risk is calculated similarly to exposure dose, for an adult the calculation uses a lifetime risk of 70 years rather than the standard 30 years. Multiplying the exposure dose by the U.S. EPA slope factor obtains the possible cancer risk. Of particular importance here is that dioxin is believed to have the ability to cause cancer even at low exposure levels.

According to the American Cancer Society, the overall probability that residents of the United States will develop some type of cancer during their lifetime is 44% (almost 1 in 2) for men and

[2] The US EPA's RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure of a chemical to the human population (including sensitive subpopulations) that is likely to be without risk of deleterious noncancer effects during a lifetime.

38% (just over 1 in 3) for women (ACS 2008). The maximum and average levels of dioxins/furans and dioxin-like PCBs in Penobscot River fish and turtle result in an estimated cancer risk between 1 in 1,000 and 1 in 10,000. 1 excess cancer case in 1,000 represents a high increased risk, and 1 excess cancer case in 10,000 represents a moderate increased risk. U.S. EPA uses a range of 1 in 10,000 (1×10^{-4}) to 1 in 1,000,000 (1×10^{-6}) to make risk management decisions at Superfund sites.

The shaded cells in Table 1 show those values above 1 in 10,000 or $1x10^{-4}$ cancer risk levels. As stated previously, eel is the fish species with the highest levels of dioxins/furans and dioxin-like PCBs. If PIN members exclude eel from their diets, the average level of dioxins/furans and dioxin-like PCBs in fish would result in an estimated cancer risk around 1 in 100,000, which represents a low increased risk. Thus for PIN members, prudent public health practice would limit or exclude eel from their diet, particularly if they want to decrease their cancer risk from dioxins/furans and dioxin-like PCBs.

In essence, ATSDR recommends that PIN members eat up to 1-2 servings per month of any fish taken from the Penobscot River, and eat no more than 2-3 turtle meals per month of any turtle taken from the Penobscot River. These limits will not only decrease PIN members' cancer risk, they will minimize health hazards due to mercury. And also as stated previously, PIN members may continue to eat duck, fiddlehead fern, and medicinal roots without increasing their possible cancer risk.

Several epidemiological studies have assessed cancer rates among the Penobscot Indian Nation. But the PIN population is small, which makes very difficult comparison with other populations. In 1994, at the request of the PIN Governor, the Centers for Disease Control and Prevention (CDC) analyzed the cancer rates among PIN members in an attempt to determine whether 1) the Indian Island population had a higher incidence of cancer than would be predicted, and 2) those malignancies that were detected were of the type generally associated with dioxin exposure (Miller and Drabant 1996). Miller and Drabant used national and local (Maine) estimates to compare the observed number of cancer cases among the PIN with the expected number.

Another study found a statistically-significant excess of lung cancer occurrence; but much of that excess was most likely attributable to smoking (Miller 1994 and Zahner et al. 1994). In addition to lung cancer, researchers found high rates of cervical cancer among the PIN (Valcarcel 1994 and Miller 1994). Cervical cancer is preventable through early detection through the Pap test, and early administration of the human papillomavirus (HPV) vaccine. Prudent public health practice would work to prevent smoking initiation and to encourage smoking cessation. Prudent public health practice would also encourage regular Pap tests for PIN adult women and HPV vaccinations for PIN young girls. The American Congress of Obstetricians and Gynecologists (ACOG) currently recommends that women 21 and over have a Pap test every 2 years. The ACOG also recommends that women 9-26 years of age have an HPV vaccination, with the target at 11-12 years of age (ACOG 2010). The Advisory Committee on Immunization Practices (ACIP) also recommends that boys and men up to 21 years of age be vaccinated against HPV.

The CDC found no evidence to suggest that cancers specifically associated with dioxin exposure were elevated (e.g., soft tissue sarcomas, Hodgkins and non-Hodgkins lymphoma, stomach, liver and nasal cancers) (Miller 1994). But, to find an elevation in those cancer cases specifically associated with dioxin exposure would be very difficult. In a population the size of the PIN, the expected cancer rates for those types of cancer are very low. Nevertheless, available cancer study results are presented here in response to community concern over cancer incidence among the tribe. Note, however, these results do not provide comprehensive information on individuals' cancer risk.

Table 1. PCB and dioxin adult exposure dose and estimated cancer risk from biota

Biota Type	Contaminant		Concentration (mg/kg) (dioxin TEQ)	Ingestion Rate (kg/day)	Exposure Dose (mg/kg/day)	Exceeds Health Guideline	Cancer Risk
Fish	total PCB congeners	max*	0.00125	0.286	5.11×10^{-6}	No	4.4×10^{-6}
		avg	0.00084	0.286	3.43×10^{-6}	No	2.9×10^{-6}
	dioxin/furan + dioxin-like PCBs	max* (eel)	0.00000542	0.286	2.21×10^{-8}	Yes (MRL)	1.4×10^{-3}
		avg (all fish)	0.0000005824	0.286	2.38×10^{-9}	Yes (RfD)	1.5×10^{-4}
		avg (w/o eel)	0.0000002332	0.286	9.53×10^{-10}	Yes (RfD)	6.1×10^{-5}
Turtle	total PCB congeners	max*	0.0214	0.286	8.74×10^{-4}	Yes (MRL)	7.5×10^{-5}
		avg	0.0108	0.286	4.41×10^{-5}	Yes (MRL)	3.8×10^{-5}
	dioxin/furan + dioxin-like PCBs	max*	0.00000486	0.286	1.99×10^{-8}	Yes (MRL-child only)	1.3×10^{-3}
		avg	0.00000177	0.286	7.23×10^{-9}	Yes (RfD)	4.6×10^{-4}
Duck	total PCB congeners	max*	0.00501	.07	5.01×10^{-6}	No	4.3×10^{-6}
		avg	0.00244	.07	2.44×10^{-6}	No	2.1×10^{-6}
	dioxin/furan +	max*	0.000001076	.07	1.08×10^{-9}	No	6.9×10^{-5}

	dioxin-like PCBs	avg	0.0000005066	.07	$5.07x10^{-10}$	Yes (RfD-child only)	$3.3x10^{-5}$
Fiddle-head Fern	total PCB congeners	max*	0.00115	0.133	$2.19x10^{-6}$	No	$1.9x10^{-6}$
		avg	0.000000461	0.133	$8.76x10^{-10}$	No	$7.5x10^{-10}$
	dioxin/furan + dioxin-like PCBs	max*	$4.42x10^{-9}$	0.133	$8.4x10^{-12}$	No	$7.2x10^{-12}$
Medicinal Root	dioxin/furan + dioxin-like PCBs	max*	0.0000000902	0.133	$1.71x10^{-10}$	No	$1.1x10^{-5}$
		avg	0.0000000428	0.133	$8.13x10^{-11}$	No	$5.2x10^{-6}$

MRL= minimal risk level

* The maximum values are not typically used to evaluate health effects that occur as a result of long term exposures, because it is not possible to eat the worst case concentration over a lifetime.

IV.C. Sediment

Researchers collected 21 sediment samples from the same six reaches along the Penobscot River as where they collected the biota samples. The sediment samples were analyzed for total mercury, methyl mercury, dioxins/furans, and dioxin-like PCBs. Nine samples were also analyzed for total PCB congeners. Contaminant concentrations were compared directly to ATSDR's screening comparison values (CVs). There are values for cancer and non-cancer outcomes. Three of the 21 sediment samples exceeded CVs for dioxins/furans and dioxin-like PCBs. They all came from the Mattaseunk impoundment, which contains fine grain organic-rich sediment that allows it to accumulate higher levels of dioxins/furans and dioxin-like PCBs than do the other reaches from where samples were taken. Dermal and incidental ingestion contaminant exposure doses were calculated for the three samples, but none exceeded health guidelines. Thus, incidental ingestion of, and dermal exposure to, Penobscot River sediment does not pose a human health hazard.

IV.D. Duck, fiddlehead fern, and medicinal roots

Duck samples were analyzed for methyl mercury, total PCB congeners, dioxins/furans and dioxin-like PCBs. Fiddlehead ferns were collected and analyzed for total and methyl mercury, total PCB congeners, dioxins/furans and dioxin-like PCBs. Medicinal roots were collected and analyzed for total and methyl mercury, dioxins/furans and dioxin-like PCBs. None of the calculated fiddlehead fern or medicinal roots contaminant doses exceeded health guidelines. The contaminant dose for children eating duck did exceed the RfD, but not the MRL or LOAEL. Thus duck, fiddlehead ferns and medicinal roots are considered safe to eat at the ingestion rates suggested in the Scenario report.

IV.E. Cumulative Effects

IV.E.1. Multiple Foods

ATSDR recognizes that PIN members may eat all the sampled biota (i.e., fish, turtle, duck, fiddlehead fern and medicinal roots) as part of a varied diet. And in doing so, PIN members are not exposed to just one contaminant dose at a time. Still, eating all these foods at the same time will not change PIN members' health risk. The biota whose chemical exposure doses exceed health guidelines (i.e., fish and turtle) were more than ten times higher than the biota whose chemical exposure doses did not exceed health guidelines (i.e., duck, fiddlehead fern, and medicinal roots). Therefore, adding all the biota exposure doses together will not increase the adverse health risk. For example, the maximum estimated fish and turtle cancer risk due to dioxin/furans and dioxin-like PCBs was approximately 1 in 1,000. For duck, the maximum risk was approximately 6 in 100,000. The risk from eating fiddlehead fern and medicinal roots was lower still. Adding cancer risks together still yields a cancer risk very close to the risk from fish and turtle alone. Thus, the maximum biota exposure dose represents the same order of magnitude as all of the biota added together.

