BRAIN FOOD

What women should know about mercury contamination of fish

Jeremiah Baumann
Julie Wolk
The State PIRGs

Jane Houlihan
Richard Wiles
Environmental Working Group™

Acknowledgments

This report was written by Jane Houlihan and Richard Wiles of the Environmental Working Group and Julie Wolk and Jeremiah Baumann of the U.S. Public Interest Research Group Education Fund, with research contributions from Graham Porell. Thanks to John Coequyt and Chris Campbell for their assistance on report production. This report was reviewed by Philip J. Landrigan, MD, M.Sc., Director of the Center for Children's Health and the Environment of the Mount Sinai School of Medicine, J. Routt Reigart, II MD of the Medical University of South Carolina, and Robert A. Goyer, MD, Chair, Committee on the Toxicological Effects of Mercury, National Research Council 1999 - 2000.

This report was made possible by a grant from The Pew Charitable Trusts. Environmental Working Group also used funding from W. Alton Jones, the Joyce Foundation, and the Turner Foundation. The U.S. PIRG Education Fund's toxics, right-to-know, and other environmental health programs are additionally supported by the Bauman Foundation and the Beldon Fund. The opinions expressed in this report are those of the authors and do not necessarily reflect the views of funders.

Copyright © April 2001 by Environmental Working Group. All rights reserved. Manufactured in the United States of America. *Printed on recycled paper.*

Environmental Working Group

The Environmental Working Group (EWG) is a nonprofit environmental research organization based in Washington, D.C. Through analysis of government and private sector databases, environmental monitoring programs, and scientifically grounded research, EWG develops high-profile publications, computer databases and Internet resources that consistently create public awareness and concern about high priority environmental problems and solutions.

Kenneth A. Cook, President
Richard Wiles, Senior Vice President
Mike Casey, Vice President for Public Affairs
Anne Keys, Vice President for Policy

U.S. PIRG Education Fund and the State PIRGs

The U.S. PIRG Education Fund is the research and public education center for the U.S. Public Interest Research Group (U.S. PIRG), the national advocacy office of the State PIRGs. The State PIRGs are a nationwide network of nonprofit, nonpartisan, state-based public interest advocacy organizations. Through U.S. PIRG and the U.S. PIRG Education Fund, they promote a national agenda of environmental and consumer protection and good government.

Gene Karpinski, Executive Director
Liz Hitchcock, Communications Director
Kimberly Larson, Assistant Field Director
Jeremiah Baumann, Environmental Health Advocate
Julie Wolk, Environmental Health Associate

To order a copy

Copies of this report may be ordered for $25.00 each (plus 6% sales tax or $1.50 for Washington, DC residents) and $3.00 for postage and handling. Payment must accompany all orders. Please make checks payable to either:

Environmental Working Group
1718 Connecticut Avenue, N.W. Suite 600
Washington, D.C. 20009
(202) 667-6982 (phone)
(202) 232-2592 (fax)

U.S. PIRG Education Fund
218 D St. SE
Washington, DC 20003

Contents

Foreword

Fish is beyond compare as a source of many nutrients vital to the developing infant, some of which may actually enhance development of the nervous system in babies and young children.

Widespread contamination of fish with toxic mercury, however, has cast a shadow over the nutritional benefits of fish.

Exposure to mercury in the womb can cause learning deficits, delay the mental development of children, and cause other neurological problems. Mercury consumed by a pregnant woman through contaminated fish can cross her placenta to damage the brain of her baby. As a National Academy of Sciences panel definitively warned last year, some children exposed in utero by their mothers' fish consumption are at risk of falling in the group of children "who have to struggle to keep up in school and who might require remedial classes of special education."

Combustion in power plants of coal containing mercury is the major source of environmental pollution. Mercury pollution from coal-fired power plants moves through the air, is deposited in water and finds its way into fish, accumulating especially in fish that are higher up the food chain. Fish like tuna, sea bass, marlin and halibut show some of the worst contamination, but dozens of species and thousands of water bodies have been seriously polluted.

As a result, women who eat a lot of fish during pregnancy, or even as little as a single serving of a highly contaminated fish, can expose their developing child to excessive levels of mercury. The toxic metal can cross the placenta to harm the rapidly developing nervous system, including the brain.

In this report, EWG researchers for the first time attempt to characterize just how common such exposures are in the U.S. population, and the associated risks. One key to the analysis is a much more refined representation of differences among women – their size, metabolism of mercury, blood volume, and many other biological variables. Government assessments use "averages" or constants for all of these factors, missing profound differences across the population of women of child bearing age.

EWG analysts also assembled the most extensive database ever developed on mercury levels in various species of fish, drawing on federal, state and other government sources, some 56,000 records in all. That exercise revealed major variations in mercury contamination across fish species, yielding vital, highly practical information women can use while pregnant to reduce mercury exposure dramatically, while still enjoying the nutritional benefits of fish. Earlier this year, the Food and Drug Administration came up with its own list of fish that pregnant and nursing women, along with infants, should avoid. Based on our analysis of much more extensive fish contamination records, the list presented in this report is more complete.

By analyzing these two data sources in combination, the study is able to provide new insights into how women can avoid excessive mercury exposures during pregnancy.

Researchers at U.S. PIRG Education Fund, co-authors of this study, made another vital contribution. PIRG painstakingly combed through hundreds of "fish advisories" issued by state agencies to warn people about mercury levels in sport and game fish in literally thousands of U.S. lakes and rivers. What they found is disturbing: while some states are doing a better job than others, virtually no fish advisories for mercury contamination are adequately protective of human health when judged against current scientific knowledge.

The importance of this new understanding about mercury risks was evidenced in a landmark study on blood levels of mercury and other toxins, released by the federal Centers for Disease Control and Prevention (CDC) in March, 2001. While "average" blood mercury levels among women were not of concern, the data indicate that in fully 10 percent of American women —roughly 7 million women—mercury levels were above the dose that may put a fetus at risk for adverse nervous system effects. Those women surely don't need *more* mercury in their system, least of all if they are already pregnant or nursing. As this report recommends, the government must start monitoring such exposures, and any possible effects, much more energetically. This is a simple, common sense matter of public health.

In the longer term, the solution is to halt mercury pollution from coal-burning power plants and other sources so the contamination of fish is avoided in the first place. Fuel switching—from coal to renewable energy sources—along with aggressive deployment of conservation measures, makes sense for any number of reasons. Fish free of mercury—the way they used to be—is just another one.

Kenneth A. Cook
President
Environmental Working Group

Executive Summary

On January 12, 2001, government health officials issued new advisories warning women to limit fish consumption during pregnancy to avoid exposing their unborn children to unsafe levels of methylmercury. Methylmercury can cross the placenta and cause learning deficits and developmental delays in children who are exposed even to relatively low levels in the womb. The principal exposure route for the fetus is fish consumption by the mother.

The Food and Drug Administration (FDA), which regulates commercially sold fish, recommends that pregnant and nursing women and young children not eat any shark, swordfish, tilefish, or king mackerel, but then recommends 12 ounces per week of any other fish. The Environmental Protection Agency (EPA), which makes recommendations to states about safe mercury levels in sport fish, allows up to 8 ounces of any fish per week for pregnant women with no prohibitions on consumption of any individual fish caught recreationally.

These restrictions are steps in the right direction, but they need to be tightened significantly to adequately protect women and their unborn children from the toxic effects of methylmercury.

The nutritional benefits of fish complicate the task faced by health officials when protecting the public from methylmercury. Protein, omega-3 fatty acids, Vitamin D, and other nutrients make fish an exceptionally good food for pregnant mothers and their developing babies. At the same time, there is no doubt that methylmercury is toxic to the fetal brain and nervous system, and that many beneficial fish species are contaminated. EPA's safe exposure estimate for methylmercury has dropped twice in the past 16 years, as new science has identified adverse effects in children exposed in the womb at lower and lower doses. Emerging evidence indicates that the safe dose may drop even lower in the future (NAS 2000). Just how long a fetus can tolerate a dose of methylmercury above a "safe level" with no observable adverse effects is a matter of ongoing debate.

Compounding this uncertainty is the lack of effective education and outreach to pregnant women about methylmercury risks and the near total absence of information for pregnant women on the levels of mercury in the fish they buy. New data from the Centers for Disease Control and Prevention (CDC) show that about 10 percent of all women of childbearing age have blood methylmercury levels above the dose that may put their fetus at risk for adverse neurological effects (CDC 2001). If these women were to increase their consumption of certain

New data from the Centers for Disease Control and Prevention (CDC) show that about 10 percent of all women of childbearing age have blood methylmercury levels above the dose that may put their fetus at risk for adverse neurological effects.

If these women were to increase their consumption of certain fish species in hopes of benefiting their babies during pregnancy, they could expose their fetuses to potentially hazardous levels of methylmercury.

fish species in hopes of benefiting their babies during pregnancy, they could expose their fetuses to potentially hazardous levels of methylmercury.

FDA's protections fall short

FDA's methylmercury safeguards are designed to protect an average-sized woman eating an average fish contaminated with an average amount of methylmercury that decays in her body at an average rate. These assumptions rarely apply to the risks faced by any individual. Instead, risks are unevenly distributed throughout the population, with a small but significant number of pregnancies exposed to far higher and potentially unsafe levels of methylmercury than the average fetus. The 10 percent most-heavily exposed American women already have blood methylmercury levels that would increase health risks to their fetuses if they became pregnant (CDC 2001). FDA's health advisory, based on average exposures, does little to protect these children.

FDA's methylmercury safeguards are designed to protect an average-sized woman eating an average fish contaminated with an average amount of methylmercury that decays in her body at an average rate. These assumptions rarely apply to the risks faced by any individual.

The Environmental Working Group assessed fetal exposure to methylmercury taking into account a host of real world differences in individual exposure, including a mother's body weight and blood volume, varying methylmercury absorption and distribution rates, and variable rates of methylmercury decay in different pregnant women (Stern 1997, CDC 2001, NAS 2000). These biological differences were matched up with a unique database of fish contamination that contains 56,000 records of methylmercury test results from seven different government sources. Fish consumption, fish contamination levels, and biological variables were matched thousands of times to create a distribution of blood methylmercury levels in women similar to that occurring in the general population.

This distribution was compared to the benchmark dose of methylmercury recommended by the Committee on the Toxicological Effects of Methylmercury of the National Academy of Sciences (NAS 2000).

Conclusions

EWG's analysis shows that:

- FDA's recommendation of 76 6-ounce fish meals during pregnancy could actually be detrimental to the health of unborn children. Fish are an important part of a healthy diet and women should be encouraged to eat fish with low methylmercury levels during pregnancy. But if American women ate a varied diet of FDA's recommended 12 ounces of fish a week (and none of the four prohibited fish) they would expose more than one-fourth of all babies born each year (1 million infants) to a potentially harmful dose of methylmercury for at least one month during pregnancy. About 20,000 of these children would be exposed to a dose of methylmercury that increases the risk of adverse neurological effects for the entire pregnancy.

The EPA and state fish advisories for sport fish

EPA provides guidance on safe methylmercury exposure levels to state officials who in turn issue consumption advisories for sport fish caught by recreational anglers. State authorities typically post fish advisories for individual water bodies where fish are contaminated with methylmercury at a level that they deem unsafe for women of childbearing age.

Some states have done a better job than others in protecting their populations from methylmercury, but an analysis by U.S. PIRG and the State PIRGs shows that only Massachusetts has adopted health safeguards that protect all women and children.

The broader issue with recreational fish, however, is whether these advisories translate into conscious choices by pregnant mothers to avoid eating contaminated fish. There is a substantial body of evidence indicating that they do not (Golden et al 2001).

Recommendations

Fish provide important health benefits to the developing fetus, and pregnant women should be encouraged to eat fish with consistently low methylmercury levels. With too many species, however, these nutritional pluses are outweighed by the hazards of methylmercury.

Federal health authorities need to take much stronger steps to protect a far greater portion of the population. They must move beyond their antiquated safeguards designed to protect an average woman from an average amount of methylmercury in fish and take a realistic and protective stance against dietary exposure to methylmercury.

Fish advisories

FDA

There are three ways that the FDA methylmercury health advisory must be improved:

1. The list of fish to avoid during pregnancy must be expanded. By advising against the consumption of just four types of fish, FDA allows heavy consumption of many fish that have unacceptably high methylmercury levels. To protect women and their babies from methylmercury, the FDA must add the following species to the list of seafood that should not be eaten by pregnant women, nursing women, and women considering pregnancy:

Tuna steaks
Sea bass
Oysters (Gulf of Mexico)
Marlin
Halibut
Pike
Walleye
White croaker
Largemouth bass

While not every serving of any of these fish is contaminated with dangerous levels of methylmercury, the odds are greater than one in 1,000 that consumption of a single meal of these fish will expose the fetus to a potentially hazardous amount of methylmercury for longer than 30 days.

2. FDA's recommendation that pregnant women eat 12 ounces a week of any fish (except the four that are not allowed) must be radically revised. Ten percent of American women enter pregnancy with elevated methylmercury levels, and current FDA safeguards, which

If American women ate a varied diet of FDA's recommended 12 ounces of fish a week (and none of the four prohibited fish) they would expose more than one fourth of all fetuses (one million babies) to a potentially harmful dose of methylmercury for at least one month during pregnancy.

The issue with recreational fish is whether advisories translate into conscious choices by pregnant mothers to avoid eating contaminated fish. There is a substantial body of evidence indicating that they do not.

Ten percent of American women enter pregnancy with elevated mercury levels, and current FDA safeguards, which are based on average exposures, do almost nothing to protect these high exposure pregnancies.

are based on average exposures, do almost nothing to protect these high exposure pregnancies. If these women follow FDA's advice of 12 ounces of any fish a week, they could easily expose their fetuses to a level of methylmercury that presents a real risk of adverse neurological effects. To protect women and children, FDA must restrict consumption of the following fish to no more than one meal per month, for all species combined:

Canned tuna
Mahi mahi
Blue mussels
Eastern oyster
Cod
Pollock
Salmon from the Great Lakes
Blue crab from the Gulf of Mexico
Channel catfish (wild)
Lake whitefish

3. Women who want to eat fish during pregnancy must have information about which species are least contaminated with methylmercury. Pregnant women have a right to this information, and FDA has a duty to provide it. In addition to strengthening restrictions on fish consumption by pregnant women, FDA should promote the following fish as safe options for pregnant women:

Trout (farmed)
Catfish (farmed)
Shrimp * (see sidebar)
Fish Sticks
Flounder (summer)
Salmon (wild Pacific)
Croaker
Blue crab (mid Atlantic)
Haddock

Freshwater Sport Fish

It was not possible for EWG to assess the methylmercury risk from every recreational fish caught in every lake in every state in the country. A review of the available data, however, shows that several large predator sport fish are so universally contaminated that FDA should add them to the list of fish that women should completely avoid during pregnancy. After analyzing the results of more than 10,000 samples from 792 lakes and rivers nationwide, we recommend that FDA add the following species to thier health advisory: walleye, northern pike, and largemouth bass. While FDA has no authority to regulate methylmercury levels in freshwater fish, they do have a responsibility to provide critical health information to the public. It is important that women receive a consistent message from one source, and the FDA is the appropriate agency to deliver this message.

Improve monitoring of fish for methylmercury contamination

A major flaw in FDA's system is the agency's own lack of comprehensive data on methylmercury in fish. In January 2001, FDA recommended that pregnant women avoid consumption of king mackerel based on methylmercury levels from a study published in 1979. There are many other species where the data on methylmercury contamination are similarly outdated, but where the available information indicates a potential problem.