IV.E.2. Multiple Chemicals in Foods

Since we calculated that it is possible for some members of the PIN to get a high dose of mercury from eating turtle and fish and that those same food sources also contain the higher amounts of dioxin/furan, we think that it is important to discuss the potential added non-cancer risk associated with the mercury and dioxin.

As mentioned above, the mercury levels measured are much lower than levels associated with neurological effects in adults, but they are a potential concern for young children, especially the developing fetus. It is therefore important to recognize the recent studies that suggest that dioxins may also pose a neurologic risk. Baccarelli et al. (2008) reported higher levels of thyroid stimulating hormone (TSH) in newborns exposed to dioxin in utero. High TSH levels in newborns can lead to neonatal hypothyroidism which, if left untreated, can cause severe mental and physical retardation (Baccarelli et al. 2008). We should stress that the added estimated risk involves extrapolations from one study to another. Nevertheless, the potential additive effect supports limiting consumption (by sensitive groups) of the same species that have higher amounts of both mercury and dioxin.

V. Conclusions

- Penobscot Indian Nation (PIN) members who eat fish and turtle at the ingestion levels suggested in the Wabanaki Traditional Cultural Lifeways Exposure Scenario report (Scenario) may be exposed to harmful levels of mercury, dioxins/furans and dioxin-like PCBs.
    - ATSDR is most concerned about mercury in fish and turtle taken from the Penobscot River. Mercury is most harmful to children and developing fetuses, therefore it is especially important for pregnant and breastfeeding women, women who may become pregnant, and children to limit their consumption of fish and turtle in order to decrease their risk of neurological damage due to mercury exposure.
- PIN members who eat duck, fiddlehead fern, or medicinal roots at the Scenario- suggested ingestion rates will not be exposed to harmful levels of mercury, PCBs, dioxins/furans or dioxin-like PCBs.
- Incidental ingestion of, and dermal exposure to, Penobscot River sediment does not pose a human health hazard.

VI. Recommendations

ATSDR recommends that PIN members:

Follow the existing Penobscot Indian Nation Department of Natural Resources' fish advisory and the State of Maine Safe Eating Guidelines for all fish caught in the Penobscot River.

Limit turtle consumption to 2-3 servings per month.

Continue to eat duck, fiddlehead fern, and medicinal roots at the ingestion levels suggested in the Scenario.

VII. Author and contributors

Author

Katherine H. Pugh, M.S.
Environmental Health Scientist
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry

Contributors

Gregory M. Zarus, M.S.
Senior Environmental Health Scientist
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry

Gary Perlman, MPH
Senior Environmental Health Scientist
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry

In collaboration with U.S. Environmental Protection Agency Regionally Applied Research Effort (RARE) team members (see Appendix E)

VIII. References

[ACOG 2010] American Congress of Obstetricians and Gynecologists. 2010. Available at: http://www.acog.org/. Accessed November 2010.

[ACS 2008] American Cancer Society, Lifetime Probability of Developing or Dying from Cancer, Mar 31, 2008, Available at: http://www.cancer.org/docroot/CRI/content/CRI_2_6x_Lifetime_Probability_of_Developing_or_Dying_From_Cancer.asp. Accessed September 2011.

[Arnold et al. 1993] Arnold DL, Bryce F, Stapley R, et al. 1993a. Toxicological consequences of Aroclor 1254 ingestion by female Rhesus (*macaca mulatta*) monkeys. Part 1A. Prebreeding phase: Clinical health findings. Food Chem Toxicol 31(11):799-810. As cited in Agency for Toxic Substances and Disease Registry. November 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Atlanta: U.S. Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html. Accessed July 2009.

[ATSDR 1998] Agency for Toxic Substances and Disease Registry. 1998. Toxicological profile for chlorinated dibenzo-p-dioxins (CDDs). Atlanta: US Department of Health and Human Services; December 1998. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=366&tid=63. Accessed January 2011.

[ATSDR 1999] Agency for Toxic Substances and Disease Registry. 1999. Toxicological Profile for Mercury. Atlanta: U.S. Department of Health and Human Services.

[ATSDR 2000] Agency for Toxic Substances and Disease Registry. November 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Atlanta: U.S. Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html. Accessed July 2009.

[ATSDR 2005] Agency for Toxic Substances and Disease Registry. January 2005. Public Health Assessment Guidance Manual. Atlanta: U.S. Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/HAC/PHAManual/. Accessed July 2009.

[ATSDR 2006] Agency for Toxic Substances and Disease Registry. June 2006. Health Consultation Penobscot River Basin located near Lincoln, Maine. Atlanta: U.S. Department of Health and Human Services.

[Baccarelli et al. 2008] Baccarelli, A; Giacomini, SM; Corbetta, C; Landi, MT; Bonzini, M; Consonni, D; Grillo, P; Patterson, DG; Pesatori, AC; Bertazzi, PA. (2008). Neonatal thyroid function in Seveso 25 years after maternal exposure to dioxin. PLoS Med 5: e161.

[Bloom 1992] Bloom NS. 1992. On the chemical form of mercury in edible fish and marine invertebrate tissue. Canadian Journal of Fisheries and Aquatic Sciences 49:1010–1017.

[EPA 1996] PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures. Washington, DC. September 1996. Available from URL: http://www.epa.gov/ORD/WebPubs/pcb/pcb.pdf.

[EPA 1993] U.S. Environmental Protection Agency. Integrated Risk Information System, Reference Dose (RfD): Description and Use in Health Risk Assessments. March 15, 1993. http://www.epa.gov/iris/rfd.htm

[EPA 2001] U.S. Environmental Protection Agency. July 2001. Methyl mercury human health assessment information. Integrated risk information system. Available at: http://www.epa.gov/iris/subst/0073.htm

[EPA 2004] U.S. Environmental Protection Agency. July 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final. Available at: http://www.epa.gov/oswer/riskassessment/ragse/pdf/part_e_final_revision_10-03-07.pdf. Accessed July 2009.

[EPA 2005] U.S. Environmental Protection Agency. 2005. National Emissions Inventory Data and Documentation. Available at: http://www.epa.gov/ttn/chief/net/2005inventory.html

[EPA 2008] U.S. Environmental Protection Agency. May 2008. EPA New England Indian Program, Regional Applied Research Effort (RARE) Developing Exposure Concentrations, For Regional Cultural Tribal Exposure Assessment, Penobscot River, Maine 2007 Quality Assurance Project Plan.

[EPA 2011] U.S. Environmental Protection Agency. Basic information about Mercury. Available at: http://www.epa.gov/mercury/about.htm

[EPA 2012] U.S. Environmental Protection Agency. Integrated Risk Information System, 2,3,7,8-tetrachorodibenzo-p-dioxin. February, 17, 2012. Available at: http://www.epa.gov/iris/subst/1024.htm

[Grandjean et al. 1997] Grandjean P, Weihe P White RF, Debes F, Araki S, Murata K, Sørensen N, Dahl D, Yokoyama K and Jørgensen PJ, Cognitive deficit in 7-year-old children with prenatal exposure to methylmercury. Neurotoxicology and Teratology 19(1997): 417–428.

[Grieb et al. 1990] Grieb TM, Bowie GL, Driscoll CT, Gloss SP, Schofield CL, Porcella DB. Factors affecting mercury accumulation in fish in the Upper Michigan Peninsula. Environmental Toxicology and Chemistry 9(7): 919-930.

[Harper and Ranco 2009] Harper, B. and Ranco, D. 2009. Wabanaki Traditional Cultural Lifeways Exposure Scenario.

[Jones and Slotten 1996] Jones AB and Slotten DG. 1996. Mercury Effects, Sources, and Control Measures. A Special Study of the San Francisco Estuary Regional Monitoring Program. San Francisco Estuary Institute, Richmond, CA.

[Miller 1994] Miller DS. 1994. Final Report, Analysis of Cancer Registry Data, Penobscot Indian Nation, 1959-1993, May 2004. Atlanta: Centers for Disease Control and Prevention.

[Miller and Drabant 1996] Miller DS and Drabant B. 1996. Letter clarifying Analysis of Cancer Registry Data for the Penobscot Indian Nation. October 8, 1996. Atlanta: U.S. Department of Health and Human Services.

[Poiger and Schlatter 1986] Poiger H and Schlatter C. 1986. Pharmacokinetics of 2,3,7,8-TCDD in man. Chemosphere 15: 1489–1494.

[Rice and Cohen 1996] Rice RH, Cohen DE. 1996. Toxic responses of the skin. In: Klaassen CD, ed. Cassarett and Doull's toxicology: The basic science of poisons. New York, NY: McGraw-Hill, 529-546. As cited in Agency for Toxic Substances and Disease Registry. November 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Atlanta: U.S. Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html. Accessed July 2009.

[Rice 1997] Rice DC. 1997. Effect of postnatal exposure to a PCB mixture in monkeys on multiple fixed interval-fixed ratio performance. Neurotoxicol Teratol 19(6):429-434. As cited in Agency for Toxic Substances and Disease Registry. November 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Atlanta: U.S. Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html. Accessed July 2009.

[Rice 1998] Rice DC. 1998. Effects of postnatal exposure of monkeys to a PCB mixture on spatial discrimination reversal and DRL performance. Neurotoxicol Teratol 20(4):391-400. As cited in Agency for Toxic Substances and Disease Registry. November 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Atlanta: U.S. Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html. Accessed July 2009.

[Rice 1999] Rice DC. 1999. Behavioral impairment produced by low-level postnatal PCB exposure in monkeys. Environ Res 80:S113-S121. As cited in Agency for Toxic Substances and Disease Registry. November 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Atlanta: U.S. Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html. Accessed July 2009.

[Rice and Hayward 1997] Rice DC, Hayward S. 1997. Effects of postnatal exposure to a PCB mixture in monkeys on nonspatial discrimination reversal and delayed alternation performance. Neurotoxicology 18(2):479-494. As cited in Agency for Toxic Substances and Disease Registry. November 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Atlanta: U.S. Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html. Accessed July 2009.

[Rice and Hayward 1999] Rice DC, Hayward S. 1999. Effects of postnatal exposure of monkeys to a PCB mixture on concurrent random interval-random interval and progressive ratio performance. Neurotoxicol Teratol 21(1):47-58. As cited in Agency for Toxic Substances and Disease Registry. November 2000. Toxicological profile for polychlorinated biphenyls

(PCBs).Atlanta: U.S. Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html. Accessed July 2009.

[Schantz et al. 1992] Schantz SL, Ferguson SA and Bowman RE. 1992. Effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin on behavior of monkeys in peer groups. Neurotoxicology and Teratology 14: 433–446.

[Tryphonas et al. 1989] Tryphonas H, Hayward S, O'Grady L, et al. 1989. Immunotoxicity studies of PCB (Aroclor 1254) in the adult Rhesus (*macaca mulatta*) monkey-Preliminary report. Int J Immunopharmacol 11:199-206. As cited in Agency for Toxic Substances and Disease Registry. November 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Atlanta: U.S. Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html. Accessed July 2009.

[Tryphonas et al. 1991] Tryphonas H, Luster MI, White KL Jr, et al. 1991. Effects of PCB (Aroclor® 1254) on non-specific immune parameters in Rhesus (*macaca mulatta*) monkeys. Int J Immmunopharmacol 13:639-648. As cited in Agency for Toxic Substances and Disease Registry. November 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Atlanta: U.S. Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html. Accessed July 2009.

[Valcarcel 1994] Valcarcel H. 1994. Penobscot Nation Health Department Cancer Registry Report 1980-1994.

[Weihe et al. 1996] Weihe P, Grandjean P, Debes F, White R. 1996. Health implications for Faroe islanders of heavy metals and PCBs from pilot whales. Science of the Total Environment 186: 141–148.

[Wester et al. 1990] Wester RC, Maibach HI, Bucks DW, et al. 1990. Percutaneous absorption and skin decontamination of PCBs: In vitro studies with human skin and in vivo studies in the Rhesus monkey. J Toxicol Environ Health 31:235-246. As cited in Agency for Toxic Substances and Disease Registry. November 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Atlanta: U.S. Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html. Accessed July 2009.

[Wester et al. 1993] Wester RC, Maibach HI, Sedik L, et al. 1993. Percutaneous absorption of PCBs from soil: In vivo rhesus monkey, in vitro human skin, and binding to powdered human stratum corneum. J Toxicol Environ Health 39(3):375-382. As cited in Agency for Toxic Substances and Disease Registry. November 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Atlanta: U.S. Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html. Accessed July 2009.

[Zahner et al. 1994] Zahner G, Mueller N, Daskalakis C, Stuver S and Smith MC. 1994. Cancer Among Native American of the Penobscot Nation, July 26, 1994. Cambridge, MA: Harvard School of Public Health.

Appendix A. ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health. This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call the agency's toll-free number, 1-800-CDC-INFO (1-800-232-4636).

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

Acute
Occurring over a short time [compare with chronic].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

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

Ambient
Surrounding (for example, ambient air).

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biologic uptake
The transfer of substances from the environment to plants, animals, and humans.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden
The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

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

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

Carcinogen
A substance that causes cancer.

Chronic
Occurring over a long time [compare with acute].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure]

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

Completed exposure pathway [see exposure pathway].

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

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

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

Dermal contact
Contact with (touching) the skin [see route of exposure].

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

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

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

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.

EPA
United States Environmental Protection Agency.

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

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

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Geographic information system (GIS)
A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

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

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

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

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

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

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

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

In vitro
An artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

In vivo
Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

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

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

Metabolite
Any product of metabolism.

mg/kg
Milligram per kilogram.

Migration
Moving from one location to another.

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

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

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

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see exposure pathway].

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

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

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

Public health statement
The first chapter of an ATSDR toxicological profile. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public meeting
A public forum with community members for communication about a site.

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

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

Remedial investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Risk
The probability that something will cause injury or harm.

Risk reduction
Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication
The exchange of information to increase understanding of health risks.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Safety factor [see uncertainty factor]

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

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

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

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

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance
A chemical.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

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

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

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

Urgent public health hazard
A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Other glossaries and dictionaries:
Environmental Protection Agency (http://www.epa.gov/OCEPAterms/)
National Library of Medicine (NIH) (http://www.nlm.nih.gov/medlineplus/mplusdictionary.html)

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

Introduction

What is meant by exposure?

ATSDR's public health evaluations are driven by exposure to, or contact with, environmental contaminants. Contaminants released into the environment have the potential to cause harmful health effects. Nevertheless, *a release does not always result in exposure.* People can only be exposed to a contaminant if they come into contact with that contaminant—if they breathe, eat, drink, or come into skin contact with a substance containing the contaminant. If no one comes into contact with a contaminant, then no exposure occurs, and thus no health effects could occur. Often the general public does not have access to the source area of contamination or areas where contaminants are moving through the environment. This lack of access to these areas becomes important in determining whether people could come into contact with the contaminants.

> An exposure pathway has five elements: (1) a source of contamination, (2) an environmental media, (3) a point of exposure, (4) a route of human exposure, and (5) a receptor population. The source is the place where the chemical or radioactive material was released. The environmental media (such as groundwater, soil, surface water, or air) transport the contaminants. The point of exposure is the place where people come into contact with the contaminated media. The route of exposure (for example, ingestion, inhalation, or dermal contact) is the way the contaminant enters the body. The people actually exposed are the receptor population.

The route of a contaminant's movement is the pathway. ATSDR identifies and evaluates exposure pathways by considering how people might come into contact with a contaminant. An exposure pathway could involve air, surface water, groundwater, soil, dust, or even plants and animals. Exposure can occur by breathing, eating, drinking, or by skin contact with a substance containing the chemical contaminant.

How does ATSDR determine which exposure situations to evaluate?

ATSDR scientists evaluate site conditions to determine if people could have been, are, or could be exposed (i.e., exposed in a past scenario, a current scenario, or a future scenario) to site-related contaminants. When evaluating exposure pathways, ATSDR identifies whether exposure to contaminated media (soil, sediment, water, air, or biota) has occurred, is occurring, or will occur through ingestion, dermal (skin) contact, or inhalation.

You can find out more about the ATSDR evaluation process by contacting ATSDR directly at 1-800-CDC-INFO (1-800-232-4636) or reading ATSDR's Public Health Assessment Guidance Manual at http://www.atsdr.cdc.gov/HAC/PHAManual/.

If someone is exposed, will they get sick?

Exposure does not always result in harmful health effects. The type and severity of health effects a person can experience because of contact with a contaminant depend on the exposure concentration (how much), the frequency (how often) and/or duration of exposure (how long), the route or pathway of exposure (breathing, eating, drinking, or skin contact), and the multiplicity of exposure (combination of contaminants). Once exposure occurs, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status of the exposed individual influence how the individual absorbs, distributes, metabolizes, and excretes the contaminant. Together, these factors and characteristics determine the health effects that may occur.

In almost any situation, there is considerable uncertainty about the true level of exposure to environmental contamination. To account for this uncertainty and to be protective of public health, ATSDR scientists typically use worst-case exposure level estimates as the basis for determining whether adverse health effects are possible. These estimated exposure levels usually are much higher than the levels that people are really exposed to. If the exposure levels indicate that adverse health effects are possible, ATSDR performs a more detailed review of exposure and consults the toxicologic and epidemiologic literature for scientific information about the health effects from exposure to hazardous substances.

Methodology

ATSDR analyzed the weight of evidence of available toxicological, medical, and epidemiological health effects data to determine whether exposures might be associated with harmful health effects (non-cancer and cancer). As a first step in evaluating non-cancer effects, ATSDR compared estimated exposure doses to ATSDR's minimal risk level (MRL) and EPA's reference dose (RfD). Both ATSDR and EPA derived the same value for chronic oral exposure to Aroclor 1254 (2.0×10^{-5} mg/kg/day). Neither ATSDR nor EPA has developed a health guideline for Aroclor 1260, but it is believed to be more toxic than Aroclor 1254. ATSDR derived an MRL of 1.0×10^{-9} mg/kg/day for chronic oral exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8- TCDD). EPA recently calculated a RfD of 7.0×10^{-10} for chronic oral exposure to 2,3,7,8- TCDD. 2,3,7,8- TCDD is the most toxic of the dioxins/furans, therefore using it's RfD and MRL for all dioxins/furans and dioxin-like PCBs is most protective of human health. ATSDR derived an MRL of 3.0×10^{-4} mg/kg/day for chronic oral exposure to methyl mercury. EPA derived an RfD of 1.0×10^{-4} mg/kg/day for oral exposure to methyl mercury. ATSDR used the health guidelines for methyl mercury in this health assessment because, in fish tissue, mercury is present predominantly as methyl mercury, the more toxic form (Bloom 1992; Grieb et al. 1990; Jones 1996).

> Exposure doses represent the amount of chemical a person is exposed to over time, and are expressed in milligrams per kilogram per day (mg/kg/day).

The MRL and RfD are conservative estimates of daily human exposure to a substance that are unlikely to result in non-cancer effects over a specified duration. *Estimated exposure doses that are less than health guidelines were not considered to be of health concern.* To maximize human health protection, MRLs and RfDs have built-in uncertainty or safety factors, making these values considerably lower than levels at which health effects have been observed. The result is that even if an exposure dose is higher than the MRL or RfD, it does not necessarily follow that harmful health effects will occur. It simply indicates to ATSDR that further evaluation is required before a conclusion can be drawn. This process enables ATSDR to weigh the available evidence in light of uncertainties and offer perspective on the plausibility of harmful health outcomes under site-specific conditions.