FDA must immediately expand its methylmercury sampling program to include a host of fish where the data

Brain Food: What Women Should Know about Mercury in Fish

Lowest in mercury	No more than one serving from this list per month	Avoid if pregnant	
Trout (farmed)	Canned tuna	Shark	Marlin
Catfish (farmed)	Mahi mahi	Swordfish	Halibut
Shrimp *	Blue mussel	King mackerel	Pike
Fish Sticks	Eastern oyster	Tilefish	Walleye
Flounder (summer)	Cod	Tuna steaks	White croaker
Salmon (wild Pacific)	Pollock	Sea bass	Largemouth bass
Croaker	Great Lakes salmon	Gulf Coast Oysters	
Blue crab (mid-Atlantic)	Gulf Coast blue crab		
Haddock	Channel catfish (wild)		
	Lake whitefish		

Data from the 1970's show high concentrations (no recent data available)

Porgy
Orange Roughy
Snapper
Lake Trout
Bluefish
Bonito
Rockfish

** Shrimp fishing and farming practices have raised serious environmental concerns.*

indicate that pregnant women and their babies could receive a potentially unsafe exposure from a relatively small amount of fish. These include:

- Sea bass
- Bluefish
- Bonito
- Atlantic cod
- Pacific cod
- Flounder, various species
- Grouper, black
- Grouper, red
- Halibut
- Orange roughy
- Sand perch
- White perch
- Pollock
- Porgy
- Red snapper
- Rockfish
- Dover sole
- Lake trout
- Yellowtail

Improve public access to mercury contamination data

Consumers have a right to know about contamination of the food supply, and FDA must be responsive to this right. Currently they are not. EWG had great difficulty obtaining relatively simple information about fish contamination from the agency through the Freedom of Information Act. FDA currently posts the results of its Total Diet Study on the web, and there is no

FDA must immediately expand its methylmercury sampling program to include a host of important fish where the data indicate that pregnant women and their babies could receive a potentially unsafe exposure from a relatively small amount of fish.

FDA must immediately post the results of all of its methylmercury testing on the web.

reason that all of the agency's mercury contamination information could not be posted as well.

Improve risk assessments

FDA needs to move beyond its antiquated and biologically implausible risk assessment methods based on average people and average fish and adopt state-of-the-art risk assessment techniques that provide a much more realistic picture of mercury exposure and risk as it is distributed throughout the population.

It is not sufficient to protect the population from average exposures when it is clear that many individuals have far greater than average exposures for extended periods of time.

Reduce Mercury Pollution at its Source

Mercury emissions from coal-fired power plants, the largest man-made source of environmental mercury, are currently completely unregulated. Federal decision-makers should require power plants to reduce their mercury pollution by 90% and ultimately move away from polluting sources of power.

Monitor human exposure and health

The U.S. lacks a comprehensive program to track disease and exposure to environmental contaminants like methylmercury. This study is only one of many demonstrating the need for a nationwide comprehensive environmental health tracking network. Such a network would be our country's first step toward assessing impacts of a range of environmental hazards on public health. In addition, it would provide a wealth of information to health care providers and health officials working to protect health. Specific recommendations include:

- *The network should begin in all 50 states by tracking:* asthma and chronic respiratory diseases, birth defects, developmental and neurological conditions like those linked to methylmercury exposure, and cancers. The tracking of human exposures to hazards would start with priorities including PCBs and dioxin; heavy metals such as mercury and lead, pesticides, and water and air contaminants.

- *An Early Warning System* would alert communities to immediate health crises such as heavy metal and pesticide poisonings. Similar to the monitoring currently in place for an outbreak of an infectious disease, this alert would help local communities identify more quickly and act immediately on health crises from environmental exposures.

- *Pilot Programs* would allow 20 different regional and state initiatives to investigate local environmental health priorities, provide flexibility for local officials, allow community groups to gather more information and serve as a model for potential inclusion in the nationwide network.

- *Federal, state and local rapid response capability* would enable health officials to investigate clusters, outbreaks and emerging threats. To respond effectively and protect the public from illness, health officials must be well-equipped and trained, and the network must be supported through state and federal resources. Steps taken to improve states' capacity should include placing an Environmental Health Investigator in every state and training health officials in environmental epidemiology.

- *Support of community interests and scientific research* will be crucial to further health tracking efforts. Five Centers of Excellence should be federally funded for environmental health research and training, and partnering with communities. Communities and the public have the right to know information that could improve their health; the information made available through the tracking network should be accessible to the public. Input from local groups on the design and implementation of the tracking and monitoring of chronic disease and environmental hazards will be needed to ensure the success of the Nationwide Health Tracking Network.

A nationwide comprehensive environmental health tracking network would be our country's first step toward assessing impacts of a range of environmental hazards on public health. In addition, it would provide a wealth of information to health care providers and health officials working to protect health.

Introduction

Power plants are contaminating the U.S. seafood supply

Nearly all of the coal burned in the United States is contaminated with trace levels of merucry. As a result, coal-fired power plants, municipal incinerators, industrial boilers, and medical waste combustors discharge more than 150 tons of mercury into the atmosphere each year (EPA 1997). Most of this mercury falls back down to the earth in rainwater, accumulating in sediment and plants, and then concentrating up the food chain in fish, other wildlife and ultimately, in people.

The top four sources of mercury pollution in the U.S. account for nearly 80 percent of total mercury emissions. Coal-fired power plants top the list, contributing 33 percent of the total emissions, but this percentage is expected to rise in the near future as the other sources of mercury pollution are controlled. Utilities have escaped regulation of mercury emissions due to specific exemptions in the Clean Air Act. Municipal waste combustors, commercial and industrial boilers, and medical waste incinerators collectively contribute the remaining 47 percent of mercury emissions from these top four sources (at 19, 18, and 10 percent, respectively) (EPA 1997).

According to the National Academy of Sciences (NAS), industrial mercury is responsible not only for polluted waterways, but for widespread mercury exposure for humans. According to the NAS Committee on the Toxicological Effects of Methylmercury, every year an estimated 60,000 children are born at a significantly increased risk of adverse neurological effects from mercury they were exposed to in the womb when their mothers ate fish contaminated with mercury (NAS 2000).

The damage from mercury polluters is widespread, yet little recognized. More than two thousand (2,073) water bodies in 41 states are polluted with mercury at levels that compel health departments to issue fish consumption warnings (EPA 2000). In 11 states, including Ohio, New Jersey, North Carolina, and Maine, mercury contamination in fish across all water bodies of the state is so pervasive that blanket, state-wide advisories have been issued to protect pregnant women and their babies. Four commercially sold species of marine fish are contaminated with mercury at levels high enough that FDA tells pregnant and nursing women and young children to avoid eating them altogether. These four -- swordfish, shark, tilefish, and king mackerel -- are

The damage from mercury polluters is widespread, yet little recognized.

officially off the menu because of the damage mercury can cause to the developing brain (FDA 2000). Beyond these four fish, many other species routinely eaten by pregnant women are contaminated at levels that are potentially dangerous.

Chapter 1

Health Effects of Mercury

When a pregnant woman eats a serving of mercury-contaminated fish, methylmercury crosses the placenta and enters her baby's brain within a matter of hours. It is stored there, where it blocks the natural formation and migration of nerve cells and slows the growth of the brain. There is no amount of mercury known to be harmless. The only limiting factor in our understanding of mercury's toxicity is scientists' ability to measure the effects (subtle neurological deficits from low-level exposures to mercury), like those of a baby in the womb whose mother eats a tuna fish sandwich once a week.

A mass poisoning in Minamata, Japan that began in the 1950s provided the first evidence that the fetal brain is particularly sensitive to methylmercury. Brain autopsies from victims of the poisoning elucidated differences between adults and children. In adults, the brain lesions caused by methylmercury were found to be concentrated in only a few areas of the brain. In the fetus, lesions were seen over nearly the entire cortex of the brain. Babies died within days of birth from symptoms of methylmercury poisoning, while their mothers were free of symptoms.

The physical effects of high doses of methylmercury on brain structure are extensive. In 1965, scientists studied segments from the brains of two children, ages 2.5 and 6, among the victims of the Minamata poisoning. They found these brains abnormal, characterized by a low brain cell density, clusters of brain cells growing outside the brain, and incomplete electrical insulation layers (myelin sheaths) around the nerve cells. They found evidence that these children's brains had stopped growing prematurely. Yet the mothers of these two children reported no symptoms of mercury poisoning (Weiss 1990).

Two child brain autopsies published in 1978 after a poisoning in Iraq confirmed the Minamata results. One of these children died at birth; the other died 33 days after appearing perfectly healthy at birth. Both brains were smaller than normal, and showed evidence that brain cells, once formed, had failed to migrate to their proper locations in the brain (a process called neuronal migration) (Weiss 1990).

More recent studies of children exposed to lower levels of mercury have found toxic effects at levels previously thought to be safe. These studies have focused on finding measures sensitive enough to quantify developmental delays and neurological deficits in children exposed to relatively low levels of

There is no amount of mercury known to be harmless. The only limiting factor in our understanding of mercury's toxicity is scientists' ability to measure the effects.

Some children exposed in utero by their mothers' fish consumption are at risk of falling in the group of children "who have to struggle to keep up in school and who might require remedial classes of special education."

Committee on the Toxicological Effects of Methylmercury, July 2000

methylmercury in utero. For example, scientists have measured delays in walking and talking, or tone and reflex abnormalities. These studies, conducted primarily over the past 10 years, have elucidated the exquisite sensitivity of the fetal brain to low levels of methylmercury.

The National Academy of Sciences (NAS) Committee on the Toxicological Effects of Methylmercury summarizes the findings of this new body of work: "Chronic, low-dose prenatal [methylmercury] exposure from maternal consumption of fish has been associated with more subtle endpoints of neurotoxicity in children. Those end points include poor performance on neurobehavioral tests, particularly on tests of attention, fine-motor function, language, visual-spatial abilities (e.g., drawing), and verbal memory" (NAS 2000).

The Committee speaks to the potential societal impacts that stem from contaminated seafood, saying that some children exposed in utero by their mothers' fish consumption are at risk of falling in the group of children "who have to struggle to keep up in school and who might require remedial classes of special education." The Committee estimates that 60,000 children born in the U.S. each year are at risk of some level of brain damage from their exposures to methylmercury in the womb.

Mass poisoning in Japan

By 1953 the first cases of Minamata Disease were surfacing among Japanese living in communities on the Shiranui Sea. At the time, the cause of the disease was unknown. The disease was named after the bay where the first victims lived.

Cases among adults were diagnosed first, children later. The cardinal features of adult exposures in Minamata included tingling and numbness, sensory impairment, loss of speech and muscle control, visual-field constriction, and hearing loss. All the children who were identified with the most severe form of the disease were mentally retarded, had primitive reflexes, experienced loss of speech and muscle control, or had limb deformities.

After several years of intense study, the cause was pinpointed. In 1959, scientists from Kumamoto University reported to the Japanese Ministry of Health and Welfare that Minamata Disease stems from methylmercury poisoning. The scientists also found that the mercury originated from industrial wastewater of an acetaldehyde facility called Chisso Co. Ltd. Nothing was done. A 1960 report by a visiting U.S. scientist recommended that fishing in Minamata Bay should be banned. This was not done, exposures continued for years, and disease rates climbed.

Decades after people finally stopped fishing in the bay, health effects still linger, and new cases are emerging among those exposed years ago. As of 1995, those diagnosed with the disease numbered 2252, of which about half had died, with many deaths being directly caused by methylmercury poisoning (Harada 1995).

Remarkably, Chisso Co. Ltd. had known of contamination of marine life close to the plant three decades before the first confirmed cases of Minamata Disease. The company compensated the fishermen's union whenever complaints were lodged, but did nothing to reduce the mercury in the plant's wastestream. A comment made by a company official reflects the company's priorities: "[the] chemical industry is essential to Japan today and some damage to marine life should be tolerated" (Harada 1995).

Although the scale of current exposures in the U.S. is much different from Minamata, with lower levels of exposure over a much broader population, the corporate influence over public health policies first seen in Minamata continues today. In FDA's 1979 revisions to its mercury action level, the agency wrote that its new, less stringent action level would "provide a significant economic benefit to those industries most seriously affected by regulatory actions under the [previous] guideline and would enhance the future development of a number of presently underutilized fisheries" (Federal Register Vol 44 No 14, January 19, 1979).

Mass poisoning in Iraq provides first clues of harmful dose

In the winter of 1971-1972, the Iraqi government distributed 88,000 tons of seed grain to Iraqi farmers, to be used for the spring planting. The farmers were warned that the grain was contaminated with methylmercury fungicide, but a drought the previous summer had depleted grain stores, and many ignored the warnings and baked the wheat into bread.

Three months later, the hospitalizations began. By the time the episode had ended, official hospital deaths numbered about 400. A more complete estimate incorporating unreported cases from the countryside puts the full number of fatalities at close to 5000 (Greenwood 1985).

A team of scientists from the University of Rochester and Iraq coordinated an investigation of the disaster. Although today their conclusions seem almost commonplace, at the time their work represented the most comprehensive data available on the increase in the severity and number of health effects that can occur as exposure to a toxic chemical increases. This kind of data is now used to construct what is called a dose-response curve, used as the basis for many safety standards in the U.S.

The key to their work was the discovery that methylmercury in hair reflects blood concentrations at the time the hair was formed, and can be used to reconstruct an ingested dose of methylmercury. This technique has since been used in epidemiological studies of populations in the Faroe Islands, Seychelles, and New Zealand, in the continuing body of work that finds ever lower levels of methylmercury associated with subtle neurological deficits and developmental delays in infants and children.

New studies focus on low-level effects to fetal brain when mothers eat fish

Two recent major epidemiological studies have expanded scientists' current understanding of the sensitivity of the fetal brain to methylm-

In FDA's 1979 revisions to its mercury action level, the agency wrote that its new, less stringent action level would "provide a significant economic benefit to those industries most seriously affected by regulatory actions under the [previous] guideline and would enhance the future development of a number of presently underutilized fisheries."

“[B]ecause there is a large body of scientific evidence showing adverse neurodevelopmental effects, including well-designed epidemiological studies, the committee concludes that an RfD [reference dose, or government’s accepted intake level for a substance] should not be derived from a study, such as the Seychelles study, that did not observe any associations with [methylmercury]."

ercury. These studies, conducted in New Zealand and in the Faroe Islands (in the North Sea, between Scotland and Ireland), include prenatal methylmercury exposures that fall within the range of some U.S. exposures. The National Academy of Sciences methylmercury committee, which published its findings last June, found low-level effects displayed most clearly in the Faroe Islands studies:

> "The [methylmercury]-associated performance decrements on the neuropsychological tests administered in the Faroe Islands and New Zealand studies suggest that prenatal [methylmercury] exposure is likely to be associated with poorer school performance. In the Faroe Islands sample, [methylmercury]-related deficits were seen across a broad range of specific domains, including vocabulary, verbal learning, visuospacial attention, and neuromotor function. Deficits of the magnitude reported in these studies are likely to be associated with increases in the number of children who have to struggle to keep up in a normal classroom or who might require remedial classes or special education." (NAS 2000).

Methylmercury exposures through fish consumption and the subtle effects manifested in infancy and childhood are extraordinarily difficult to measure. Each fish eaten has a unique concentration of methylmercury. Each woman eating a fish has a unique ability to absorb and excrete methylmercury. Each child in the womb has a unique susceptibility to the harmful effects of mercury. Given the tremendous variability inherent in these studies, the true surprise is that scientists are able to measure an effect at all.

According to the NAS, uncertainties have the potential to mask effects, making it more difficult for scientists to find statistically significant results. That is one reason that the committee recommended that public health protections not be based on studies like that in the Seychelles off the coast of Tanzania that fail to find significant effects in infants and children exposed in utero. The committee writes: "because there is a large body of scientific evidence showing adverse neurodevelopmental effects, including well-designed epidemiological studies, the committee concludes that an RfD [reference dose, or government’s accepted intake level for a substance] should not be derived from a study, such as the Seychelles study, that did not observe any associations with [methylmercury]" (NAS 2000). NAS recommended instead, that a reference dose be derived from a study that did find associations, such as the study that took place in the Faroe Islands.

The Faroe Islands study focused on 1022 babies born over a 21-month period. Each baby’s in utero exposures to methylmercury was estimated from their mother’s hair and blood concentrations, and from the concentration of methylmercury in the blood of the umbilical cord at birth. When the children reached age 7, they each went through 5 hours of detailed neuropsychological tests. A total of 917 children completed the examinations.

The tests given to the children ranged from simple tests designed to measure motor skills (such as the standard Finger Tapping Test, which measures how many times a child can repeatedly tap a key in 15 seconds), to complex tests of intelligence such as the Boston Naming Test, in which a child is presented with line drawings of objects that they then are asked to name, first without and then with clues if the child cannot answer within 20 seconds.

The scientists' conclusions encompass specific results of their studies as well as possible societal impacts of low-level mercury exposures: "Overall, the results suggest that several domains of brain function may be affected by prenatal methylmercury exposure. The findings (especially those involving language) suggest that this exposure has widespread effects on cerebral function, and they are consistent with the literature reporting widespread neuropathological involvement in prenatal methylmercury poisoning. A discernible, insidious effect seems to be present below a limit of 10 [parts per million] for mercury in maternal hair" (Grandjean et al 1997). In other words, at low levels of prenatal mercury exposure, widespread impacts are seen on a child's neurological development.

Broad societal impacts of mercury exposure

The scientists in the Faroe Islands study go on to postulate that the statistically significant developmental delays seen between high and low exposure groups could affect society as a whole: "Such decrements in average cognitive function, especially if permanent, could well be of societal significance in the populations affected" (Grandjean et al 1997).

For a particular child born to a mother who eats fish with elevated methylmercury levels, like canned tuna, the effects of methylmercury would likely go unnoticed. For instance, a doubling in a mother's dose of mercury is associated with about a two-month delay in walking and talking, well within the normal range of differences among children. An increase in dose by a factor of 10 is associated with a developmental delay of four to seven months (NAS 2000, citing data from Grandjean et al 1997).

But these differences become extremely important when considered in the context of the four million pregnant women exposed to methylmercury every year. What this broad, low-level exposure would do, in effect, would be to push a greater percentage of the population into the group of children who struggle to keep up in school, or who require remedial education (NAS 2000). Apart from an unknown number of children who are severely affected by methylmercury, either because of the unusually high exposures of their mothers or their particular sensitivity, it is the broad impact of developmental delays that becomes the significant effect to society when millions of babies are exposed to low doses of a developmental toxin like methylmercury every year.

Adults at risk decades after exposures

Even for adults, the assumed safe dose continues to decrease as

Overall, the results suggest that several domains of brain function may be affected by prenatal methylmercury exposure.

Faroe Island researchers 1997

It appears that small amounts of methyl-mercury can damage the adult brain through what has been called an "erosion of nerve cells" that "silently and gradually narrows the plastic potential of the brain"

more is learned about the toxicity of methylmercury.

FDA's safety standard for methylmercury has its roots in a Swedish analysis of data from the 1950s mass poisoning episode in Minamata, Japan. In their analysis, the Swedish Commission on Evaluating the Toxicity of Mercury in Fish derived a "no effect" level of 200 parts per billion (ppb) of mercury in blood.

In 1990, the World Health Organization (WHO) found that this same "no effect" concentration, 200 ppb, would cause five percent of adults to manifest neurological effects like tingling and numbness. But an analysis done six years later by independent scientists found that a concentration of 200 ppb would, in fact, cause neurological effects in anywhere from 11 to 31 percent of the adult population (WHO 1990 and Kosatsky and Foran 1996, referenced in NAS 2000).

Furthermore, it appears that small amounts of methylmercury can damage the adult brain through what has been called an "erosion of nerve cells" that "silently and gradually narrows the plastic potential of the brain" (Weiss 1996). New evidence from victims of Minamata Disease shows that relative neurological deficits, like those indicated by an older person requiring help dressing or bathing, can emerge decades after exposure and appear to increase with age, long after exposures have ended. One theory is that the brain may age and degenerate more quickly because of a stressed neuronal structure induced by chemical exposures when the brain is developed in the womb and early childhood (Weiss 1996). A more recent study has linked mercury with Alzheimers disease (Leong 2001).

Mercury appears toxic to the immune system and the heart

Studies are beginning to show that the heart and the developing immune system are possibly even more sensitive to low doses of methylmercury than is the fetal brain.

In general, regular consumption of fish seems to provide protection from heart disease. Researchers in Finland were surprised, therefore, to find that high fish consumption among a study of 1,833 fishermen was associated with a doubling or tripling of the risk of dying from a heart attack. In this case, the risk was correlated to methylmercury ingestion. Damage to the heart muscle from methylmercury appeared to outweigh the beneficial effects of fish consumption (Salonen 1995).

In reviewing this study, NAS notes that the mercury exposure in this study is the lowest that has been associated with any other health effect, even developmental effects among children. Preliminary research on the developing immune system shows the same result – the immune system may be compromised at even lower levels than the fetal brain is. While public health agencies alter their safety levels to be consistent with the body of literature on fetal brain effects, research on the heart and immune system will continue and may eventually drive the safety standards even lower.

Inadequate Government Protections from Mercury in Fish

Utilities fend off controls on their mercury pollution

If political contributions are any indication of political influence, electric utilities have significant muscle in Washington. Between 1990 and 2000, electric utilities contributed more than $53 million to political campaigns and parties, with their overall annual contributions skyrocketing 340% over that same period. Republicans reaped most of the benefits, receiving twice as much money as Democrats during the last election cycle.

The top givers among utilities during the 1999-2000 election cycle were the National Rural Electric Cooperative Association ($4.5 million), Southern Company ($3.9 million), Entergy Corporation ($2.4 million), Edison International ($2 million), PG&E and Edison Electric Institute both at $1.9 million, and Texas Utilities at $1.8 million (Center for Responsive Politics 2000). (Table 1)

Delay as an art form

The history of failure to control mercury pollution reads like a textbook on the art of regulatory delay. This art can be viewed as a circle that the utilities carefully navigate in three steps. The first step is pushing for studies, the second step is arguing that the studies' recommendations will be too expensive, particularly if they involve participation by the utilities themselves, and the third step, is arguing that the first round of studies are inconclusive and that yet further study is needed.

The first step is well illustrated by an industry-motivated, 1998 congressional mandate for a study of mercury toxicity by the National Academy of Sciences. This request followed immediately on the heels of a 5-year study of the same issue by EPA, previously mandated by Congress in the 1990 Clean Air Act. Both studies reached the same conclusion that mercury is ex-

The history of failure to control mercury pollution reads like a textbook on the art of regulatory delay.

Table 1. Electric utilities maintain control of their emissions through generous political contributions.

Electric Utility	Donations to campaigns and candidates 1990-2000
National Rural Electric Cooperative Assoc.	$4.5 million
Southern Company	$3.9 million
Entergy Corporation	$2.4 million
Edison International	$2.0 million
PG&E	$1.9 million
Edison Electric Institute	$1.9 million
Texas Utilities	$1.8 million

Source: Center for Responsive Politics. Compiled from FEC Data.

In 1990, members of Congress sympathetic to utilities attached an amendment to the Clean Air Act that prohibited the EPA from controlling mercury emissions at power plants. Other sources of airborne mercury did not receive this immunity, and ultimately were controlled.

tremely toxic and that current safeguards are inadequate.

The second step, criticizing the cost of the study recommendations, is well illustrated by the National Rural Electric Cooperative Association (NRECA) in response to EPA's request for mercury testing by utilities: "To summarize, NRECA is very disappointed with this proposed ICR [Information Collection Rule]. EPA should reconsider and repropose an ICR that would significantly reduce the overall informational requirements and cost burdens placed on electric utility owners and operators…" (NRECA, 1998). Here, electric utilities are decrying the cost of simply monitoring their own emissions.

Wisconsin Electric gives us a great example of step three. After a decade of unprecedented review of mercury toxicity and exposure by both the EPA and the National Acadamy of Sciences, Wisconsin Electric is still calling for more study (Wisconsin Electric 2001): "While much has been learned about mercury behavior in the environment, Wisconsin Electric believes that it is wise to allow the EPA and other research groups sufficient time to complete ongoing and planned research… We firmly believe that wise decision-making is possible only when all stakeholders have a clear understanding of this multifaceted problem and its possible solutions."

During the past two decades the electric utility lobby has won notable victories amending two major environmental statutes. Each hamstrung EPA's ability to control mercury pollution and protect the public health.

Under the Emergency Planning and Community Right to Know Act, passed in 1986, the electric utilities avoided requirements to report their mercury emissions to the Toxics Release Inventory (TRI), our country's best source of public information on toxic pollution for more than a decade. This move not only kept the public in the dark about their emissions, but deprived regulators at the Environmental Protection Agency of specific plant-by-plant data on mercury emissions (until 1997, when EPA finally required electric utilities to report their emissions to the TRI).

But the coup de gras was under the Clean Air Act, the electric utilities have managed to completely avoid any limit on their mercury emissions. In 1990, members of Congress sympathetic to utilities attached an amendment to the Clean Air Act that prohibited EPA from controlling mercury emissions at power plants. Other sources of airborne mercury did not receive this immunity, and ultimately were controlled.

Even more delays were built into the 1990 Clean Air Act, despite the fact that at the time of the bill's passage mercury was one of the best-understood chemicals in the realm of human toxicology. The law directed EPA to summarize the health effects of mercury and to submit this report to Congress. This study was finalized in 1996, but was held internally by the agency for months while the 1996 election and budget were finalized. When EPA finally released its report to Congress in 1997, it concluded that mercury was probably more toxic than previously thought. This was not the conclusion the electric utilities had sought.

After a year in which their political contributions were higher than for any other period - $11 million to all political campaigns and parties - the utilities won another delay in 1998. Congress required EPA to contract with the National Academy of Sciences to conduct (yet another) comprehensive review of the science on mercury's risk to human health. In particular, the NAS was instructed to resolve the controversy on whether to use the results of epidemiological studies in the Seychelles Islands or the Faroe Islands as the basis for federal health protections from mercury.

The NAS panel concluded unanimously that the Faroe Island data are the most appropriate for setting health safeguards. The committee also concluded that 60,000 children each year may get a potentially unsafe dose of mercury in the womb during development. The utility lobby once again found itself with an unpalatable conclusion.

Only days before President Clinton left office, EPA announced that it finally had the data in hand to regulate mercury from power plant emissions (Browner, December 14, 2001), and that these regulations would be moving forward. With a new President and Administration, however, it remains to be seen whether regulations will indeed be forthcoming.

FDA's failure to regulate methylmercury in fish

FDA has a 32-year history of failed health advisories and nonenforceable mercury contamination guidelines. The agency's seafood monitoring programs do almost nothing to test the most commonly eaten fish, and then fail to act on the results even when testing shows mercury contamination for some species consistently above its own health advisory levels.

FDA's mercury action level stands out among a long list of questionable policies. The action level is the level of mercury in fish above which FDA recommends that the fish not be sold. Under law, an action level is not enforceable, but it does represent the agency's best judgment of a safe level of mercury contamination in fish.

FDA's action level: Take 1

In 1969, FDA established a nonenforceable "action level" of 0.5 parts per million (ppm) of mercury in seafood set to protect adult men from mercury poisoning. In its description of the action level in a 1974 rulemaking, the agency explained: "The 0.5 ppm action level for mercury in fish and shellfish established by the Food and Drug Administration in 1969 incorporated all the significant aspects of the mercury-in-fish problem known at the time of its establishment."

The significant aspects of the dangers of mercury exposure were drawn from a 20-year mass poisoning episode in Minimata, Japan that surfaced in the 1950s. FDA scientists relied on calculations by a Swedish Commission finding that the lowest blood mercury concentrations associated with toxic effects in Minimata would be

The NAS panel concluded unanimously that the Faroe Island data are the most appropriate for setting health safeguards. The committee also concluded that 60,000 children each year may get a potentially unsafe dose of mercury in the womb during development.

The agency falls back, by default, on calculations that assume a 150-pound man and a 1-pound fetus to be essentially the same in their response to mercury.

What little public health protection is provided by FDA's current action level has its origins in a calculation provided 21 years ago by a circuit court judge.

achieved by a 150-pound man eating a pound of fish every eight days (2 ounces per day) containing 0.5 ppm mercury (Federal Register Vol. 39, No. 236, December 6, 1974).

FDA adopted the results of this calculation as their action level – 0.5 ppm mercury in fish. This outdated method of exposure assessment specifically excludes consideration of the population most at risk – pregnant women and their babies. In spite of major advancements made by other federal agencies in exposure assessments that consider the unique vulnerability of babies, FDA continues to resist this concept. Instead, the agency falls back, by default, on calculations that assume a 150 pound man and a 1 pound fetus to be essentially the same in their response to mercury.

FDA's action level: Take 2

In 1974, FDA reevaluated its mercury action level in light of new data from another mercury poisoning episode, this one in Iraq in 1972. The agency found that the threshold exposure level for the onset of poisoning symptoms, which appeared to be about 25 to 40 milligrams of mercury, was similar to that seen in the Minimata poisonings. The agency concluded that its action level, set to protect a 150-pound adult male, was appropriate.

The agency further defended its action level by pointing out that only about two percent of the population eats more than a pound of fish every eight days – the consumption rate that forms the basis of their action level. The FDA Commissioner found that "it is not possible… to provide this same high level of protection to every person without excluding a great amount of fish and shellfish from the market." The Commissioner added that "it would be inappropriate to exclude a vast amount of fish and shellfish from the market in order to provide a large margin of safety for those who consume far more than the average person." (Federal Register Vol. 29, No. 236, December 6, 1974).

One could argue with the superlatives, but the concept is clear: FDA's action level is set to protect an average person, in this case an average 150-pound adult male. Even more importantly, the Commissioner makes it clear that this public health agency considers the commercial interests of the seafood industry to be an integral part of their public health mission.

Even in 1974 FDA recognized that it might at some point be appropriate to replace the nonenforceable action level with an enforceable limit that the Agency calls a tolerance level. "Because this important Iraqi study is incomplete and other mercury studies are in progress, the Commissioner concludes that it would be inappropriate to set a formal tolerance at this time. When the study of the Iraqi poisoning episode is fully developed and published, the Commissioner will reevaluate it and all other available information and consider whether to establish a formal tolerance for mercury in fish and shellfish" (Federal Register Vol. 29, No. 236, December 6, 1974). Twenty-seven years later, FDA is still reevaluating.

Commercial break: The seafood industry fights back

The seafood industry wanted more than FDA's official declaration of its goal to support the commercial interests of the seafood industry. They wanted the (nonenforceable) action level rescinded. So in 1977, Anderson Seafoods, Inc. and a coalition of seafood distributors sued FDA over their finding that swordfish contaminated with mercury above the action level of 0.5 ppm was unsafe (United States v. Anderson Seafoods, Inc., 622F.2d157, 1980).

What little public health protection is provided by FDA's current action level has its origins in a calculation provided 21 years ago by the circuit judge presiding over this case, Chief Judge Arnow. In the trial, Anderson Seafood presented calculations to the judge showing that swordfish contaminated with mercury at up to 2 ppm is safe. Judge Arnow, in turn, calculated his own action level of 1 ppm based on evidence presented in the trial. The judge's calculations are presented in the summary judgment and remain the basis of the action level in effect today.

In his written memorandum decision, Judge Arnow describes the findings of the court used as the basis for his calculations. First, he writes that the court found that Anderson Seafoods' swordfish contains mercury at levels up to 1 ppm. Second, the court agreed with Anderson Seafood's assessment that the harmful level of mercury in the blood is 400 ppb. This is twice the level decided in the 1970s by scientific consensus based on the Minimata and Iraqi poisonings. It is 69 times the safe level of 5.8 ppb recommended last year by the National Academy of Sciences based on recent studies focused on fetal brain damage (NAS 2000).

The court then multiplied by two and found that, since Anderson Seafood showed that 300 micrograms (ug) of mercury ingested per day gives a blood level of 200 parts per billion (ppb), then 600 ug of mercury gives a blood level of 400 ppb (the court's "effects" level).

The court then agreed with Anderson Seafood that a safety factor of 5, not 10, is sufficient to account for possible differences between a 150-pound adult man and other affected populations, such as a 1-pound fetus in the first trimester of development. The National Academy of Sciences, two decades later, would recommend a safety factor of 10.

Then the judge divided his allowable ingestion level, 600 ug of mercury, by his new safety factor of 5, to get his allowable intake of 120 ug of mercury per day per person. Next the judge had to decide how much fish people eat. For this, he again turned to Anderson Seafood. The company cited a study of people eating fish from Lake Michigan where, at most, people were eating 5.5 ounces of fish per day (157 grams per day). The judge then calculated that this person would be ingesting 157 ug per day were the mercury concentration in the fish 1 ppm.

Since this dose of 157 ug per day is higher than the judge's allowable dose of 120 ug per day, the judge

FDA data shows that swordfish samples routinely fail the 1 ppm action level, with single samples containing mercury at levels as high as 2.9, 2.94, and 3.22 ppm.

Full compliance with FDA's seafood safety program does not include any testing for methylmercury.

recalculated the exposure assuming that all swordfish with mercury concentrations greater than 1 ppm were removed from the market. With this maneuver, he found that a 150-pound man from Michigan eating 6 ounces of swordfish per day with an average mercury concentration of 0.8 ppm would fall within the level the judge had decided was safe.