Sources for Toxicologic, Medical, and Epidemiologic Data

By Congressional mandate, ATSDR prepares toxicological profiles for hazardous substances found at contaminated sites. ATSDR's Toxicological Profiles for mercury, PCBs, and dioxin were used to evaluate potential health effects in this health assessment (ATSDR 2000). ToxFAQs for mercury, dioxin, and PCBs are provided in Appendix C. ATSDR's toxicological profiles are available on the Internet at http://www.atsdr.cdc.gov/toxprofiles/index.asp or by contacting the National Technical Information Service (NTIS) at 1-800-553-6847.

EPA also develops health effects guidelines. These guidelines are found in EPA's Integrated Risk Information System (IRIS)—a database of human health effects that could result from exposure to various substances found in the environment. IRIS is available on the Internet at http://www.epa.gov/iris. For more information about IRIS, please call EPA's IRIS hotline at 1-301-345-2870 or e-mail at Hotline.IRIS@epamail.epa.gov.

Evaluating Ingestion of Biota

Mercury, dioxins/furans, or PCBs can enter your body if you ingest biota contaminated with them. Once inside your body, dioxins/furans and PCBs tend to accumulate in lipid-rich tissues, such as the liver, fat, skin, and breast milk (ATSDR 2000). Methyl mercury accumulates primarily in the muscle and may enter the brain where it may harm the nervous system (ATSDR 1999).

The following equation was used to estimate PIN ingestion of mercury, dioxins/furans, and PCBs in fish, turtle, duck, fiddlehead fern and medicinal roots. The ingestion rates came from the Wabanaki Traditional Cultural Lifeways Exposure Scenario, which was designed to be a realistic scenario if members were able to use natural resources in their traditional manner (Harper and Ranco 2009). Where possible, ATSDR used site-specific information regarding the frequency and duration of exposures. When site-specific information was not available, ATSDR employed several conservative assumptions to estimate exposures.

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

where:

C: Concentration of chemical in biota (mg/kg)

IR: Ingestion rate (adult = 0.286 kg/day and child = 0.143 kg/day for fish and turtle; adult = 0.07 kg/day and child = 0.035 kg/day for duck; adult = 0.133 kg/day and child = 0.066.5 kg/day for fiddlehead fern and medicinal roots)

EF: Exposure frequency (365 days/year)

ED: Exposure duration (30 years for an adult, 6 for a child)

BW: Body weight (adult = 70 kg and child = 16 kg, which are standard body weights for an average adult and children 1 through 6 years old; ATSDR 2005)

AT: Averaging time, or the period over which cumulative exposures are averaged (ED x 365 days/year)

Table B-1. Estimated Biota Contaminant Ingestion Exposure Doses

Biota	*Contaminant*		*Concentration (mg/kg)*	*Estimated Child Dose (mg/kg/day)*	*Estimated Adult Dose (mg/kg/day)*
Fish	Mercury	max	0.9789	$8.75x10^{-3}$	$4.0x10^{-3}$
		avg	0.5366	$4.8x10^{-3}$	$2.19x10^{-3}$
	PCBs	max	0.00125	$1.12x10^{-5}$	$5.11x10^{-6}$
		avg	0.00084	$7.51x10^{-6}$	$3.43x10^{-6}$
	Dioxin/ Furan + Dioxin-like PCBs	max (eel)	$5.42x10^{-6}$	$4.84x10^{-8}$	$2.21x10^{-8}$
		avg (all fish)	$5.824x10^{-7}$	$5.21x10^{-9}$	$2.38x10^{-9}$
		avg (w/o eel)	$2.332 x10^{-7}$	$2.08 x10^{-9}$	$9.53 x10^{-10}$
Turtle	Mercury	max	1.046	$9.35x10^{-3}$	$4.27x10^{-3}$
		avg	0.606	$5.42x10^{-3}$	$2.48x10^{-3}$
	PCBs	max	0.0214	$1.91x10^{-4}$	$8.74x10^{-5}$
		avg	0.0108	$9.65x10^{-5}$	$4.41x10^{-5}$
	Dioxin/ Furan + Dioxin-like PCBs	max	$4.86x10^{-6}$	$4.34x10^{-8}$	$1.99x10^{-8}$
		avg	$1.77x10^{-6}$	$1.58x10^{-8}$	$7.23x10^{-9}$
Duck	Mercury	max	0.0479	$1.05x10^{-4}$	$4.79x10^{-5}$
		avg	0.0291	$6.37x10^{-5}$	$2.91x10^{-5}$
	PCBs	max	0.00501	$1.1x10^{-5}$	$5.01x10^{-6}$
		avg	0.00244	$5.34x10^{-6}$	$2.44x10^{-6}$
	Dioxin/ Furan + Dioxin-like PCBs	max	$1.076x10^{-6}$	$2.35x10^{-9}$	$1.08x10^{-9}$
		avg	$5.066x10^{-7}$	$1.11x10^{-9}$	$5.07x10^{-10}$
Fiddle-head Fern	Mercury	max	0.0063	$2.62x10^{-5}$	$1.2x10^{-5}$
	PCBs	max	0.00115	$4.78x10^{-6}$	$2.19x10^{-6}$
		avg	$4.61x10^{-7}$	$1.92x10^{-9}$	$8.76 x10^{-10}$
	Dioxin/ Furan + Dioxin-like PCBs	max	$4.42x10^{-9}$	$8.4x10^{-12}$	$1.84x10^{-11}$
Medicinal Root	Mercury	max	0.00861	$3.58x10^{-5}$	$1.64x10^{-5}$
	Dioxin/ Furan + Dioxin-like PCBs	max	$9.02x10^{-8}$	$3.75x10^{-10}$	$1.71x10^{-10}$
		avg	$4.28x10^{-8}$	$1.78 x10^{-10}$	$8.13x10^{-11}$

Mercury

Mercury contamination of fish and wildlife results from incineration of coal, and medical and other waste; alkali and metal processing; and mining of gold and mercury, in some areas. However, atmospheric deposition is the dominant source of mercury over most of the landscape. Once in the atmosphere, mercury is widely disseminated and can circulate for years, accounting for its widespread distribution. Some natural sources of atmospheric mercury include volcanoes, geologic deposits of mercury, and volatilization from the ocean. Although all rocks, sediments, water and soils naturally contain small but varying amounts of mercury, scientists have found some local mineral occurrences and thermal springs that are naturally high in mercury. When coal is burned, mercury is released into the environment. Coal-burning power plants are the largest human-caused source of mercury emissions to the air in the United States, accounting for over 50 percent of all domestic human-caused mercury emissions (EPA 2005).

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

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

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

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

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

The oral health guideline for methyl mercury is based on the Seychelles Child Development Study (SCDS) in which people who were exposed to 1.3×10^{-3} mg/kg/day of methylmercury in their food did not experience any adverse health effects (Davidson et al. 1998 as cited in ATSDR 1999). Over 700 mother-infant pairs were followed and tested from parturition through 66 months of age. The Seychellois regularly eat a large quantity and variety of ocean fish, with 12 fish meals per week representing a typical exposure. The results revealed no evidence of adverse effects attributable to chronic ingestion of low levels of methylmercury in fish (median total mercury concentration was <1 mg/kg with a range of 0.004 to 0.75 mg/kg; Davidson et al. 1998 as cited in ATSDR 1999). The estimated exposure doses for adults and children eating fish and turtle from the Penobscot River are on the same order of magnitude of this NOAEL, and exceed it. Therefore, ATSDR cautions that eating fish and turtle from the Penobscot River at the consumption rates suggested in the Scenario could cause harmful non-cancer health effects.

Another study from which a risk can be calculated is the Faroes Island study (Grandjean et al. 1997). This study found a reduction in performance on the “Boston Naming Test” in children who had higher mercury in their umbilical cord blood at birth. Follow up studies of the children at adolescence also found an association with neurological effects. The mercury concentrations in cord blood were associated with maternal consumption of pilot whale during pregnancy. The pilot whale had mercury levels that averaged 3.3 mg/kg methyl mercury (Weihe et al. 1996). Although an exposure dose is not provided for the Faroes population, the concentration of mercury in whale was about six times the average levels of the fish and turtle from the Penobscot River.

ATSDR’s MRL is based on the Seychelles study. The selection of the critical study for the methyl mercury MRL was based on several factors, including the overall quality of the studies, exposure regimen, freedom from confounding and influencing factors, and relevance to U.S. exposures.

PCBs

Polychlorinated biphenyls (PCBs) are a group of synthetic organic chemicals that can cause a number of different harmful effects. The name PCB defines the chemical makeup as having many (poly) chlorines (chlorinated) on a double benzene ring (biphenyl). There are no known natural sources of PCBs in the environment. Because they don't burn easily and are good insulating materials, PCBs were used widely as coolants and lubricants in transformers, capacitors, and other electrical equipment. The manufacture of PCBs stopped in the United States in August 1977 because there was evidence that PCBs build up in the environment and may cause harmful effects (ATSDR 2000).