Through these various calculations, the judge found that "swordfish poses no reasonable possibility of injury to anyone's health," based on a safe dose an order of magnitude higher than what is now known to damage the fetal brain. American taxpayers covered the cost of the trial. Judge Arnow's health limit for mercury in fish, 1 ppm, is now FDA's action level, still in effect 21 years after his decision.

FDA's action level: Take 3

While the Anderson case was pending, and presumably while FDA experts were attempting to defend the Agency's action level of 0.5 ppm, FDA published a notice stating that an action level of 1 ppm would provide adequate protection to consumers (Federal Register Vol 44 No 14, January 19, 1979). They based this level on a new study by the National Marine Fisheries Service (NMFS) showing essentially that an average person does not normally eat fish contaminated at high levels.

In this proposed rulemaking FDA concurs with the NMFS finding that a higher action level (1 ppm instead of 0.5 ppm) would "provide a significant economic benefit to those industries most seriously affected by regulatory actions under the 0.5 ppm guideline and would enhance the future development of a number of presently underutilized fisheries." FDA reiterates the NMFS conclusion that a less restrictive regulatory approach would significantly increase consumer confidence in seafood.

The sequel: FDA's new advisory for pregnant women

After consulting extensively with key state officials and seafood industry representatives over the past year, FDA doubled the number of fish on their warning list for pregnant women. To their standing advice that pregnant women avoid shark and swordfish, FDA added king mackerel and tilefish.

To arrive at these new listings FDA scientists did not comprehensively review mercury contamination in fish. Instead, apparently, they stumbled onto a recent EPA document. In the document, EPA summarized a 1978 FDA analysis of data from a National Oceanic and Atmopheric Administration (NOAA) survey which showed average mercury levels in king mackerel and tilefish higher than FDA's action level. Based on this EPA summary of an FDA analysis of NOAA data now 25 years old, FDA added these two fish to the advisory list.

As it stands now, FDA's advice to pregnant women is to avoid eating the four species of fish for which at least half the fish seem to have average methylmercury levels above 1 ppm.

FDA claims that the odds of someone eating a contaminated fish are slim, which is the justification the agency uses for its lax action level and nonexistent testing requirements. Yet FDA's own testing proves them wrong. For swordfish, for instance, FDA data shows that samples routinely fail the action level, with single samples containing mercury at levels as high as 2.9, 2.94, and 3.22 ppm (FDA Seafood Surveillance Monitoring data).

FDA blasted in recent government review

The most recent attack on FDA's methylmercury policies came from the General Accounting Office (GAO) on January 31, 2001 (GAO, 2001). In its report to Senators Richard Lugar and Tom Harkin of the Committee on Agriculture, Nutrition, and Forestry, GAO found that FDA fails on multiple fronts to protect consumers from mercury.

First, the GAO analysis found that FDA's broad seafood safety program – which relies on individual seafood firms to write and implement their own safety programs – is failing. As of 1999, 56 percent of seafood firms were not following FDA's requirements to ensure the safety of their seafood -- even for pathogens for which health risks can be immediate and life-threatening.

In the case of methylmercury, the situation is even worse. GAO found that in FDA's guidance documents to the seafood industry, the Agency neglects to mention methylmercury testing even once. The effect of the omission is that full compliance with FDA's seafood safety program does not include any testing for methylmercury.

This omission is bewildering given that FDA's own testing of seafood shows routinely high methylmercury levels in a number of species. FDA testing of shark and swordfish in 1998 and 1999 found methylmercury above the Agency's action level (1 ppm) in 8 of 19 samples.

The effects of FDA's methylmercury policies are far-reaching. Any fish can go into the marketplace at any time, regardless of the mercury level. This situation is made even more hopeless by FDA's scant methylmercury testing program that fails to fully characterize methylmercury levels in many of the most commonly eaten fish. For instance, FDA's 10 tests of methylmercury in sea bass indicate it may be among the most contaminated fish on the market. Yet the Agency has no plans to warn consumers of a potential concern, let alone to further test this increasingly popular fish.

Chapter 3

The Fish We Eat

FDA and EPA use flawed methods to assess the risk from methylmercury in fish

The subtle effects of methylmercury are inextricably linked to the amount of the metal in a fish eaten by a pregnant woman, and to the unique biology of an individual woman and her baby.

Every fish eaten has its own concentration of methylmercury. Every woman eating a fish has a different ability to absorb and excrete methylmercury based on her size and a set of unique physiologic and metabolic factors. Every child in the womb has a unique susceptibility to the harmful effects of methylmercury. Scientists have shown that these biological differences matter tremendously. A recent study found that two women eating the exact same fish could get a dose of mercury different by a factor of 70, and that one in every 100 women would be expected to retain in her body three times the methylmercury that an average woman would retain (Stern 1997).

Remarkably, though, both FDA and EPA use an average person as a stand-in for all women in the U.S. when they assess the risk the developing fetus faces when its mother eats contaminated fish (Table 2).

A better alternative

To better represent variability in fetal exposure to methylmercury the Environmental Working Group developed a probabilistic method for assessing methylmercury risk.

Probabilistic risk assessments simulate the distribution of real-world exposures that occur within large populations. To do this, a computer program generates hundreds of thousands of virtual women based on the range of biological variability known to exist within the population. Our model simulates the dose of methylmercury each of these women would receive from a given fish that she is assumed to eat. Mercury concentrations in fish in our analyses are drawn from federal databases of measured mercury concentrations in fish tissue. How much of each individual type of fish a woman eats is scaled to match actual fish consumption data maintained by the National Marine Fisheries Service. For example, in our model a woman is 34 times more likely to eat canned tuna than tuna steak.

The distribution of data resulting from the model represents hundreds of thousands of methylmercury exposures, each one corresponding to one of the model's biologically unique women, and each one

Both FDA and EPA use an average person as a stand-in for all women in the U.S. when they assess the risk the developing fetus faces when its mother eats contaminated fish.

Table 2. FDA's and EPA's simplifying assumptions result in both agencies significantly underestimating risks to pregnant women.

	FDA (Circuit Judge Arnow)	EPA	EWG method	Effect on the Agency's risk assessment
Type of person used as basis for public health policy…	An average man	An average woman	The range of all women in the United States	FDA protects a man, not a woman or fetus. EPA leaves half the women in the U.S. out of their assessment.
This person weighs…	150 pounds	148 pounds	From 79 to 412 pounds	More than half of all women weigh less than what EPA and FDA assume. For these women, eating the same amount of fish results in a higher methylmercury exposure.
This person has a blood volume of…	not considered	5 liters	On average, a woman would have to weight 212 pounds to have 5 liters of blood. Ninety-nine percent of women have blood volumes between 2.58 and 4.87 liters.	A high blood volume like that assumed by EPA has the effect of diluting methylmercury and understating risk.
This person absorbs this fraction of methylmercury into their bloodstream…	not considered	95 percent	From 90 to 98 percent (accounts for 99 percent of all women).	An estimated 27 percent of all women would absorb more methylmercury than EPA assumes.
This person's blood concentration of methylmercury reflects this percentage of the absorbed dose…	not considered	5.9 percent	Between 3.1 and 13.2 percent (accounts for 99 percent of all women).	Sixty-three percent of women receive a higher blood dose of methylmercury than what EPA assumes.
Half of this person's blood methylmercury is gone (excreted or distributed to other organs) within this many days…	not considered	50 days	Between 31 and 81 days (accounts for 99 percent of all women).	About 50% of all women retain methylmercury longer in their blood than EPA assumes.
Uncertainty factor to account for differences between people and for what is unknown about the dangers of methylmercury…	5	10	10	FDA's safety factor is half what NAS recommends. EPA concurs with NAS, but their error in blood volume alone eats up about a third of their safety factor.
Benchmark level of methylmercury in blood…	200 ppb	5.8 ppb	5.8 ppb	The benchmark dose of 5.8 ppb was calculated by design to have a 5 percent chance of being underprotective. Health effects have been associated with concentrations as low as 2 ppb, 100 times lower than FDA assumes.

Source: Environmental Working Group.

reflecting that woman's fish consumption based on real-world data.

Women and children are at risk under current fish advisories

Our analysis shows that FDA's recommendation of 76 6-ounce fish meals during pregnancy could actually be detrimental to the health of unborn children. Fish are an important part of a healthy diet and women should be encouraged to eat fish with low methylmercury levels during pregnancy. But eating a varied diet of FDA's recommended 12 ounces of fish a week (and none of the four prohibited fish) could expose more than one fourth of all pregnancies (one million babies) to a potentially harmful dose of methylmercury for at least one month during pregnancy. About 20,000 of these children would be exposed to a dose of methylmercury that increases the risk of adverse neurological effects for the entire pregnancy (Figure 1).

Antiquated risk assesments

FDA's reliance on outdated risk assessment methods results in two fundamental errors in their seafood advisory to pregnant women. First, their list of four prohibited fish is far too short. Many other commonly-eaten fish (tuna steaks and halibut, to name just two) also have methylmercury levels that may be unsafe for pregnant women.

The second and perhaps more serious error is encouraging women to eat 12 ounces of essentially any other fish throughout pregnancy. Notably, the Agency does not advise women to eat *up to* 12 ounces of fish per week. Instead, the Agency uses this portion of its advisory as a public health announcement, in which they tell women to eat 12 ounces of fish per week because of the known health benefits of fish consumption (vitamin D, omega-3 fatty acids, and protein, for example). The beneficial effects of fish consumption under this scenario, however, could very easily be outweighed by the risk to the fetus, as a mother-to-be eats methylmercury-contaminated fish from FDA's "safe" menu.

In order to examine the extent of methylmercury exposure women and developing fetuses could experience, and the margin by which FDA's and EPA's advisories err, we simulated several different scenarios using the computer model. Four scenarios are represented in Figure 2. The first represents the doses that real women, not just the average woman, would get if they ate 12 ounces of fish per week (except for the banned four) throughout pregnancy. Over 28 percent of women would have a blood methylmercury level exceeding NAS's recommended benchmark level of 5.8 ppb – for at least 30 days during pregnancy. This analysis incorporates mercury exposure from 9 of the top 10 fish and shellfish consumed in the U.S. and 10 additional species consumed less frequently.

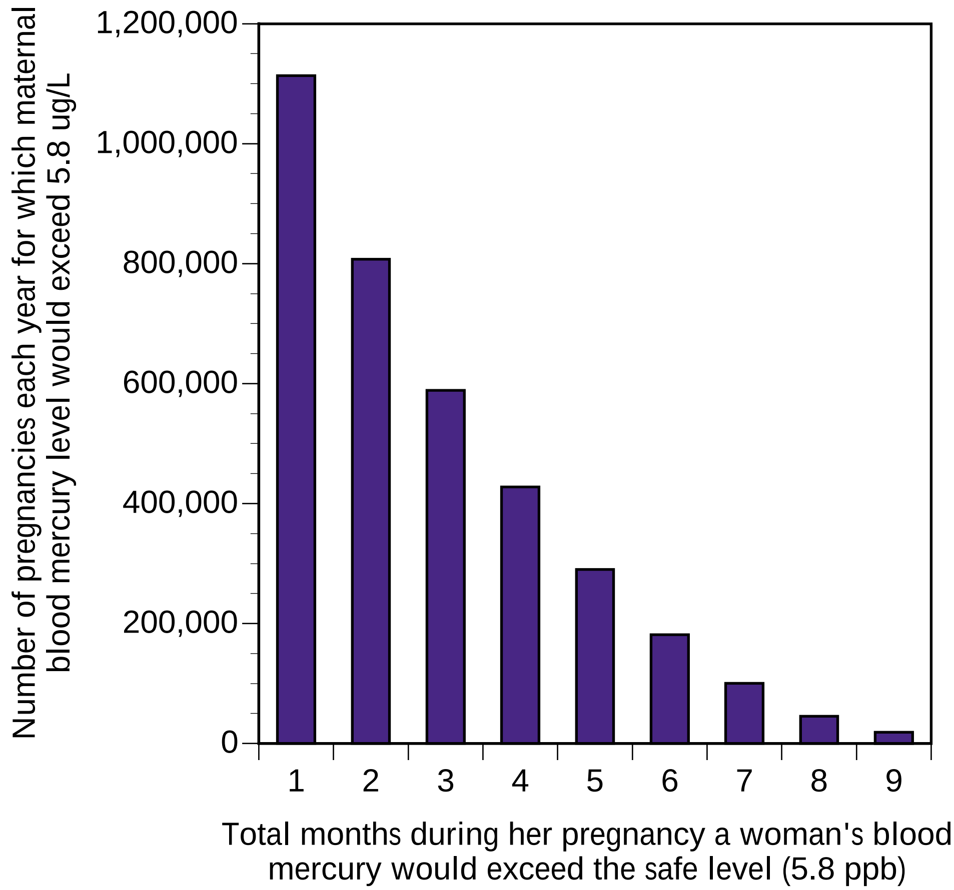
The second scenario assumes that a woman starts her pregnancy with no methylmercury in her body. This assumption is widely known to be false (CDC 2001), but it is used by the Agencies to simplify their analyses. The effect is to significantly understate the risk.

When background blood concentrations are not considered in the analysis, 24 percent of women, as opposed to 28 percent, exceed the benchmark blood methylmercury level for 30 days during pregnancy. This four percent difference represents 200,000 of the approximately four million women who give birth in the U.S. each year.

The third scenario is another reflection of the importance of current blood methylmercury levels. It represents the hypothetical case of women beginning pregnancy with methylmercury levels in their blood that reflect measured distributions in normal people (Stern 1997 and Nixon 1996), and then consuming no fish whatsoever. This case shows that even if pregnant women eat absolutely no fish throughout pregnancy, nearly five percent of these women would be over the

The beneficial effects of fish consumption from FDA's advisory could easily be outweighed by the risk to the fetus, as a mother-to-be eats methylmercury-contaminated fish from FDA's "safe" menu.

Figure 1. At FDA's recommended fish consumption levels, about 20,000 pregnant women each year would have high mercury blood levels for 9 months of their pregnancy.



Source: Environmental Working Group.

Women have a 44 percent chance of exceeding the safe blood level at some point during her pregnancy eating FDA's recommended 12 ounces of fish per week.

safe level of blood mercury for part of their pregnancy just by virtue of the fish they ate in the months before conception (and other sources of methylmercury exposure less significant than fish consumption). A new study of a much larger population of women from the Centers for Disease Control and Prevention shows that about 10 percent of all women have blood methylmercury levels above the benchmark dose recommended by the NAS (CDC 2001). The raw data from their study, however, are not yet publicly available and are not analyzed here.

The fourth scenario shows how the average woman fails to represent the diverse population of women in the U.S. Under EPA's risk assumptions (Table 2) the average woman eating FDA's 12 ounces of fish per week has only a two percent chance of exceeding the safe blood level of mercury for any period of time during her pregnancy. In contrast, when the real world variability among women is factored in, a woman has a 44 percent chance of exceeding the safe blood level at some point during her pregnancy.

Which fish are safe for pregnant women?

How much fish can a woman eat through pregnancy if she wants to play it safe? That depends on the fish she eats, her size, and weight, and a host of biological factors described above (Table 2).

To gauge which fish are relatively more dangerous than others, we calculated the number of meals a woman could eat of each fish and still avoid having an unsafe methylmercury level for a month of pregnancy. We estimated the percent increase in the number of women whose blood methylmercury level would exceed the benchmark rose for more than 30 days during pregnancy, as the number of fish meals eaten throughout pregnancy increase from one, to FDA's recommendation of 76. The results show that the type and amount of fish a woman chooses to eat matters tremendously.

If pregnant women limit their consumption of the fish known to be low in methylmercury, women can get the nutritional benefits of fish consumption without the risk of adverse neurological fetal effects. For the following fish, data from government and university studies show that methylmercury levels are consistently low:

Trout (farmed)
Catfish (farmed)
Shrimp * (see endnote)
Fish Sticks
Flounder
Salmon (wild Pacific)
Croaker
Blue crab (mid Atlantic)
Haddock

Which fish are *not* safe for pregnant women?

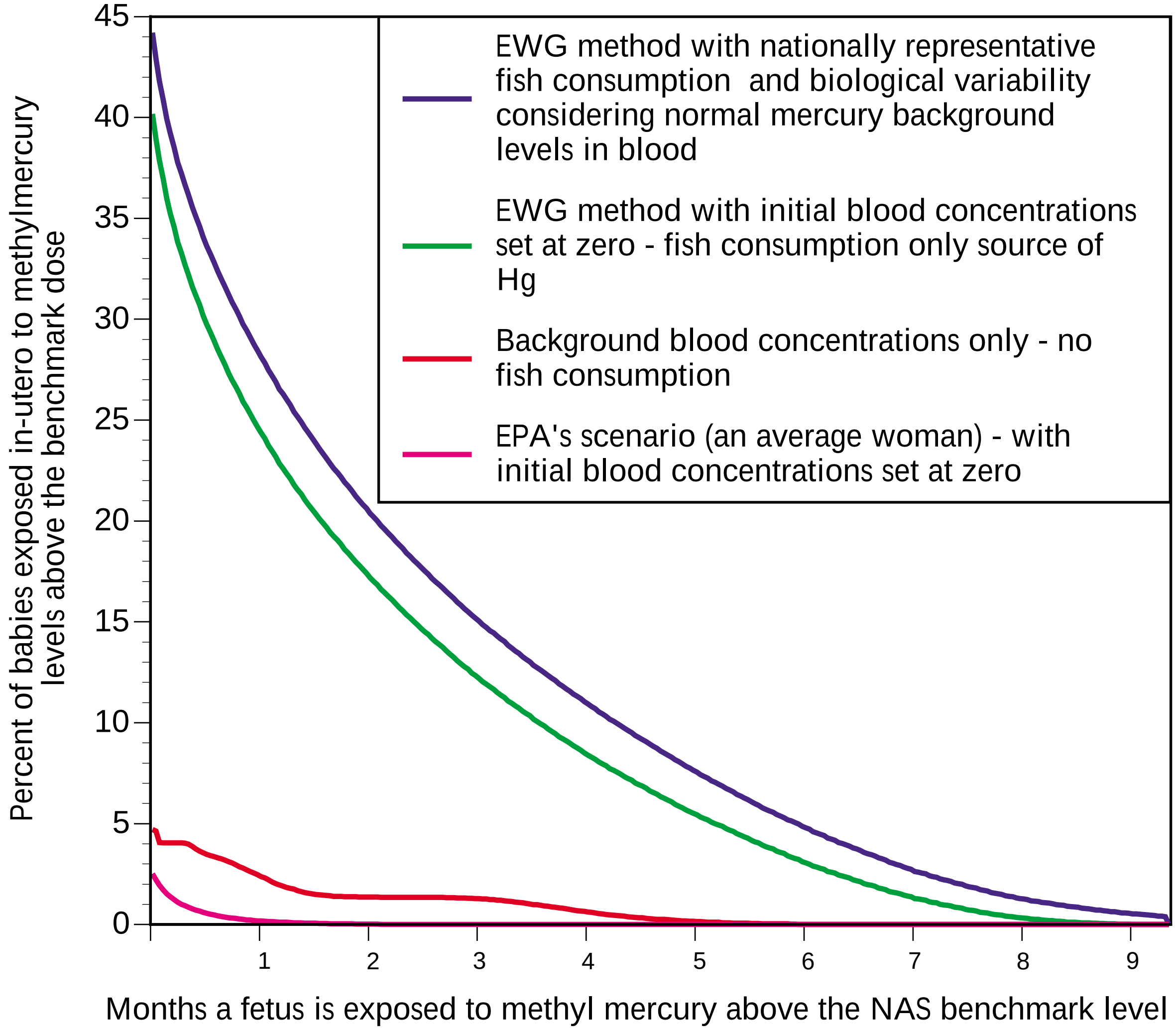
For more than half of the fish we studied in detail (10 out of 19 species), between one 6 ounce fish meal per pregnancy, and one 6 ounce meal *a month* during pregnancy, presents an unacceptable level of risk. Unacceptable is defined here as a rate of consumption that will cause more than one out of every 1,000 pregnant women to exceed the NAS benchmark blood level of methylmercury (5.8 ppb) for more than 30 days during pregnancy.

Four fish species; sea bass, tuna (steaks), halibut, and white croaker, were added to our list of species that pregnant women should avoid completely during pregnancy. For all of these species it is clear that 6 ounces of consumption presents a significant risk of elevated methylmercury exposure across the general population (Figure 3). As shown in figure 3, by the sixth month of pregnancy or sooner, monthly consumption of these fish translates into sharply rising risk. Marlin and three fresh water sportfish (pike, largemouth bass, and walleye) were added to our list pregnant women should avoid due to their very high mercury concentration levels.

Ten other species were placed on a "eat with caution" list, where consumption must be restricted to no more than one fish on the list per month to keep population-wide risks in the acceptable range. For some species on this list, particularly tuna (canned), risk starts to rise across the population after about seven months of even this severely restricted level of intake.

The type and amount of fish a woman chooses to eat matters tremendously.

Figure 2. If FDA's advice to eat 12 ounces of fish per week were adhered, over 28 percent of American women would have a blood mercury level that exceeded NAS's recommended benchmark level of 5.8 ppb – for an entire month of pregnancy.



Source: Environmental Working Group. Note: all scenarios assume consumption of 12 ounces of fish per week.

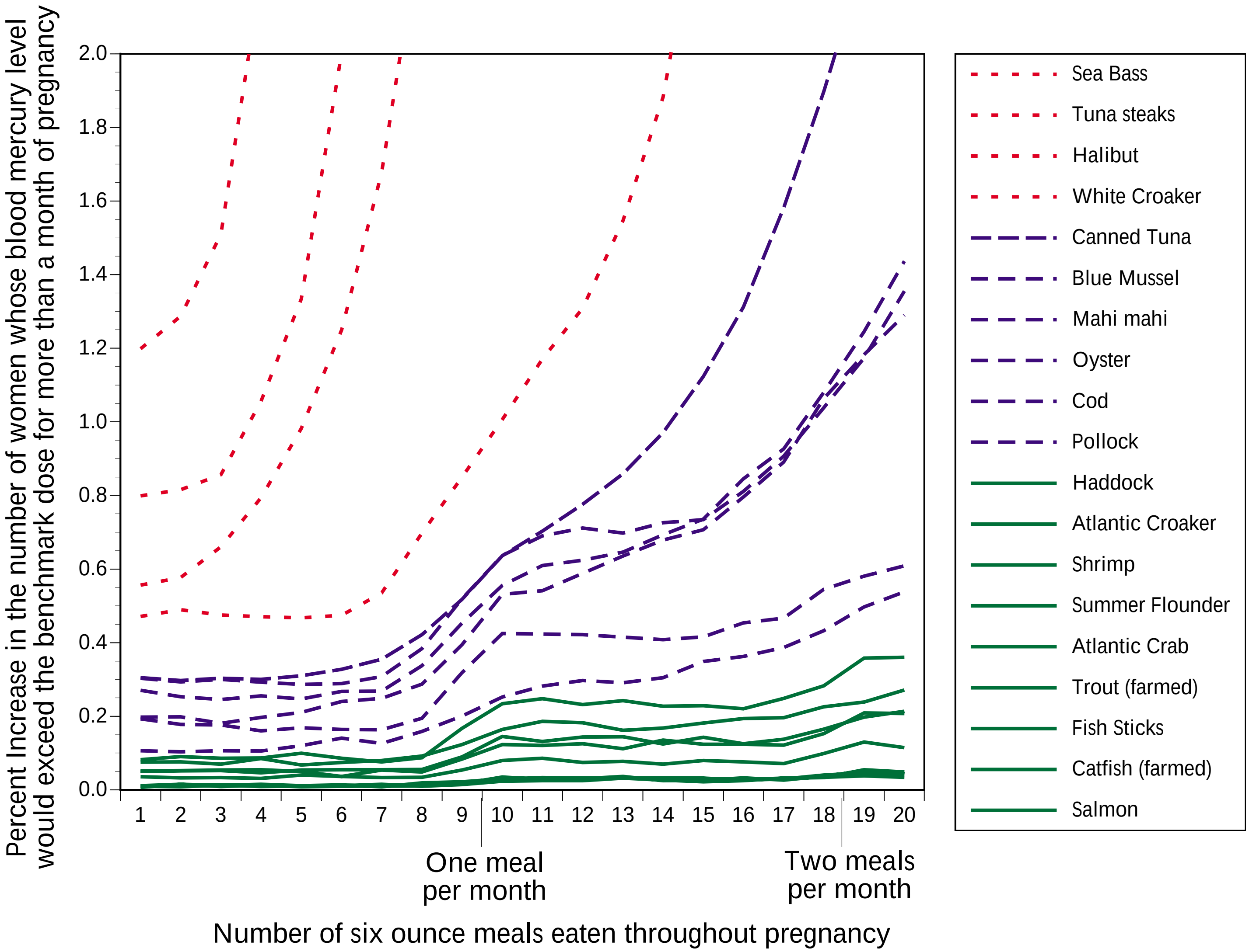
After a thorough review of the literature, numerous conversations and a meeting with FDA staff, however, we must conclude that the Agency's information on methylmercury contamination for many fish species is neither current nor complete.

Improving FDA's information base

The Environmental Working Group submitted a Freedom of Information Act request to the FDA nine months before the release of this study (June 2000), requesting mercury testing data in electronic form. Our request was denied for being too broad.

As a result, we have no way of knowing what data the FDA actually has in its files to assess the risks of methylmercury in fish. After a thorough review of the literature, numerous conversations and a meeting with FDA staff, however, we must conclude that the Agency's information on methylmercury contamination for many fish species is neither current nor complete. For example, in January 2001, FDA added king mackerel to the list of

Figure 3. A number of fish on FDA's safe list present unacceptable risk to pregnant women and their babies.



Source: Environmental Working Group.

fish pregnant women should not eat based on information from a 1979 study of mercury contamination levels.

Apparently FDA scientists have no more recent information on which to judge contamination levels in king mackerel. Based on our conversation with Agency staff we must conclude that this absence of current data applies to many other species as well.

EWG did ultimately receive paper copies of FDA data – 132 pages of mercury testing results – from Michael Bender of the Mercury Policy Project, who had received paper copies of the data from the Agency a year ago.

EWG analysts hand-entered these 132 pages of test results into an electronic database. They were used along with thousands of other methylmercury test results from

In January 2001, FDA added king mackerel to the list of fish pregnant women should not eat based on information from a 1979 study of mercury contamination levels.

Table 3. Mercury contaminated fish identified more than 20 years ago.

Atlantic cod
Pacific cod
Flounder, various species
Grouper, black
Grouper, red
Halibut
Sand perch
White perch
Pollock
Red snapper
Dover sole
Tuna, various species
Yellowtail

other agencies in the exposure analyses presented in this study.

Priorities for monitoring

A 1997 analysis published by FDA scientists lists 13 fish with an average mercury concentration at or above that for canned tuna (Cramer 1997) (Table 3).

Our analyses show that fish with this amount of mercury pose an unacceptable level of risk across the population for adverse neurological effects to the fetus if consumed just once a month. These data, however, are now over 20 years old. Twenty-five years has brought significant increases in global mercury emissions and significant increases in fish consumption. As a first step in protecting women from methylmercury, FDA must improve monitoring of these potentially contaminated fish and make the results available to the public.

Endnote

** Shrimp fishing and farming practices have raised serious environmental concerns.)*

The Chaotic Web of State Mercury Advisories

U.S. PIRG compared different systems used by the states to issue fish consumption advisories. These systems vary widely from state to state, resulting in a situation that is both confusing to consumers and, in many cases, inadequately protective of the health of a growing fetus or child. These systems vary in several key elements. Many states do not monitor their water bodies routinely for mercury contamination in fish. If a state is not testing for mercury contamination in fish, they cannot be protecting residents from mercury exposure. A further inconsistency is that the levels of mercury contamination that trigger advisories vary by a factor of more than 10 among the states, so that residents of some states can be exposed to significantly higher levels of mercury than others before the state issues an advisory. Finally, the advice that states give their consumers about how much fish should be consumed at a given contamination level varies widely as well.

Inadequate monitoring

Fifteen states do not have a routine monitoring program in place to test mercury levels in fish tissue, and five states monitor mercury contamination somewhat routinely, meaning that some testing is performed, although not on a consistent basis. Thus, even if a state has a system for issuing advisories at reasonably low levels of mercury contamination, scores of water bodies will not be tested for contamination.

It is important to note that most states with no routine monitoring also have very few fish consumption advisories – some of these states might find mercury contamination that merits issuing an advisory if they implemented routine monitoring programs. There are a few states listed as having “no or somewhat routine monitoring” that do have active advisories based on monitoring performed in the past. In addition, a few states have erred on the side of caution by issuing statewide advisories even though a monitoring system is not in place, or not all waters have been tested. New Jersey and Massachusetts are two states taking this precautionary measure and advising their residents to avoid potential harm. The following states do not monitor fish for mercury contamination: Arizona, Arkansas, Colorado, Connecticut, Hawaii, Idaho, Nevada, North Dakota, Oregon, Rhode Island, Texas, Utah, Washington, West Virginia, and Wyoming. The following states perform somewhat routine monitoring: Alaska, California, Massachusetts, Montana, and New Mexico.

Fifteen states do not have a routine monitoring program in place to test mercury levels in fish tissue.

EPA should determine the level of mercury contamination in fish that will protect at least 999 out of every 1,000 pregnant women exposed, and recommend this level as the trigger for fish advisories.

Varying threshold levels

Much of the inconsistency among the state advisory systems comes from the different levels of mercury contamination in fish that states use to determine when to issue an advisory. Most states follow either FDA's or EPA's guidance, although some have performed their own scientific assessments to set thresholds of mercury contamination (Table 4).

Nine states issue advisories when mercury contamination reaches FDA's action level of one ppm. FDA's action level is inadequate to protect public health, and particularly the health of a growing fetus or child (see Chapter 3).

Other states follow EPA's guidance, which advise limiting mercury intake to 0.1 micrograms of mercury per kilogram of body weight per day. States use assumptions or data on fish consumption rates and body weights to determine how much mercury can be "safely" present in fish in order to avoid exceeding the reference dose. This is intended to provide flexibility for states to determine action levels based on the characteristics of their population, on the notion that people who weigh more can "safely" ingest more mercury, or that people who eat fish less often can ingest more mercury when they do eat fish. In practice, however, the flexibility model has resulted in inappropriate advisory systems in many states. These arise from a variety of flaws in implementation – states may base their extrapolations on assumptions about body weight or fish consumption from national averages rather than state-specific data. The more a state uses factors like average consumption rates for a given body of water or species of fish to tailor consumption advice, the less the advisory will protect someone to whom the average does not apply. The person who eats the species most others do not or who consumes fish more often from bodies of water that few others consume from will not be protected by the advisory.

While FDA's recommended threshold of one ppm of mercury in fish tissue is too high to be protective of fetal health and childhood development, its one virtue is its simplicity and, in theory, its consistency. If the threshold were an enforceable tolerance, any fish above the threshold, regardless of species or where it was caught, would be under an advisory for human consumption. EPA's advised reference dose for mercury ingestion, on the other hand, results in a system where different levels of mercury contamination in fish will be considered safe or unsafe by different states. To make advisories simpler and more protective, EPA should determine the level of mercury contamination in fish that will protect at least 999 out of every 1,000 pregnant women exposed, and recommend this level as the trigger for fish advisories. Currently, no state fish advisory meets this standard of public health protection except Massachusetts, which advises pregnant women to avoid all fish from state waters. This level should trigger an advisory regardless of location or species.

Other states follow neither EPA's nor FDA's advice, but rather use their own scientists and risk assessments to determine the level at which to issue an advisory. The adequacy of these programs depends on the assumptions made. Some states use extremely non-protective numbers in their risk assessments, while a few go above and beyond both FDA and EPA recommendations.

Protecting general and sensitive populations

Because of mercury's ability to harm a developing fetus or a growing child, many states issue more protective fish consumption advisories for sensitive populations in addition to their advisories for the general public. Sensitive populations typically include pregnant women, nursing women, women of childbearing age or who are considering pregnancy, and children. State advisory systems can be roughly divided into three categories based on how they advise sensitive populations.

In many states, one level of mercury contamination triggers advisories for both general and sensitive populations. In many of these states that threshold is too high to protect not only sensitive populations but also the general public. Often this level is FDA's threshold of one ppm. In general, using the same threshold for both the general public and for sensitive populations means that a state is not taking extra precautions to protect the most sensitive populations, unless the threshold used for both groups is extremely low and therefore protective of both.