ATSDR reviewed the scientific literature for noncarcinogenic effects from exposure to PCBs. The estimated doses for children (1.91×10^{-4} mg/kg/day) and adults (8.74×10^{-5} mg/kg/day) exposed to the highest detected concentration of PCBs (0.0214 mg/kg) in biota from the

Penobscot River were above ATSDR's minimal risk level (MRL), but one to two orders of magnitude lower than doses in which health effects were observed in animals. Immunological health effects (specifically, decreased antibody response and eyelid and toe/finger nail changes) were observed in female Rhesus monkeys chronically exposed to 5.0×10^{-3} mg/kg/day of Aroclor 1254 (Arnold et al. 1993; Tryphonas et al. 1989; Tryphonas et al. 1991). This is the lowest-observed-adverse-effect-level (LOAEL) identified in the scientific literature for chronic exposure to PCB mixtures. Neurobehavioral effects were observed in infant monkeys exposed to 7.5×10^{-3} mg/kg/day (Rice 1997; Rice 1998; Rice 1999; Rice and Hayward 1997; Rice and Hayward 1999). Because the PCB exposure doses were lower than the LOAEL, non-cancer health effects are not expected, but are possible, from exposure to PCB-contaminated biota in the Penobscot River.

Studies of workers provide evidence that exposure to PCBs is associated with certain types of cancer in humans, such as cancer of the liver and biliary tract. Rats that ate commercial PCB mixtures throughout their lives developed liver cancer. Based on the evidence for cancer in animals, the Department of Health and Human Services (DHHS) has stated that PCBs may reasonably be anticipated to be carcinogens. Both EPA and the International Agency for Research on Cancer (IARC) have determined that PCBs are probably carcinogenic to humans. The maximum estimated lifetime dose (7.5×10^{-5} mg/kg/day) from ingesting PCB-contaminated biota from the Penobscot River is five orders of magnitude lower than the cancer effect levels (CELs) reported in the literature (CELs ranged from 1.0–5.4 mg/kg/day in animals; no CELs exist for humans; ATSDR 2000). As such, no excess cancers from PCB exposure are expected from ingesting contaminated biota from the Penobscot River.

Dioxins/Furans and Dioxin-like PCBs

Dioxins are a family of 75 different compounds that have varying harmful effects. They are divided into eight groups based on the number of chlorine atoms, which can be attached to the dioxin/furan molecule at any one of eight positions. The name of each dioxin or furan indicates both the number and the positions of the chlorine atoms. For example, the dioxin with four chlorine atoms at positions 2, 3, 7, and 8 on the molecule is called 2,3,7,8- tetrachlorodibenzo-p-dioxin (2,3,7,8- TCDD, or TCDD), which is one of the most toxic of the dioxins to mammals and has received the most attention (ATSDR 1998).

The most common way for dioxins to enter the body is through eating food contaminated with dioxins. In general, absorption of dioxins is vehicle-dependent and congener-specific—about 87 percent of TCDD was absorbed in one human volunteer who ingested a single dose (Poiger and Schlatter 1986). Dioxins are lipophilic, meaning that they are attracted to lipids (fats) and tend to accumulate in body parts that have more fat, such as the liver. They can also concentrate in maternal milk. The body can store dioxins in the liver and body fat for many years before eliminating them.

A toxic equivalency factor (TEF) approach to evaluating health hazards has been developed for dioxins (see ATSDR 1998 for more details). In short, the TEF approach compares the relative potency of individual dioxins and furans with that of TCDD, the best-studied member of this chemical class. The concentration or dose of each dioxin and furan is multiplied by its TEF to arrive at a toxic equivalent (TEQ) and the TEQs are added to give the total toxic equivalency.

The total toxic equivalency is then compared to reference exposure levels for TCDD expected to be without significant risk for producing health hazards.

Twelve PCB congeners fall into a category of "dioxin-like" PCBs. Because of their structure and mechanism of action, they exhibit toxic behavior similar to that of chlorinated dibenzo-p-dioxins. However, their toxicity is 0.00001 to 0.1 times lower than the most toxic dioxin, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). A toxic equivalency factor (TEF) approach to evaluating health hazards has been developed and used to some extent to guide public health decisions (see EPA 1996 and ATSDR 2000 for more details). In short, the TEF approach compares the relative potency of individual congeners with that of TCDD, the best-studied member of the dioxin chemical class. The concentration or dose of each dioxin-like congener is multiplied by its TEF to arrive at a toxic equivalent (TEQ), and the TEQs are added to give the total toxic equivalency. The total toxic equivalency is then compared to reference exposure levels for TCDD expected to be without significant risk for producing health hazards.

Some of the exposure doses calculated with the TEQ approach yielded results above non-cancer health guidelines for dioxin. The maximum and average dioxin levels (dioxins/furans + dioxin-like PCBs) for fish exceeded the dioxin MRL and RfD. The average dioxin levels in turtle exceeded the MRL and RfD, and the maximum dioxin levels in turtle exceeded the MRL for children only. The average dioxin levels in duck exceeded the RfD for children only. Although these exposure doses exceeded the dioxin MRL and/or RfD, none exceeded the NOAEL or LOAEL.

The estimated doses for children (4.84×10^{-8} mg/kg/day) and adults (2.21×10^{-8} mg/kg/day) exposed to the highest detected concentration of dioxins (5.42×10^{-6} mg/kg) in biota from the Penobscot River were above ATSDR's minimal risk level (MRL), but one order of magnitude lower than doses in which health effects were observed in animals. The oral health guideline for the most toxic dioxin, TCDD, is based on a study in which health effects were observed in female Rhesus monkeys fed a diet containing 1.2×10^{-7} mg/kg/day of TCDD (Schantz et al. 1992). The estimated exposure doses for fish, turtle, and duck are one to two orders of magnitude lower than this health effects level. Further, dioxins are a well-studied family of compounds, and this dose is the lowest health effects level reported in the 33 chronic-duration studies on TCDD. Therefore, although ATSDR does not expect that eating fish, turtle, and duck with the detected levels of dioxin would cause harmful non-cancer health effects, the possibility cannot be ruled out entirely.

The possible cancer risk indicated that ATSDR should carefully review the toxicology literature to evaluate potential cancer effects. The Department of Health and Human Services (DHHS) has determined that it is reasonable to expect that TCDD may cause cancer. The International Agency for Research on Cancer (IARC) has determined that TCDD can cause cancer in people, but that it is not possible to classify other dioxins as to their carcinogenicity to humans. EPA has determined that TCDD is a probable human carcinogen (ATSDR 1998). The cancer risk levels for the maximum and average levels of dioxin (dioxins/furans + dioxin-like PCBs) found in fish and turtle were above 1×10^{-4}. Cancer risk levels above 1×10^{-4} are of concern, therefore ATSDR cautions that eating fish and turtle at the rates listed in the Scenario over a lifetime could cause an elevated cancer risk.

Appendix C. ToxFAQs for Mercury, Dioxin, and PCBs

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

MERCURY
CAS # 7439-97-6

Agency for Toxic Substances and Disease Registry ToxFAQs April 1999

This fact sheet answers the most frequently asked health questions (FAQs) about mercury. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It's important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to mercury occurs from breathing contaminated air, ingesting contaminated water and food, and having dental and medical treatments. Mercury, at high levels, may damage the brain, kidneys, and developing fetus. This chemical has been found in at least 714 of 1,467 National Priorities List sites identified by the Environmental Protection Agency.

What is mercury?

(Pronounced mŭr′kyə-rē)

Mercury is a naturally occurring metal which has several forms. The metallic mercury is a shiny, silver-white, odorless liquid. If heated, it is a colorless, odorless gas.

Mercury combines with other elements, such as chlorine, sulfur, or oxygen, to form inorganic mercury compounds or "salts," which are usually white powders or crystals. Mercury also combines with carbon to make organic mercury compounds. The most common one, methylmercury, is produced mainly by microscopic organisms in the water and soil. More mercury in the environment can increase the amounts of methylmercury that these small organisms make.

Metallic mercury is used to produce chlorine gas and caustic soda, and is also used in thermometers, dental fillings, and batteries. Mercury salts are sometimes used in skin lightening creams and as antiseptic creams and ointments.

What happens to mercury when it enters the environment?

- Inorganic mercury (metallic mercury and inorganic mercury compounds) enters the air from mining ore deposits, burning coal and waste, and from manufacturing plants.
- It enters the water or soil from natural deposits, disposal of wastes, and volcanic activity.
- Methylmercury may be formed in water and soil by small organisms called bacteria.
- Methylmercury builds up in the tissues of fish. Larger and older fish tend to have the highest levels of mercury.

How might I be exposed to mercury?

- Eating fish or shellfish contaminated with methylmercury.
- Breathing vapors in air from spills, incinerators, and industries that burn mercury-containing fuels.
- Release of mercury from dental work and medical treatments.
- Breathing contaminated workplace air or skin contact during use in the workplace (dental, health services, chemical, and other industries that use mercury).
- Practicing rituals that include mercury.

How can mercury affect my health?

The nervous system is very sensitive to all forms of mercury. Methylmercury and metallic mercury vapors are more harmful than other forms, because more mercury in these forms reaches the brain. Exposure to high levels of metallic, inorganic, or organic mercury can permanently damage the brain, kidneys, and developing fetus. Effects on brain functioning may result in irritability, shyness, tremors, changes in vision or hearing, and memory problems.

Short-term exposure to high levels of metallic mercury vapors may cause effects including lung damage, nausea,

MERCURY
CAS # 7439-97-6

vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation.

How likely is mercury to cause cancer?

There are inadequate human cancer data available for all forms of mercury. Mercuric chloride has caused increases in several types of tumors in rats and mice, and methylmercury has caused kidney tumors in male mice. The EPA has determined that mercuric chloride and methylmercury are possible human carcinogens.

How can mercury affect children?

Very young children are more sensitive to mercury than adults. Mercury in the mother's body passes to the fetus and may accumulate there. It can also can pass to a nursing infant through breast milk. However, the benefits of breast feeding may be greater than the possible adverse effects of mercury in breast milk.