Almost twenty states have one action level for all populations, but issue a stricter advisory for sensitive populations. For example, in

Table 4. Threshold levels for sensitive populations.

State	Threshold - Sensitive Populations (ppm)
Alabama	1
Iowa	1
Mississippi	1
Missouri	1
New York	1
North Carolina	1
Oklahoma	1
Rhode Island	1
Virginia	1
Texas	0.7*
Arkansas	0.5
Colorado	0.5
Florida	0.5
Idaho	0.5
Illinois	0.5
Louisana	0.5
Michigan	0.5
Tennessee	0.5
Oregon	0.35
South Dakota	0.3
Maryland	0.26
Nebraska	0.25
New Mexico	0.25
South Carolina	0.25
Georgia	0.23
Connecticut	0.2
Maine	0.2
New Hampshire	0.2
Pennsylvania	0.13
Kentucky	0.12
Delaware	0.12**
New Jersey	0.08
Ohio	0.05
Minnesota	0.038
West Virginia	0.028
Indiana	0
Montana	0
Massachusetts	not applicable
Wisconsin	not applicable
North Dakota	no set threshold
Arizona	no set threshold
California	no set threshold
Nevada	no set threshold
Vermont	no set threshold
Washington	no set threshold
Alaska	no system
Hawaii	no system
Kansas	no system
Utah	no system
Wyoming	no system

* approximately
** triggers testing only

Source: The State PIRGs

A complete review of all state fish consumption advisory systems shows that while some states are far better than others, nearly all (49 out of 50) states inadequately protect the health of sensitive populations from methylmercury.

Nine states continue to issue advisories at FDA's extremely high mercury contamination level of one ppm: Alabama, Iowa, Mississippi, Missouri, New York, North Carolina, Oklahoma, Rhode Island, and Virginia.

Florida, mercury contamination at 0.5 ppm triggers an advisory for both populations. However, the advisory for the general population is one meal per week, and the advisory for sensitive populations is one meal per month. While Florida's system and others like it are an improvement over across-the-board thresholds, they will not be protective of fetal health unless the single threshold is set extremely low to protect sensitive populations. In Florida's case, although one meal per month is a step in the right direction, 0.5 ppm is too high a level of mercury contamination to protect a developing fetus or growing child.

Some states increase protection for sensitive populations by using a separate threshold to issue advisories for sensitive populations. This system can be protective if thresholds are low enough. For example, New Jersey uses a 0.35 ppm threshold for the general population and 0.08 ppm for sensitive populations. New Jersey's threshold for sensitive populations (and general populations) is among the lowest in the country, meaning New Jersey's residents are among the first in the country to know if mercury levels in fish start to rise. By contrast, however, Oklahoma uses a 1.5 pppm threshold for the general population, and one ppm for sensitive populations. Oklahoma's thresholds allow a much higher level of mercury contamination in fish before warning residents of the hazard and are clearly less protective. Although Oklahoma has no fish consumption advisories at all for mercury, it should be noted that mercury would have to reach extremely high levels of contamination before Oklahoma would issue an advisory.

How the states stack up

A complete review of all state fish consumption advisory systems shows that while some states are far better than others, nearly all (49 out of 50) states inadequately protect the health of sensitive populations from methylmercury. See Appendix D for more detail. Adequate protection is defined here as no more than 1 in 1,000 women exceeding the NAS benchmark dose for methylmercury in maternal blood for 30 days during pregnancy. Based on the level of methylmercury contamination at which states begin to issue advisories, in all states, with the exception of Massachusetts, women will exceed this level of risk.

Nine states continue to issue advisories at FDA's extremely high mercury contamination level of one ppm: Alabama, Iowa, Mississippi, Missouri, New York, North Carolina, Oklahoma, Rhode Island, and Virginia. While the amount of consumption recommended under these advisories ranges from no consumption to four 8-ounce meals per month, allowing this level of mercury in fish before issuing an advisory is not protective of fetal health or childhood development.

A few states issue advisories that recommend no fish consumption at relatively low levels of mercury contamination. For example, Connecticut advises sensitive populations to avoid consumption of fish completely when mercury contamination in fish tissue reaches 0.2 ppm. However, consumption of even one 8-ounce meal per month of fish contaminated at this level (or just below it) can expose the developing fetus to harmful levels of mercury. In fact, unless a state issues advisories recommending that sensitive populations consume no fish above a mercury contamination level of approximately 0.05 ppm, more than 1 in 1,000 pregnancies could be exposed to unacceptably high levels of mercury.

Some states begin to issue advisories at levels low enough to potentially protect fetal health and childhood development, but these do not recommend that women avoid fish consumption completely when levels rise above 0.05 ppm. States issuing limited consumption advisories at levels at or below 0.05 ppm include: Montana and Indiana (both begin to issue advisories at the lowest detectable level of mercury contamination), West Virginia, Minnesota, and Ohio.

Arizona, California, Delaware, Nevada, Vermont, and Washington issue advisories using risk assessments on a case-by-case basis, meaning that there is no set level of mercury contamination that triggers an advisory. North Dakota has no set level at which it issues an advisory, but employs a statewide advisory based on EPA's reference dose. In many of these states, officials take into account not only the level of contamination, but also other variables like the degree to which a body of water is used for recreational fishing or the frequency that a given species is caught or eaten.

While some variables do change with respect to water body or species, the amount of mercury that can do harm to human health does not.

Five states, Alaska, Hawaii, Kansas, Utah, and Wyoming, currently have no system for issuing advisories. For certain states, mercury contamination may not be a major problem. For others, there is simply no routine monitoring for mercury contamination. Of these five states, only Kansas routinely monitors mercury contamination in water.

Massachusetts is the only state that adequately protects fetal health and childhood development. Massachusetts' statewide advisory advises no consumption for all lakes and rivers in the state no matter what level of mercury is present. This sends a straightforward message and does not require consumers to know which species are on what type of limited consumption advisory and which water body the advisory applies to.

Chapter 5

Health Tracking Recommendations

When the first cases of West Nile virus were discovered on the East Coast, one of the first actions taken by health officials was to establish multi-state tracking and monitoring so that they would immediately know when and where West Nile virus was occurring. But when it comes to most chronic diseases and potentially related environmental exposures to toxic substances we have not made the same connom-sense investment.

The Centers for Disease Control and Prevention (CDC) has just begun to track Americans' exposure to methylmercury through biomonitoring, the testing of tissue samples for the metal. But, this is limited to a broad federal survey and there are no state or local data to inform health officials where mercury levels are highest or lowest in the American population. Similarly, there is no comprehensive tracking of when and where children experience developmental and neurological deficits that have been linked to mercury exposure. Knowing when and where Americans are exposed to the highest levels of mercury and other neurological and developmental toxicants and when and where American children display health impacts that could be related is a basic step in fighting environmental impacts on health.

The State PIRGs, EWG, and a growing coalition of health and environmental organizations are calling on Congress and the CDC to establish a comprehensive nationwide health tracking network with several key components, listed below.

A comprehensive nationwide environmental health tracking network is a key first step toward assessing the impacts of a range of environmental hazards on public health. Such a system would provide vital information to health care providers and agencies working to protect public health.

- The network should begin in all 50 states by tracking: asthma and chronic respiratory diseases, birth defects, developmental and neurological conditions like those linked to mercury exposure, and cancers. The tracking of human exposures to hazards would start with priorities including PCBs and dioxin, heavy metals such as mercury and lead, pesticides, and water and air contaminants.

- An Early Warning System would alert communities to immediate health crises such as heavy metal and pesticide

A comprehensive nationwide environmental health tracking network is a key first step toward assessing the impacts of a range of environmental hazards on public health.

poisonings. Similar to the monitoring currently in place for an outbreak of an infectious disease, this alert would help local communities identify more quickly and act immediately on health crises from environmental exposures.

- Pilot Programs would allow 20 different regional and state initiatives to investigate local environmental health priorities, provide flexibility for local officials, allow community groups to gather more information and serve as a model for potential inclusion in the nationwide network.

- Federal, state and local rapid response capability would enable health officials to investigate clusters, outbreaks and emerging threats. To respond effectively and protect the public from illness, health officials must be well-equipped and trained, and the network must be supported through state and federal resources. Steps taken to improve states' capacity should include placing an Environmental Health Investigator in every state and training health officials in environmental epidemiology.

- Support of community interests and scientific research will be crucial to further health tracking efforts. Five Centers of Excellence should be funded for environmental health research and training, and partnering with communities. Communities and the public have the right to know information that could safeguard their health; the information made available through the tracking network should be accessible to the public. Input from local groups on the design and implementation of the tracking and monitoring of chronic disease and environmental hazards will be needed to ensure the success of the Nationwide Health Tracking Network.

Appendix A
Exposure Assessment Methodology

Summary

The Environmental Working Group (EWG) has developed a computational procedure that allows for the calculation of time-dependent mercury concentrations in the blood of a woman who eats seafood during her pregnancy.

These procedures combine work done by Stern (1997) on biological variability and Ginsberg and Toal (2000) on non-steady state modeling of mercury in blood. On top of these two pieces of work, we add a new piece: the concentrations of mercury in fish from a compilation of seven government databases compiled by EWG. With these three components, we are able to estimate the concentrations of mercury in a woman's blood, with time, throughout a pregnancy, after each meal of fish she eats.

The procedure is a probabilistic model based on Monte Carlo methods which incorporate measured variability in body weight, background levels of mercury in blood (used as initial concentrations in the model), the body's absorption of mercury, and the decay rate of mercury in blood. Monte Carlo techniques are also used to account for variability of mercury in fish. The mercury data used are 52,395 records compiled by EWG that comprise publicly-available fish tissue data from seven government databases maintained by the Environmental Protection Agency (EPA), the Food and Drug Administration (FDA), and the National Oceanic and Atmospheric Administration (NOAA). These concentrations in fish tissue serve as exposure concentrations for a pregnant woman eating one or more servings of fish throughout her pregnancy.

In the model, mercury from fish is absorbed through the gut, distributed to the blood, and is subsequently redistributed in and excreted from the body consistent with the National Academy of Science's recent review of the toxicity of methylmercury (NAS, 2000). Biological variability in absorption, distribution, and decay of mercury in blood is represented by the statistical distributions presented in Stern (1997).

Our model allows us to calculate the probability that the concentration of mercury in the blood of a pregnant woman would be above a level of concern for a specified period of time, and for a specified amount of fish eaten during pregnancy. Model parameters used in the model are summarized in Table 5.

Model Procedures

Initial concentration

The model assumes that the initial concentration of mercury in a pregnant woman's blood is consistent with the distribution found in Stern et al's study of 149 pregnant women in New Jersey. Since this study had a high rate of non-detects (due to a relatively high detection limit of 0.5 ppb), we have assumed that, for values below Stern's detection limit, the blood concentrations fit the distribution from Nixon et al's study of 902 blood samples from a normal human population with no known occupational exposures (Nixon et al 1996). This study has a detection limit of 0.2.

During model simulations, we allow the blood concentration to fall below the initial concentration, down to a minimum concentration of 0 ug/L, as dictated by an exponential decay term that represents the fall-off of mercury in blood between doses.

Mercury concentration of concern

For purposes of these calculations, we derived a "safe" concentration of mercury in maternal blood to which we compare calculated blood concentrations. This safe concentration was derived from the results of the Faroe Islands study (Grandjean et al., 1997, 1998, 1999) using recommendations proposed in the NAS study (NAS 2000).

Table 5. Model parameters used in EWG monte carlo simulations.

Parameter	Values used in Monte Carlo simulations	99% of population encompassed by…	Reference
Body weight, pounds	mean 151 pounds, 4935 records for women age 15-40	90 to 303 pounds	NHANES IV
Initial mercury concentration in blood	range of detected values in NJ pregnant population, supplemented with distribution from large Quebec population for levels below the NJ non-detect levels		Stern 2001, Nixon et al 1996
Elimination constant, d-1	mean 0.014, SD 0.0026, lognormal distribution	31 to 81 day half-life (avg 50)	Stern 1997
Blood volume, L	volume = 0.037L/kg*kg + 1.43 L (function of body weight)	2.9 to 6.5 liters	Stern 1997
Fraction of absorbed Hg distributed to blood	mean 0.067, SD 0.019, lognormal distribution	0.031 - 0.13	Stern 1997
Fraction of ingested Hg absorbed thru gut	mean 0.94, SD 0.016	0.90 - 0.98	Stern 1997
Blood level of concern	5.8 ppb (58 ppb benchmark dose, uncertainty factor = 10)		NAS 2000

Source: Environmental Working Group.

NAS recommends that an allowable level of methylmercury exposure be derived from the mercury concentration in the Faroe Islands study found to be protective of 95% of the population, with an uncertainty factor of at least 10 to account for natural biological variability and database deficiencies. NAS found that the cord blood level corresponding to this statistically significant effect was 58 ug/L. Applying the NAS-recommended uncertainty factor of 10, and assuming a maternal blood concentration equal to the cord blood concentration gives a concentration of concern of 5.8 ug/L in the mother's blood.

Mercury concentrations in fish tissue

Our analysis uses exposure concentrations derived from seven government databases of mercury concentrations in fish tissue, shown in Table 6.

For the purposes of our analyses, we assume a mercury concentration of 0.0 mg/kg where mercury was not detected in a sample. Previous studies have assumed a concentration equal to half the detection limit for these "non-detect" samples, but in this case we are not able to apply this convention consistently, as the FDA and NOAA databases do not include the detection limit. Therefore, we chose instead to assign consistently a mercury concentration of 0.0 mg/kg to non-detect samples throughout our analysis. This convention results in the underestimation of mercury concentrations in maternal blood.

Table 6. EWG's mercury analysis draws on fish tissue data from 3 government agencies and 7 databases.

Source of data	Database	Number of records	Years of record
Environmental Protection Agency	1990-1995 Mercury in Fish Tissue Database	37,525	1990-1995
Environmental Protection Agency	Fish Tissue Database within the National Fish and Wildlife Advisory Database	12,906	1990-1998
Environmental Protection Agency	Environmental Monitoring and Assessment Program database	873	1997-1998
Food and Drug Administration	Mercury monitoring in seafood	1,282	1991-1998
Food and Drug Administration	FDA Tuna Study	218	1991
Food and Drug Administration	Total Diet Study	112	1994-1996
National Oceanic and Atmospheric Administration	Gulfchem Database	2,702	1990-1998

Source: Environmental Working Group.

Consumption of fish

We look at two major scenarios – one to simulate FDA's advisory stating that women can safely eat 12 ounces of fish per week as long as those fish do not include shark, swordfish, king mackerel and tilefish; and another to simulate EPA's advisory that pregnant women can safely eat one gamefish per week.

For the FDA scenario, we assume a pregnant women eats two six-ounce servings of fish per week. For the EPA scenario, we assume a woman eats one 8-ounce portion of fish each week. In both scenarios, the mercury concentration in fish is chosen randomly from our fish concentration database.

EPA reports an 8 ounce portion of fish to be the 95th percentile consumption quantity for females age 19 through 34, based on their analysis of the United States Department of Agriculture's (USDA's) Continuing Survey of Food Intake by Individuals (CSFII) database (EPA 1997). Their estimates, however, include meals for which fish is not necessarily the main course, and also include data on consumption of canned tuna fish, which is typically packaged in six-ounce portions. In fact, canned tuna consumption, plain or as tuna salad, accounts for 30% of the available fish consumption data for women of childbearing age in the CSFII database, and the quantities consumed tend to be less than those corresponding to fish fillets. EPA's estimates are, therefore, strong indicators of canned tuna consumption, but not necessarily consumption of fish fillets.

Using CSFII data, we calculated consumption numbers corresponding to fish fillets only, exclusive of canned tuna and other types of seafood. We included in our analysis fish fillets for which the cooking method was recorded as steamed, poached, broiled, or baked, as these methods of cooking would tend to add little weight to the fish (relative to breading or frying). From this analysis, we find that the 95th percentile consumption amount for women of childbearing age (ages 13 through 50, inclusive), is about 11 ounces, or about 40% greater than EPA's estimate. The 8 ounce serving we have assumed for these preliminary analysis corresponds to about the 91st percentile consumption for women of childbearing age – in other words, women eat more than 8 ounces of fish in nearly 1 of every 10 meals of fish.