Mercury's harmful effects that may be passed from the mother to the fetus include brain damage, mental retardation, incoordination, blindness, seizures, and inability to speak. Children poisoned by mercury may develop problems of their nervous and digestive systems, and kidney damage.

How can families reduce the risk of exposure to mercury?

Carefully handle and dispose of products that contain mercury, such as thermometers or fluorescent light bulbs. Do not vacuum up spilled mercury, because it will vaporize and increase exposure. If a large amount of mercury has been spilled, contact your health department. Teach children not to play with shiny, silver liquids.

Properly dispose of older medicines that contain mercury. Keep all mercury-containing medicines away from children.

Pregnant women and children should keep away from rooms where liquid mercury has been used.

Learn about wildlife and fish advisories in your area from your public health or natural resources department.

Is there a medical test to show whether I've been exposed to mercury?

Tests are available to measure mercury levels in the body. Blood or urine samples are used to test for exposure to metallic mercury and to inorganic forms of mercury. Mercury in whole blood or in scalp hair is measured to determine exposure to methylmercury. Your doctor can take samples and send them to a testing laboratory.

Has the federal government made recommendations to protect human health?

The EPA has set a limit of 2 parts of mercury per billion parts of drinking water (2 ppb).

The Food and Drug Administration (FDA) has set a maximum permissible level of 1 part of methylmercury in a million parts of seafood (1 ppm).

The Occupational Safety and Health Administration (OSHA) has set limits of 0.1 milligram of organic mercury per cubic meter of workplace air (0.1 mg/m^3) and 0.05 mg/m^3 of metallic mercury vapor for 8-hour shifts and 40-hour work weeks.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological profile for mercury. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

CHLORINATED DIBENZO-p-DIOXINS (CDDs)

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Division of Toxicology and Environmental Medicine ToxFAQs™ **February 1999**

This fact sheet answers the most frequently asked health questions (FAQs) about dibenzo-p-dioxins. For more information, call the ATSDR Information Center at 1-800-232-4636. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because these substances may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to chlorinated dibenzo-p-dioxins (CDDs) (75 chemicals) occurs mainly from eating food that contains the chemicals. One chemical in this group, 2,3,7,8-tetrachlorodibenzo-p-dioxin or 2,3,7,8-TCDD, has been shown to be very toxic in animal studies. It causes effects on the skin and may cause cancer in people. This chemical has been found in at least 91 of the 1,467 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What are CDDs?

CDDs are a family of 75 chemically related compounds commonly known as chlorinated dioxins. One of these compounds is called 2,3,7,8-TCDD. It is one of the most toxic of the CDDs and is the one most studied.

In the pure form, CDDs are crystals or colorless solids. CDDs enter the environment as mixtures containing a number of individual components. 2,3,7,8-TCDD is odorless and the odors of the other CDDs are not known.

CDDs are not intentionally manufactured by industry except for research purposes. They (mainly 2,3,7,8-TCDD) may be formed during the chlorine bleaching process at pulp and paper mills. CDDs are also formed during chlorination by waste and drinking water treatment plants. They can occur as contaminants in the manufacture of certain organic chemicals. CDDs are released into the air in emissions from municipal solid waste and industrial incinerators.

What happens to CDDs when they enter the environment?

- When released into the air, some CDDs may be transported long distances, even around the globe.
- When released in waste waters, some CDDs are broken down by sunlight, some evaporate to air, but most attach to soil and settle to the bottom sediment in water.
- CDD concentrations may build up in the food chain, resulting in measurable levels in animals.

How might I be exposed to CDDs?

- Eating food, primarily meat, dairy products, and fish, makes up more than 90% of the intake of CDDs for the general population.
- Breathing low levels in air and drinking low levels in water.
- Skin contact with certain pesticides and herbicides.
- Living near an uncontrolled hazardous waste site containing CDDs or incinerators releasing CDDs.
- Working in industries involved in producing certain pesticides containing CDDs as impurities, working at paper and pulp mills, or operating incinerators.

How can CDDs affect my health?

The most noted health effect in people exposed to large amounts of 2,3,7,8-TCDD is chloracne. Chloracne is a severe skin disease with acne-like lesions that occur mainly on the face and upper body. Other skin effects noted in people exposed to high doses of 2,3,7,8-TCDD include skin rashes, discoloration, and excessive body hair. Changes in blood and urine that may indicate liver damage also are seen in people. Exposure to high concentrations of CDDs may induce longterm alterations in glucose metabolism and subtle changes in hormonal levels.

In certain animal species, 2,3,7,8-TCDD is especially harmful and can cause death after a single exposure. Exposure to lower levels can cause a variety of effects in animals, such as weight loss, liver damage, and disruption of the endocrine system. In many species of animals, 2,3,7,8-TCDD weakens the immune system and causes a decrease in the system's ability to fight bacteria and viruses. In other animal studies, exposure to 2,3,7,8-TCDD has caused reproductive damage and birth defects. Some animal species exposed to CDDs during pregnancy had miscarriages and the offspring of animals exposed to 2,3,7,8-TCDD during pregnancy often had severe birth defects including skeletal deformities, kidney defects, and weakened immune responses.

How likely are CDDs to cause cancer?

Several studies suggest that exposure to 2,3,7,8-TCDD increases the risk of several types of cancer in people. Animal studies have also shown an increased risk of cancer from exposure to 2,3,7,8-TCDD.
The World Health Organization (WHO) has determined that 2,3,7,8-TCDD is a human carcinogen.
The Department of Health and Human Services (DHHS) has determined that 2,3,7,8-TCDD may reasonably be anticipated to cause cancer.

How can CDDs affect children?

Very few studies have looked at the effects of CDDs on children. Chloracne has been seen in children exposed to high levels of CDDs. We don't know if CDDs affect the ability of people to have children or if it causes birth defects, but given the effects observed in animal studies, this cannot be ruled out.

How can families reduce the risk of exposure to CDDs?

- Children should avoid playing in soils near uncontrolled hazardous waste sites.
- Discourage children from eating dirt or putting toys or other objects in their mouths.
- Everyone should wash hands frequently if playing or working near uncontrolled hazardous waste sites.
- For new mothers and young children, restrict eating foods from the proximity of uncontrolled sites with known CDDs.
- Children and adults should eat a balanced diet preferably containing low to moderate amounts of animal fats including meat and dairy products, and fish that contain lower amounts of CDDs and eat larger amounts of fruits, vegetables, and grains.

Is there a medical test to determine whether I've been exposed to CDDs?

Tests are available to measure CDD levels in body fat, blood, and breast milk, but these tests are not routinely available. Most people have low levels of CDDs in their body fat and blood, and levels considerably above these levels indicate past exposure to above-normal levels of 2,3,7,8-TCDD. Although CDDs stay in body fat for a long time, tests cannot be used to determine when exposure occurred.

Has the federal government made recommendations to protect human health?

The EPA has set a limit of 0.00003 micrograms of 2,3,7,8-TCDD per liter of drinking water (0.00003 μg/L). Discharges, spills, or accidental releases of 1 pound or more of 2,3,7,8-TCDD must be reported to EPA. The Food and Drug Administration (FDA) recommends against eating fish and shellfish with levels of 2,3,7,8-TCDD greater than 50 parts per trillion (50 ppt).

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1998. Toxicological Profile for Chlorinated Dibenzo-p-Dioxins. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology and Environmental Medicine, 1600 Clifton Road NE, Mailstop F-62, Atlanta, GA 30333. Phone: 1-800-232-4636, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html. ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

POLYCHLORINATED BIPHENYLS

Division of Toxicology ToxFAQs™ **February 2001**

This fact sheet answers the most frequently asked health questions (FAQs) about polychlorinated biphenyls. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It's important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Polychlorinated biphenyls (PCBs) are a mixture of individual chemicals which are no longer produced in the United States, but are still found in the environment. Health effects that have been associated with exposure to PCBs include acne-like skin conditions in adults and neurobehavioral and immunological changes in children. PCBs are known to cause cancer in animals. PCBs have been found in at least 500 of the 1,598 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What are polychlorinated biphenyls?

Polychlorinated biphenyls are mixtures of up to 209 individual chlorinated compounds (known as congeners). There are no known natural sources of PCBs. PCBs are either oily liquids or solids that are colorless to light yellow. Some PCBs can exist as a vapor in air. PCBs have no known smell or taste. Many commercial PCB mixtures are known in the U.S. by the trade name Aroclor.

PCBs have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because they don't burn easily and are good insulators. The manufacture of PCBs was stopped in the U.S. in 1977 because of evidence they build up in the environment and can cause harmful health effects. Products made before 1977 that may contain PCBs include old fluorescent lighting fixtures and electrical devices containing PCB capacitors, and old microscope and hydraulic oils.

What happens to PCBs when they enter the environment?

- ❑ PCBs entered the air, water, and soil during their manufacture, use, and disposal; from accidental spills and leaks during their transport; and from leaks or fires in products containing PCBs.
- ❑ PCBs can still be released to the environment from hazardous waste sites; illegal or improper disposal of industrial wastes and consumer products; leaks from old electrical transformers containing PCBs; and burning of some wastes in incinerators.
- ❑ PCBs do not readily break down in the environment and thus may remain there for very long periods of time. PCBs can travel long distances in the air and be deposited in areas far away from where they were released. In water, a small amount of PCBs may remain dissolved, but most stick to organic particles and bottom sediments. PCBs also bind strongly to soil.
- ❑ PCBs are taken up by small organisms and fish in water. They are also taken up by other animals that eat these aquatic animals as food. PCBs accumulate in fish and marine mammals, reaching levels that may be many thousands of times higher than in water.

How might I be exposed to PCBs?