Absorption and distribution of methylmercury

The fraction of ingested mercury absorbed from the gut to the blood is a random variable in our model which fits the normal distribution given in Stern (1997) – with mean of 0.94 and a standard deviation of 0.016.

The amount of the absorbed mercury that is distributed to the blood is also treated as a random variable in the model, using the log-normal distribution presented by Stern (1997) – with mean of 0.067 and a standard deviation of 0.019. In our model absorption and distribution to the blood occurs instantaneously.

A woman's blood volume is also treated as a random variable in this model. Using all weight data for women of childbearing age from NHANES IV, we calculate a blood volume from the equation given in Stern (1997):

$$BV = 0.037*weight + 1.43 \qquad \text{(Equation 1)}$$

where: BV = blood volume in liters; weight = body weight in kilograms

In our model, then, the concentration of mercury in a woman's blood immediately after she eats a fish is calculated as:

$$C_t = C_o + (C_{fish}W/BV)K_1K_2 \qquad \text{(Equation 2)}$$

where: C_t and C_o = concentrations of mercury in blood immediately following and immediately prior to ingestion of contaminated seafood, respectively (ug/L), where ingestion occurs at time t; W = weight of fish portion consumed (g) – assumed in this analysis to be 8 ounces, or 227 g; BV = blood volume (L) – random variable in our analysis; K_1 = fraction of methylmercury absorbed by gut; and K_2 = fraction of absorbed methylmercury that is distributed to blood.

Decay of mercury concentrations in blood

In our model, we assume mercury in blood decays in time with half-life consistent with the distribution presented in Stern (1997). Stern calculates a decay constant represented by a lognormal distribution with a mean of 0.014 d^{-1} and a standard deviation of 0.0026 d^{-1}. This decay constant is a random variable in our model.

The concentration of mercury in blood following ingestion of fish is therefore calculated as:

$$C_t = C_o\exp(-kt) \qquad \text{(Equation 3)}$$

where: C_t = concentration of mercury in blood at time t (ug/L); C_o = concentration of mercury in blood immediately following ingestion of seafood (this term is represented as C_t in Equation 2); k = decay constant chosen randomly from the assumed lognormal distribution; and t = time over which mercury is allowed to decay, or in our case, time between fish consumption (days). Note that C_t is constrained in our analysis by a lower bound of 0.0 ug/L.

Calculation of probability of exceeding blood mercury level of concern

The probability of exceeding blood mercury levels of concern throughout a woman's pregnancy is calculated using Monte Carlo techniques to choose concentrations of mercury corresponding to meals of fish a pregnant woman is assumed to eat.

The model pulls records from the fish tissue database compiled by EWG according to the individual or group of species we specify as input data for each model run. These records contain mercury concentrations in fish tissue that, in the Monte Carlo portion of the analysis, serve as exposure concentrations for individual meals.

If a group of species is selected, the model will, during the simulation, either give equal weight to the individual species when randomly choosing a tissue concentration to serve as an exposure dose, or will weight the species according to parameters in the input file, if we know the relative consumption of individual species among the general population and can provide this data. (We know, for example, the relative frequency with which various species of salmon are eaten, and can therefore provide weighting factors in a salmon consumption analysis that cause the model to choose samples consistent with those weighting factors.)

A "simulation" of this model refers to a scenario in which the mercury concentration in a pregnant woman's blood is modeled through the entire period of gestation, given a particular species or group of fish she will consume during her pregnancy, and given a specified number of evenly-spaced (in time) meals of fish she will eat throughout her pregnancy.

The answers from the model are a sequence of probabilities that, given a certain number of fish and type of fish eaten throughout pregnancy, a woman's blood mercury level would exceed the level of concern for at least x days, with x ranging from less than 1 day up to the entire period of gestation (265 days).

The total time of exceedence in any given simulation is the sum of all individual exceedence times that follow each meal of fish:

$$E_{total} = \Sigma\ E_i \qquad \text{(Equation 4)}$$

where: E_{total} = total time during pregnancy for which mercury blood concentration exceeds the level of concern (days); and E_i = total time immediately following an individual meal of fish for which mercury blood concentration exceeds the level of concern (days); and i = the number of meals of fish consumed by a woman during the length of her pregnancy – set as a basic input parameter for each simulation. Meals of fish are assumed in the model to be evenly-spaced throughout pregnancy.

The probability of exceedence is initially calculated after a large number of Monte Carlo-based simulations are completed for a given simulation:

$$P_i = (\Sigma_i\, n \big|_{Et>i})/n_{total} \qquad \text{(Equation 5)}$$

where: P_i = the probability that a woman's blood mercury concentration will be above the level of concern for at least i days during her pregnancy, given a specified number of meals and types of fish eaten through pregnancy;

$\Sigma_i\, n \big|_{Et>i}$ is the total number of Monte Carlo runs for which the simulated exceedence time E_t (calculated as E_{total} in equation 4) is greater than i days; and n_{total} = the total number of Monte Carlo runs completed.

A new probability array is calculated after another sequence of Monte Carlo-based simulations. The new probability array is compared to the previous array until convergence, with new sequences of Monte Carlo-based simulations conducted as many times as necessary. When subsequent solutions are found to be essentially the same, the simulation is complete. We find that a convergence criteria of 0.1 percent between the old and the updated probability arrays is sufficient for these simulations.

FDA's New Advisory

FDA's updated fish advisory states that pregnant women can safely eat 12 ounces of fish per week if the species of fish eaten exclude all shark, swordfish, king mackerel, and tilefish. This is the model scenario we have constructed.

This scenario includes canned tuna, tuna steaks, shrimp, crab, salmon, pollock including fishsticks, haddock, channel catfish and lake trout. In this scenario, fish consumption – that is, the type of fish chosen for a particular run in the Monte Carlo simulation — is weighted by the actual amount of each type of fish eaten per year in the U.S. So, for instance, canned tuna is much more likely to be chosen in a particular model run than is tuna steak, which is eaten much less frequently.

Model results are described in the main body of this report.

Appendix B: State Survey Method

State Surveys

The raw data used for this report comes from a phone survey of each of the fifty states. State contacts at Departments of Health or Departments of Environmental Protection, depending on who was responsible in each state for issuing the advisories, were asked the following questions:

- How many fish consumption advisories for mercury are there in the state?
- Is there a statewide advisory?
- What is the threshold (in parts per million) used to issue a fish consumption advisory for the general population?
- What is the threshold (in parts per million) used to issue a fish consumption advisory for sensitive populations?
- How is that threshold decided upon?
- Does that threshold trigger NO or LIMITED consumption? If limited,

  Please describe what level of fish consumption is recommended at the threshold level indicated above for both sensitive and general populations (i.e., how many ounces of fish is a person advised to consume at the indicated threshold level?).

  Also, if there is a statewide advisory, what level of fish consumption is recommended at the threshold for the statewide advisory?

- Are advisories issued based on average fish tissue data, highest concentration, or another method?
- How are advisories publicized?
- Is there a routine monitoring system in place in the state for testing water for mercury contamination?

The surveyor contacted the appropriate officials in each state. The data was then summarized state by state, and each official was contacted again for verification of the information given. Information from approved fact sheets was put into shorter form for the purposes of this report.

Number of Advisories and Statewide Advisories

The figures listed for number of advisories and statewide advisories come from data given to U.S. PIRG by Jeffrey Bigler at U.S. EPA. It is also available on EPA's 1999 National Listing of Fish Consumption Advisories, http://www.epa.gov/ost/fish. For purposes of consistency, data given to us by EPA was used, although there were some slight changes in the year following the release of the most recent data, and data given to us by the states may have differed slightly.

Evaluating State Advisory Systems

Evaluations of state advisory systems were based on the level of mercury contamination at which the state advises sensitive populations to avoid fish consumption completely. Fish advisories in 49 states do not protect the health of sensitive populations based on a probabilistic assessment of the risks allowed under each advisory. Fish advisories are considered adequate when they allow no more than one of every 1,000 pregnancies to exceed the NAS benchmark blood level for mercury for 30 days. Eleven states do not have a set threshold for issuing advisories or do not have a fish consumption advisory system in place.

Appendix C:
Notes on Individual Fish Species

Blue mussel

Domestic blue mussel comes primarily from Maine, and to a lesser extent from Washington. Of the 979 metric tons landed in 1999, 84 percent (821 metric tons) came from Maine, and 15 percent (94 metric tons) came from Washington.

Imports dominate the market. In 1999 less than one percent of the mussels consumed in the U.S. were domestic. In 1999 U.S. landings were 979 metric tons; imports were 15862 metric tons; exports were 844 metric tons. Imports come primarily from Canada (as live, farmed mussels), and from New Zealand (in a form NMFS designates as frozen/dried/salted/brine).

FDA has not tested any blue mussel for methylmercury, imported or domestic. In our analysis, we assume the domestic blue mussel data apply only to the market represented by domestic landings less exports.

Our data: 269 samples from NOAA Gulfchem relational database. Average concentration is 0.144 ppm MeHg (Table 7).

Consumption: Calculated based on total domestic landings less exports. Assume meat is 25% of landing weight minus export weight. Gives 0.00014 lb/person/year = 1 pound (live weight) for every 7100 people. This represents consumption of domestic mussels only – Maine and to a lesser extent Washington are the states that are most likely affected.

Table 7. Contamination of Blue Mussels with methyl mercury.

State	Average MeHg (ppm)	Minimum MeHg (ppm)	Maximum MeHg (ppm)	Samples	Water bodies represented
California	0.180	0.003	0.909	41	8
Connecticut	0.081	0.015	0.153	12	1
Delaware	0.107	0.051	0.162	4	1
Maine	0.190	0.030	0.507	16	3
Massachusetts	0.174	0.042	0.492	50	7
New Jersey	0.219	0.075	0.336	20	5
New York	0.167	0.012	0.543	38	4
Oregon	0.069	0.000	0.123	16	4
Rhode Island	0.111	0.045	0.168	13	2
Washington	0.090	0.033	0.210	51	10
Alaska	0.064	0.000	0.090	8	2

Source: Environmental Working Group.

Catfish, Farmed

Nearly all catfish eaten in the U.S. are raised on farms. In 1999, 270,856 metric tons of catfish were sold from farms (live weight, from Johnson 2000). The commercial catch of catfish and bullheads in 1999 was 3798 metric tons, or about one percent of the farmed catfish amount. Catfish caught commercially have much higher levels of mercury than farmed catfish.

Our data represent mercury concentrations in farmed catfish: generated data distribution from statistics presented in (Santerre 2001): mean = 0.00841 ppm, standard deviation = 0.01401 ppm, from 196 fillet samples collected from channel catfish producers.

FDA has sampled 12 domestic catfish – not designed if farmed or wild. Some of the concentrations are an order of magnitude higher than the maximum concentration found in (Santerre 2001) – these high concentrations might represent wild catfish. The FDA data were not used in our analyses.

Consumption: 1.16 pounds/person/year, from NMFS Top 10 list.

Cod

1999 domestic landings: 247,409 mtons
Pacific cod accounted for 96.1% of total landings (247,409 mtons)
Alaska is the source of 99.9% of the Pacific cod (237,259 mtons)

1999 cod imports: 73,992 mtons
1999 cod exports: 68,729 mtons

Imports are 42% Atlantic cod, remainder is "other" cod. Primary importing countries are Canada and Iceland.

Imports are significant. They accounted for an estimated 29% of consumption in the U.S. in 1999 (based on mass balance of landings, imports, and exports).

Nearly all domestic cod eaten is Pacific cod from Alaska. Imported cod could be Atlantic cod (42% chance), or some other cod (58% chance).

Overall chances:

71% chance of eating domestic cod (Pacific cod from Alaska)
12% chance of eating imported Atlantic cod
17% chance of eating imported "other" cod

Our data:
18 samples from FDA's seafood surveillance program
domestic: 3 Atlantic cod, 12 Pacific cod
import: one black cod, with the highest mercury level in the data set (0.42 ppm), 2 samples called "Cod." The black cod sample was not used in our analyses.

Sampling needs: This fish is eaten frequently – it falls sixth on the top ten list. FDA has tested only 18 of these fish. The single sample they have called "Black cod" has a very high concentration – 0.42 ppm.

Crab, blue

1999 landings: 88,671 mtons, led by North Carolina, Maryland, Virginia, Louisiana
1999 imports: 69,562 metric tons imported for all crabs (blue crab data not given separately)
1999 exports: 27,825 metric tons exported for all crabs (blue crab data not given separately)

Blue crab accounted for 42 percent of crabs landed in the U.S. in 1999, with 77 percent from the Atlantic, and 23 percent from the Gulf of Mexico.

Our data: From EPA's Environmental Monitoring and Assessment Program tissue database. 20 samples from Atlantic states (Maryland – 15; New Jersey – 2; Virginia – 2; and Delaware – 1). NOAA's Gulfchem database contains blue crab data from the Gulf of Mexico, but the majority of samples are from Lavaca Bay, and average concentrations in that data set are an order of magnitude higher than samples from the Atlantic. Data from the Gulf of Mexico were not used in our analyses. FDA has tested 3 crab samples for mercury in their seafood surveillance program. Two of these samples had results an order of magnitude higher than the EMAP data. These three samples were not used in our analyses.

Consumption: 0.54 lb/person/year for all crab (NMFS Top Ten list). Blue crab consumption assumed to be 42% of that, based on relative domestic landings. This gives total blue crab consumption of 0.23 lb/person/yr. This is divided between the Gulf and Atlantic data sets, again based on relative landings. Gulf landings account for 23 percent of total blue crab catch, and Atlantic landings account for 77 percent. This gives Gulf of Mexico blue crab consumption as 0.05 lb/person/year, and Atlantic blue crab consumption as 0.18 lb/person/yr.

Data needs: FDA should test crab, all species, domestic and imported.

Croaker (Atlantic and Pacific White)

Two croakers are caught commercially in the U.S. – Atlantic croakers and the Pacific white croaker.

Atlantic croakers dominate the commercial landings. They accounted for 99 percent (12,177 metric tons) of the 12,250 metric tons of croakers landed in 1999. (NMFS, commercial landings data available online). White croakers account for less than one percent (74 metric tons) of the 12,250 metric tons of croakers landed in 1999 (NMFS, commercial landings data available online).

Croakers are not imported in any significant amount – NMFS does not maintain data on croaker imports.

Atlantic croakers are caught in the Southeast drum and croaker fisheries. Landings in Virginia account for 48% of total Atlantic croaker landings, and North Carolina accounts for 38%. White croaker is caught off the coast of California.

Our Atlantic croaker data: 202 samples from EPA's Environmental Monitoring and Assessment Program. Samples collected from 1991-1994. Nine samples are from the Chesapeake Bay – these may best represent what is caught from the major croaker states (Virginia and North Carolina). The average methylmercury concentration in the Chesapeake Bay samples is 0.01 ppm. These nine samples were supplemented with 193 samples from the Atlantic Ocean between Texas and the Southern tip of Florida. The average concentration of methylmercury in these samples is higher than the average from the nine Chesapeake Bay samples (0.05 ppm vs 0.01 ppm), but even with these higher concentrations included in EWG's exposure analysis, the data indicate that Atlantic croaker appears to be a safe fish for pregnant women to eat.

Our white croaker data: White croaker are the only croaker that FDA has tested for mercury in their seafood monitoring program. They have tested 15 samples. The average methylmercury from these samples is 0.258 ppm, or about an order of magnitude higher than the concentrations in Atlantic croaker from EPA data.

Atlantic croaker consumption: Calculated based on total domestic landings. 0.052 lb/person/year = 1 pound (live weight) for every 19 people.

White croaker consumption: Calculated based on total domestic landings. 0.00032 lb/person/year = 1 pound (live weight) for every 3,125 people.

Fish Sticks

1999 production: 29,510 metric tons (NMFS 1999 summary report)
1999 imports: 11,908 metric tons
1999 exports: 9,992 metric tons

Balance in U.S. in 1999: 31,426 metric tons. Imports account for 38% of supply.

Our data: FDA Total Diet Study contains mercury data for 16 samples of fish sticks.

Consumption: scaled to catfish consumption. 0.13 lb/person/yr. No adjustment made for breading and oil weight.