- ❑ Using old fluorescent lighting fixtures and electrical devices and appliances, such as television sets and refrigerators, that were made 30 or more years ago. These items may leak small amounts of PCBs into the air when they get hot during operation, and could be a source of skin exposure.
- ❑ Eating contaminated food. The main dietary sources of PCBs are fish (especially sportfish caught in contaminated lakes or rivers), meat, and dairy products.
- ❑ Breathing air near hazardous waste sites and drinking contaminated well water.
- ❑ In the workplace during repair and maintenance of PCB transformers; accidents, fires or spills involving transformers, fluorescent lights, and other old electrical devices; and disposal of PCB materials.

How can PCBs affect my health?

The most commonly observed health effects in people exposed to large amounts of PCBs are skin conditions such as acne and rashes. Studies in exposed workers have shown changes in blood and urine that may indicate liver damage. PCB exposures in the general population are not likely to result in skin and liver effects. Most of the studies of health effects of PCBs in the general population examined children of mothers who were exposed to PCBs.

Animals that ate food containing large amounts of PCBs for short periods of time had mild liver damage and some died. Animals that ate smaller amounts of PCBs in food over several weeks or months developed various kinds of health effects, including anemia; acne-like skin conditions; and liver, stomach, and thyroid gland injuries. Other effects

POLYCHLORINATED BIPHENYLS

of PCBs in animals include changes in the immune system, behavioral alterations, and impaired reproduction. PCBs are not known to cause birth defects.

How likely are PCBs to cause cancer?

Few studies of workers indicate that PCBs were associated with certain kinds of cancer in humans, such as cancer of the liver and biliary tract. Rats that ate food containing high levels of PCBs for two years developed liver cancer. The Department of Health and Human Services (DHHS) has concluded that PCBs may reasonably be anticipated to be carcinogens. The EPA and the International Agency for Research on Cancer (IARC) have determined that PCBs are probably carcinogenic to humans.

How can PCBs affect children?

Women who were exposed to relatively high levels of PCBs in the workplace or ate large amounts of fish contaminated with PCBs had babies that weighed slightly less than babies from women who did not have these exposures. Babies born to women who ate PCB-contaminated fish also showed abnormal responses in tests of infant behavior. Some of these behaviors, such as problems with motor skills and a decrease in short-term memory, lasted for several years. Other studies suggest that the immune system was affected in children born to and nursed by mothers exposed to increased levels of PCBs. There are no reports of structural birth defects caused by exposure to PCBs or of health effects of PCBs in older children. The most likely way infants will be exposed to PCBs is from breast milk. Transplacental transfers of PCBs were also reported In most cases, the benefits of breast-feeding outweigh any risks from exposure to PCBs in mother's milk.

How can families reduce the risk of exposure to PCBs?

❑ You and your children may be exposed to PCBs by eating fish or wildlife caught from contaminated locations. Certain states, Native American tribes, and U.S. territories have issued advisories to warn people about PCB-contaminated fish and fish-eating wildlife. You can reduce your family's exposure to PCBs by obeying these advisories.
❑ Children should be told not play with old appliances, electrical equipment, or transformers, since they may contain PCBs.
❑ Children should be discouraged from playing in the dirt near hazardous waste sites and in areas where there was a transformer fire. Children should also be discouraged from eating dirt and putting dirty hands, toys or other objects in their mouths, and should wash hands frequently.
❑ If you are exposed to PCBs in the workplace it is possible to carry them home on your clothes, body, or tools. If this is the case, you should shower and change clothing before leaving work, and your work clothes should be kept separate from other clothes and laundered separately.

Is there a medical test to show whether I've been exposed to PCBs?

Tests exist to measure levels of PCBs in your blood, body fat, and breast milk, but these are not routinely conducted. Most people normally have low levels of PCBs in their body because nearly everyone has been environmentally exposed to PCBs. The tests can show if your PCB levels are elevated, which would indicate past exposure to above-normal levels of PCBs, but cannot determine when or how long you were exposed or whether you will develop health effects.

Has the federal government made recommendations to protect human health?

The EPA has set a limit of 0.0005 milligrams of PCBs per liter of drinking water (0.0005 mg/L). Discharges, spills or accidental releases of 1 pound or more of PCBs into the environment must be reported to the EPA. The Food and Drug Administration (FDA) requires that infant foods, eggs, milk and other dairy products, fish and shellfish, poultry and red meat contain no more than 0.2-3 parts of PCBs per million parts (0.2-3 ppm) of food. Many states have established fish and wildlife consumption advisories for PCBs.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 770-488-4178. ToxFAQs™ Internet address is http://www.atsdr.cdc.gov/toxfaq.html . ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

FOR MORE INFORMATION

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

You may also contact:

U.S. Environmental Protection Agency
Office of Water
Fish Contamination Program (4305)
401 M Street, SW
Washington, DC 20460

email address: www.epa.gov/ost/fishadvice

This brochure may be reproduced without EPA permission at no charge.

Printed on recycled paper

United States Environmental Protection Agency
Office of Science and Technology (4305)
EPA 823-B-97-009
September 1997

Should I Eat the Fish I Catch?

A guide to healthy eating of the fish you catch

Developed in collaboration with the Agency for Toxic Substances and Disease Registry, U.S. Public Health Service

INTRODUCTION

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

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

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

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

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

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

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

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

Health Note

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

CATCHING FISH

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

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

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

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

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

Health Note

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

Do some fish contain more pollutants than others?

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

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

CLEANING FISH

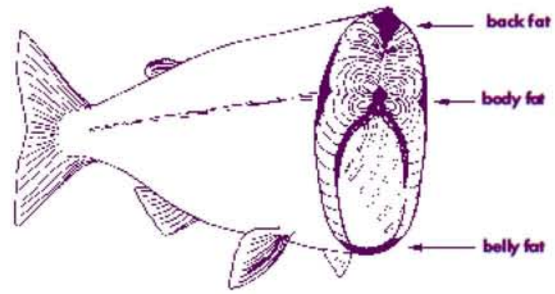
Can I clean my fish to reduce the amount of chemical pollutants that might be present?

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

As an added precaution:

- Remove and throw away the head, guts, kidneys, and the liver.
- Fillet fish and cut away the fat and skin before you cook it.
- Clean and dress fish as soon as possible.

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



Health Note

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

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

COOKING FISH

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

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

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

Appendix E. Regional Applied Research Effort (RARE) Team

United States Environmental Protection Agency

Robert Hillger, US EPA Senior Science Advisor
RARE Project Role: RARE Program Coordinator
New England Regional Laboratory
11 Technology Dr.
North Chelmsford, MA 01863
(617) 918-8660
Hillger.Robert@epa.gov

Valerie Marshall, US EPA Region 1
RARE Project Role: Project Leader and QAPP Approver
EPA Boston, MA
(617) 918-1674
Marshall.Valerie@epa.gov

Janet J. Diliberto, Research Biologist
RARE Project Role: Project Leader and QAPP Approver
USEPA/ORD/NHEERL/ISTD; Office B458
109 TW Alexander Drive, Mail Drop B105-01
Research Triangle Park, NC 27711
(919) 541-7921; FAX: (919) 541-9464
Diliberto.Janet@epa.gov

Linda S. Birnbaum, US EPA Senior Toxicologist
RARE Project Role: Project Leader and QAPP Approver
DIRECTOR, National Institute of Environmental Health Sciences (NIEHS) National Institutes of Health (NIH) and National Toxicology Program (NTP)
Mail Drop B2-01
P.O. Box 12233
Research Triangle Park, NC 27709
(919) 541-3201
birnbaumls@niehs.nih.gov

Thomas Hughes, US EPA, QA and Records Manager
RARE Project Role: QA Officer and Records Manager and QAPP Approver
EPA/ORD/NHEERL/RCU
109 TW Alexander Drive, Mail Drop B105-01
Research Triangle Park, NC 27711
(919) 541-7644
Hughes.Thomas@epa.gov

David M. DeMarini, Toxicologist
RARE Project Role: Mutagenicity Study
USEPA/ORD/NHEERL/ISTD
109 TW Alexander Drive, Mail Drop B105-03
Research Triangle Park, NC 27711
(919) 541-1510
Demarini.David@epa.gov

Sarah H. Warren
RARE Project Role: Mutagenicity Study
USEPA/ORD/NHEERL/ISTD
109 TW Alexander Drive, Mail Drop B105-03
Research Triangle Park, NC 27711
(919) 541-0975
Warren.Sarah@epa.gov

Adam Swank
RARE Project Role: Mutagenicity Study
USEPA/ORD/NHEERL/RCU
109 TW Alexander Drive, Mail Drop B105-01
Research Triangle Park, NC 27711
(919) 541-0614
Swank.Adam@epa.gov

Steve DiMattei, US EPA, QA Chemist Region 1
RARE Project Role: QA Officer, QAPP Approver, and Region 1 QA contact
New England Regional Laboratory
11 Technology Drive
North Chelmsford, MA 01863
(617) 918-8369
dimattei.steve@epa.gov

Dave McDonald, US EPA, Biology Laboratory Manager
RARE Project Role: Biology QA Officer for US EPA NERL, QAPP Reviewer
New England Regional Laboratory
11 Technology Dr.
North Chelmsford, MA 01863
(617) 918-8609; FAX (617) 918-8509
mcdonald.dave@epa.gov

Joseph Ferrario, US EPA, Lab Director/Dioxin Team Leader
RARE Project Role: Leader of OPP/Stennis dioxins, furans, WHO PCBs; QAPP Reviewer, Lab Contact for RARE Project
EPA/Office of Pesticide Programs, Biological and Economic Analysis Division, Environmental Chemistry Branch
NASA/SSC Building 1105
Stennis Space Center, MS 39529-6000
(228) 688-3171/3212
ferrario.joseph@epa.gov

Christian Byrne, US EPA-OPP Quality Assurance Officer
RARE Project Role: OPP Data Approval; QAPP Reviewer
EPA/OPP/BEAD/ECB
NASA/SSC Bldg 1105
Stennis Space Center, MS 39529-6000
(228) 688-3213
Byrne.Christian@epa.gov

Craig Vigo, Mass Spectrometrist
RARE Project Role: Chemical Analysis
EPA/OPP/BEAD/ECB
Stennis Space Center, MS 39529-6000
(228) 688-1229
Vigo.Craig@epa.gov

Tripp Boone, Safety Officer/ Sample Prep Coordinator
RARE Project Role: Sample Custodian for samples shipped to US EPA-OPP Stennis.
EPA/OPP/BEAD/ECB
Stennis Space Center, MS 39529-6000
(228) 688-2242
Boone.Tripp@epa.gov

Stanley Mecomber
RARE Project Role: Sample Custodian
EPA/OPP/BEAD/ECB
Stennis Space Center, MS 39529-6000
(228) 688-3172/3212
mecomber.stanley@epa.gov

Steve Stodola, US EPA, QA Chemist
RARE Project Role: Data validation.
US EPA -NERL, OEME
11 Technology Drive
North Chelmsford, MA 01863
(617) 918-8634
stodola.steve@epa.gov

Alan VanArsdale, Direct Mercury Analyzer (DMA)
RARE Project Role: Responsible for scheduling and analyzing samples for mercury analysis using the Direct Mercury Analyzer (DMA).
New England Regional Laboratory
11 Technology Dr.
North Chelmsford, MA 01863
(617) 918-8610
vanarsdale.alan@epa.gov

ESAT

ESAT or Technician from Narragansett Lab
RARE Project Role: Fish processing with field team
Wannalancit Mills Technology Park
175 Cabot Street, Suite 415
Lowell, MA 01854
(978) 275-9730

TechLaw, Inc.

RARE Project Role: Data Validation
Wannalancit Mills Technology Park
175 Cabot Street, Suite 415
Lowell, MA 01854
(978) 275-9730

Penobscot Indian Nation Department of Natural Resources

Daniel H. Kusnierz, PIN-DNR, Water Resources Program Manager
RARE Project Role: RARE PIN-DNR Leader; Assist in field sampling; QAPP Review
Penobscot Indian Nation – DNR
12 Wabanaki Way
Indian Island, Old Town, ME 04468
(207) 817-7361 or (207) 827-7776 ext. 7361
DKusnierz@penobscotnation.org

Jason Mitchell, PIN DNR, Water Resources Field Coordinator
RARE Project Role: Assist with sampling
Penobscot Indian Nation – DNR
12 Wabanaki Way
Indian Island, Old Town, ME 04468
(207) 817-7381
jmitchell@penobscotnation.org

Jan Paul, PIN DNR Water Resources Field/Lab Technician
RARE Project Role: Assist with sampling
Penobscot Indian Nation – DNR
12 Wabanaki Way
Indian Island, Old Town, ME 04468
(207) 817-7382
janpaul@penobscotnation.org

Kristin Peet, PIN DNR Wildlife Biologist
RARE Project Role: Assist with collecting ducks and other sampling
Penobscot Indian Nation – DNR
12 Wabanaki Way
Indian Island, Old Town, ME 04468
(207) 817-7363
kpeet@penobscotnation.org

Frontier GeoSciences, Inc.

Matthew Gomes
RARE Project Role: FGS Project Manager
Frontier GeoSciences, Inc.
414 Pontius Ave. N
Seattle, WA 98109
(206) 622-6960 x 1449
mattg@frontiergeosciences.com

Patrick Garcia Strickland
RARE Project Role: FGS Lab Manager
Frontier GeoSciences, Inc.
414 Pontius Ave. N
Seattle, WA 98109
(206) 622-6960 x 1428
patricks@frontiergeosciences.com

Ryan Nelson
RARE Project Role: FGS Lab Mercury Group Leader
Frontier GeoSciences, Inc.
414 Pontius Ave. N
Seattle, WA 98109
(206) 622-6960 x 2012
ryann@frontiergeosciences.com

Kristina Spadafora
RARE Project Role: FGS QA Officer
Frontier GeoSciences, Inc.
414 Pontius Ave. N
Seattle, WA 98109
(206) 622-6960 x 1423
kristinas@frontiergeosciences.com

United States Geological Survey

Robert W. Dudley, USGS, Hydrologist
RARE Project Role: Field Sampling Leader; QAPP Review
USGS Maine Water Science Center
196 Whitten Road
Augusta ME 04330
(207) 622-8201 ext. 115
rwdudley@usgs.gov

Charles Culbertson
USGS Maine Water Science Center
196 Whitten Road
Augusta, ME 04330
(207) 622-8201 ext. 127

James Caldwell
USGS Maine Water Science Center
196 Whitten Road
Augusta, ME 04330
(207) 622-8201 ext. 107

Robert M. Lent, USGS, Director of Maine Water Science Center
RARE Project Role: USGS Field Sampling Project Manager, review sampling method SOPs, QAPP Review
USGS Maine Water Science Center
196 Whitten Road
Augusta ME 04330
(207) 622-8201 ext. 102
rmlent@usgs.gov

Carl E. Orazio, PhD. USGS-CERC Branch Chief Environmental Chemistry
RARE Project Role: USGS Project Officer (CERC/USGS US EPA IAG); QAPP Preparation; Review Analytical Methods SOPs, CERC USGS Lab Contact: Congener-specific PCB and Mercury analyses
USGS Columbia Environmental Research Center (CERC)
4200 New Haven Road
Columbia, MO 65201
(573) 876-1823
corazio@usgs.gov

Robert Gale, PhD. USGS/CERC Leader Environmental Fate and Dynamics
RARE Project Role: Supervisor of congener-specific PCB analysis
USGS Columbia Environmental Research Center (CERC)
4200 New Haven Road
Columbia, MO 65201
(573) 875-5399

Kathy Echols, PhD. USGS/CERC Leader Complex Contaminant Mixtures
RARE Project Role: Review of congener-specific PCB analysis
USGS Columbia Environmental Research Center (CERC)
4200 New Haven Road
Columbia, MO 65201
(573) 875-5399

John Meadows, USGS/CERC, Dioxin and PCB Chemist
RARE Project Role: Conduct congener-specific PCB analysis
USGS Columbia Environmental Research Center (CERC)
4200 New Haven Road
Columbia, MO 65201
(573) 875-5399

George Tegerdine, USGS/CERC, PCB congener analysis technician,
RARE Project Role: Conduct congener-specific PCB GC analysis
USGS Columbia Environmental Research Center (CERC)
4200 New Haven Road
Columbia, MO 65201
(573) 875-5399

Tom May, USGS/CERC Leader Toxic Element Research
RARE Project Role: Supervisor of Total-Mercury Analysis
USGS Columbia Environmental Research Center (CERC)
4200 New Haven Road
Columbia, MO 65201
(573) 876-1858

William Brumbaugh, USGS/CERC Research Chemist
RARE Project Role: Mercury Analysis expert and methods reviewer
USGS USGS Columbia Environmental Research Center (CERC)
4200 New Haven Road
Columbia, MO 65201
(573) 876-1857

Paul Peterman, USGS/CERC Trace Organic Contaminants Research Chemist
RARE Project Role: Dioxin and PCB analysis expert and methods reviewer
USGS Columbia Environmental Research Center (CERC)
4200 New Haven Road
Columbia, MO 65201
(573) 875-5399
ppeterman@usgs.gov

Kevin Feltz, USGS/CERC Trace Organic Contaminants Chemist
RARE Project Role: Dioxin and PCB Analysis expert and methods reviewer
USGS Columbia Environmental Research Center (CERC)
4200 New Haven Road
Columbia, MO 65201
(573) 875-5399

Michael Walther, USGS/CERC Technician
RARE Project Role: Total-Mercury Analysis
USGS Columbia Environmental Research Center (CERC)
4200 New Haven Road
Columbia, MO 65201
(575) 875-5399

Jesse Arms, USGS technician, sample receiving
RARE Project Role: sample receiving
USGS Columbia Environmental Research Center (CERC)
4200 New Haven Road
Columbia, MO 65201
(575) 876-1856

Paul Heine, USGS CERC QA Officer
USGS Columbia Environmental Research Center (CERC)
4200 New Haven Road
Columbia, MO 65201
(573) 876-1815

Bureau of Indian Affairs

Christina Stringer, Eastern Regional Hydrologist
Bureau of Indian Affairs
545 Marriott Drive, Suite 700
Nashville, TN 37124
(615) 564-6838; FAX: (615) 564-6571

Kelly Gupton, Water Resources
RARE Project Role: Representative of BIA
Bureau of Indian Affairs
Eastern Regional Office
545 Marriott Drive, Suite 700
Nashville, TN 37214
(615) 564-6838; FAX (615) 564-6571

United State Fish & Wildlife Services

Steve Mierzykowski, Senior Fish & Wildlife Biologist
U.S. Fish & Wildlife Service
17 Godfrey Drive, Suite #2
Orono, ME 04473
Office: (207) 866-3344 ext. 112; Cell: (207) 944-3007; Fax: (207) 866-3351
steve_mierzykowski@fws.gov

Adria Elskus, USGS Research Fishery Biologist; Aquatic Toxicology
University of Maine
School of Biology & Ecology
5751 Murray Hall
Orono, ME 04469-5751
(207) 581-2579; FAX (207)581-2537
aelskus@usgs.gov