Flounder, Summer

1999 landings: 4,761 metric tons
1999 imports: 9,762 metric tons (all flounder)
1999 exports: no record in NMFS online database

Summer flounder accounts for 15 percent of all domestic flounder landings. For all flounder, imports represent 27 percent of the flounder supply (based on 1999 mass balance of landings, exports, and imports).

Our data: 30 samples from EPA's Environmental Monitoring and Assessment Program database. (Maryland – 17; Virginia – 11; Delaware – 2).

Consumption: Scale to catfish based on total U.S. landings. Gives 0.02 lb/person/year.

Data needs: FDA's seafood surveillance program has 9 samples, for yellowtail, winter, and unspecified flounder. Of these nine samples, 2 are very high (0.43, 0.4 ppm). These data were not used in our analysis because they were so few and so different from the summer flounder data. Yellowtail and winter flounder are both significant in the U.S. seafood supply. FDA needs to sample all species of flounder eaten in the U.S.

Haddock

1999 landings: 3,146 mtons
1999 imports: 25,219 mtons
1999 exports: 157 mtons

Imports are dominant. They accounted for an estimated 89% of consumption in the U.S. in 1999 (based on mass balance of landings, imports, and exports). Norway, Iceland, Faroe Islands, and Canada are major importers.

Our data: 23 samples altogether. 20 samples of pan-cooked haddock from FDA's Total Diet Study. 3 samples of haddock from FDA's domestic seafood surveillance program. It is likely that the 20 samples from the TDS program are primarily imported, since imports dominate the market. The 3 domestic samples and the 20 TDS samples have comparable methylmercury concentrations.

Consumption: scaled from catfish data. 0.12 lb/person/yr

Halibut (Pacific and Atlantic)

1999 landings: 36,600 mtons, 98% (35,970 mtons) is Pacific Halibut nearly all from Alaska
1999 imports: 11,920 mtons, approx 7% Atlantic, 93% Pacific (breakdown from NMFS Imports and Exports of Fishery Products Annual Summary, 1999).
1999 exports: 9,442 mtons

Imports accounted for an estimated 31% of consumption in the U.S. in 1999 (based on mass balance of landings, imports, and exports). Canada is the dominant importer. China and Japan are also significant. On balance, chances are good in the U.S. that the halibut on a plate is a Pacific halibut (about a 98% chance).

Our data: 33 samples from FDA's seafood surveillance monitoring program.
Two samples for which "whole" fish was indicated: methylmercury in fillet = methylmercury in whole body divided by 0.7 (based on EPA 1999).
Two samples from California are probably California halibut – not used.
23 domestic samples, 8 import samples. The highest concentration (1.52 ppm) was from an imported sample – not designated if this was an Atlantic or Pacific halibut.

Consumption: scaled from catfish data. 0.16 lb/person/year

Mahi mahi

1999 landings: 534 metric tons (Florida and North Carolina)
1999 imports: 4,299 metric tons (more than half from Taiwan; Japan and Costa Rica also significant)
1999 exports: 0

Imports accounted for 89% of U.S. supply last year.

Our data: 18 samples from FDA's seafood surveillance program. One domestic sample from Hawaii, 17 import samples.

Consumption: scaled to catfish. 0.02 lb/person/year.

Oyster, Eastern

1999 landings: 8,501 metric tons (11749 metric tons for all oysters)
1999 imports: 8,312 metric tons (all oysters)
1999 exports: 1,237 metric tons (all oysters)

Domestic Eastern oysters are primarily from Louisiana, Texas, Florida, and Maryland. Eastern oysters account for 72% of all domestic oysters. For all oysters, imports account for 44% of consumption (1999 mass balance based on landings, exports, and imports).

Our data: 396 samples from NOAA Gulfchem database (Table 8).

Table 8. Contamination of eastern oysters with methyl mercury.

State	Water bodies represented	Number of samples	Average MeHg	Minimum MeHg	Maximum MeHg
Alabama	1	9	0.085	0.057	0.126
Delaware	1	3	0.07	0.063	0.084
Florida	18	112	0.152	0	0.477
Georgia	3	11	0.077	0.036	0.129
Louisiana	11	58	0.079	0.03	0.246
Maryland	2	17	0.036	0.018	0.066
Mississippi	1	10	0.102	0.072	0.189
New Jersey	1	8	0.093	0.063	0.15
North Carolina	4	27	0.113	0.024	0.882
South Carolina	3	15	0.085	0.036	0.126
Texas	16	102	0.117	0	1.392
Virginia	5	24	0.078	0	0.177

Source: Environmental Working Group.

Assume these data are representative of concentrations in domestic Eastern oyster supply. Oysters were #10 on NMFS Top Ten list in 1998 at 0.23 lb/person/year, but fell off the list in 1999, replaced by scallops. Assume oyster consumption in 1999 is 0.19 lb/person/year, just below 1999 scallop consumption, which was 0.20 lb/person/year. Then assume that 72% of the total oyster supply in the U.S. is Eastern oyster (based on domestic catch ratio). This gives consumption of 0.19*0.72 = 0.14 lb/person/year.

Pollock, pacific

1999 landings: 1,055,016 metric tons
1999 imports: 100,329 metric tons
1999 exports: 20,996 metric tons

Domestic Pacific pollock are from Alaska. Most imported pollock are from China and Russia to a lesser extent. Imports account for about 9 percent of pollock consumption in the U.S. (based on 1999 mass balance between landings, exports, and imports). Of the imports, about 99% is Pacific pollock, 1% is Atlantic pollock.

Our data: 32 samples from FDA seafood surveillance program. 24 domestic samples, 8 imported samples (unknown if imported samples are Atlantic or Pacific pollock). High value of 0.78 ppm in imported samples was retained for our analysis.

Data needs: This fish is widely consumed in the U.S. – falls as #4 on NMFS's Top Ten list. Mercury in one of the eight imported samples was quite high. More sampling is needed to fully characterize variability.

Consumption: 1.57 pounds/person/year (NMFS Top Ten list). Did not correct for fish stick consumption, which might reduce that figure by about 10% if we assume all fish sticks are pollock.

Salmon

1999 landings: 369,744 metric tons, 98 percent from Alaska
1999 imports: 131,991 metric tons, primarily Atlantic salmon from Canada and Chile (farmed).
1999 exports: 153,593 metric tons
1999 U.S. farmed: 18,659 metric tons (Johnson 2000)

In the U.S. for any given time a person eats salmon, there is about a 38 percent chance it will be a domestic pink salmon, and a 30 percent chance it will be an imported Atlantic salmon. Domestic chum and sockeye salmon are the next most common, with a relative chance of about 12 percent for each (calculated from landing, import, and export data compiled by NMFS).

Some chinook and coho salmon are caught commercially from the Great Lakes. Concentrations of mercury appear to be much higher in these fish than in Alaska and imported salmon (EPA fish tissue databases). These salmon account for 0.03 percent of the commercial catch. These data were not used in our calculations.

Our data: 51 samples from FDA seafood surveillance program.

Domestic samples: Atlantic – 4, Chum – 8, Coho – 2, Pink – 8, "Salmon" – 4, Canned salmon – 20

Imported samples: "Salmon" – 4, Sockeye - 1

These 51 samples were equally weighted, and used together in exposure assessments for salmon, since the data for individual species are insufficient for species-specific analyses.

Consumption: 1.7 lb/person/yr (NMFS Top 10 seafood list)

Shrimp

1999 landings: 142144 metric tons
1999 imports: 331706 metric tons
1999 exports: 12138 metric tons

U.S. landings are primarily from Louisiana and Texas. Imported shrimp (Asia, South America, Central America) accounts for 72% of the shrimp consumed in the U.S. (based on mass balance of landings, imports, and exports).

We have EPA mercury data for brown and white shrimp. Brown shrimp accounts for 44 percent of U.S. landings. White shrimp accounts for 33 percent of U.S. landings.

Our data:

FDA's Total Diet Study includes 16 samples of shrimp tested for mercury. In our analyses, these concentrations are assumed to represent imported shrimp.

Brown and white shrimp: EPA's Environmental Monitoring and Assessment Program (EMAP) data. Brown shrimp are caught primarily in the Gulf of Mexico (Texas and Louisiana). White shrimp are caught primarily in Louisiana, with minor landings in the southern Atlantic states. In our analyses, data for brown and white shrimp are taken to represent concentrations in all domestic shrimp (Table 9). Consumption: 3.00 pounds per person (NMFS Top Ten list). 72% assumed to be from imported shrimp (2.16 pounds/person/yr), and the remaining 28% split between brown and white shrimp based on their relative 1999 landings (0.48 and 0.36 pounds per person per year, respectively).

Table 9. Contamination of shrimp with methyl mercury.

	Water bodies	Number of samples	Average MeHg	Minimum MeHg	Maximum MeHg
Shrimp - Total Diet Study	N/A	16	0.022	0	0.048
Brown shrimp - Gulf of Mexico	9	15	0.028	0	0.177
White shrimp - FL, GA, LA, NC, SC	20	28	0.043	0	0.126

Source: Environmental Working Group.

Trout, Rainbow, farmed

Nearly all trout eaten in the U.S. are farm-raised. In 1999, 27,376 metric tons were produced. In contrast, the commercial catch of lake and rainbow trout in 1999 was 613 metric tons, or about two percent of the farmed weight. Trout are caught commercially in Michigan, Oregon, Washington, and Wisconsin.

Our data represent mercury concentrations in farmed rainbow trout: generated data distribution from statistics presented in (Santerre 2001): mean = 0.00954 ppm, standard deviation = 0.00923 ppm, from 33 fillet samples collected from rainbow trout producers.

FDA has not tested trout.

Consumption: scaled from catfish numbers. 0.12 lb/person/yr.

Tuna, canned

Imports account for 34% of the U.S. canned tuna supply. Of the 76 percent canned in the U.S., 45% is lightmeat, and 21% is albacore.

FDA's Tuna Study (Yess, 1993) included the following samples with corresponding mercury concentrations:

Chunk light: 106 samples, 0.1 ppm MeHg, standard deviation 0.11 ppm
Solid white: 71 samples, 0.26 ppm MeHg, standard deviation 0.16 ppm

Chunk white: 19 samples, 0.31 ppm MeHg, standard deviation 0.17 ppm
Chunk: 14 samples, 0.10 ppm MeHg, standard deviation 0.12 ppm

Our data: 219 samples from the Yess study (Yess, 1993) – samples collected in 1991; 115 additional samples from FDA's seafood surveillance program (1992 and later), and 27 samples from FDA's Total Diet Study. Average of these 361 samples is 0.166 ppm MeHg. For most samples, the type of tuna (e.g., chunk light or solid white) was not available. Therefore, we were not able to segregate the data by product type.

Tuna, Steaks

The data below are for all tuna consumed in the U.S. – canned and steaks. Of the per-capita average of 3.5 pounds of tuna consumed per year in 1999, 3.4 pounds per year was canned, and 0.1 pounds per year was steaks (Johnson, 2000).

1999 landings: 26,806 metric tons
1999 imports: 308,493 metric tons, primarily from
1999 exports: 12,770 metric tons

Imports account for 96 percent of the supply in the U.S. In 1999 the biggest importers were Thailand, Taiwan, Phillipines, Ecuador, and Indonesia. Albacore and yellowfin are imported in the greatest quantities. Albacore is the most frequently landed tuna domestically, followed by yellowfin and skip-jack. About forty percent of domestic tuna comes through California. Tuna imports on the NMFS online import database are not given in sufficient detail to allow an assessment of relative consumption of each species of tuna eaten in the U.S.

Our data: 122 samples from FDA's seafood surveillance program, 85 imported, 38 domestic.

Domestic data, methylmercury:

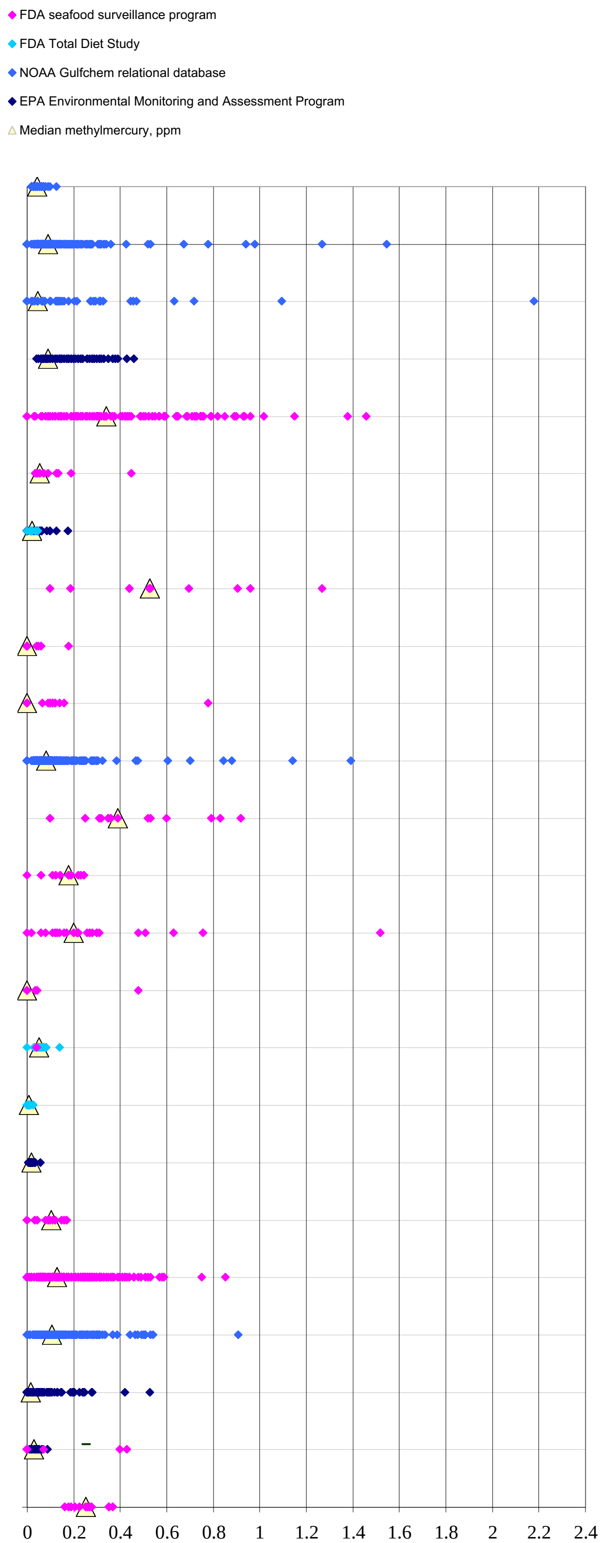
Ahi tuna:	1 sample, 0.2 ppm
Albacore tuna:	6 samples, average 0.347 ppm, range 0.036 – 0.510
Bigeye tuna:	3 samples, average 0.739 ppm, range 0.550 – 0.936
"Tuna"	19 samples, average 0.272 ppm, range 0.030 – 0.540
Yellowfin tuna:	8 samples, average 0.377 ppm, range 0.19 – 0.75

Import data, methylmercury:

Albacore tuna:	7 samples, average 0.363 ppm, range 0 – 0.82
Bigeye tuna:	2 samples, average 0.875 ppm, range 0.369 – 1.38
"Tuna"	63 samples, average 0.489 ppm, range 0 – 1.46
Yellowfin tuna:	13 samples, average 0.234 ppm, range 0.06 – 0.65

We treated all these data equally in our analysis, as methylmercury concentrations were not numerous enough to allow for species-specific analyses.

Table 10. Distribution of methyl mercury detections in different fish species.



	number of samples	average MeHg, ppm	median MeHg, ppm	range, ppm
Lake Whitefish	88	0.051	0.045	.018 - .126
Gulf Coast Oysters	396	0.123	0.09	0 - 1.55
Gulf Coast Crabs	47	0.228	0.047	1 - 2.18
Great Lakes Salmon	88	0.173	0.09	0.05 - 0.43
Tuna steaks	122	0.417	0.34	0 - 1.46
Smelt	16	0.097	0.054	0.036 - 0.45
Shrimp	59	0.033	0.023	1 - 0.177
Sea bass	10	0.606	0.529	0.1 - 1.27
Salmon	51	0.008	0	0 - 0.18
Pollock	32	0.063	0	0 - 0.78
Oyster	396	0.111	0.083	0 - 1.392
Marlin	15	0.467	0.39	0.1 - 0.92
Mahi mahi	18	0.164	0.18	0 - 0.245
Halibut	31	0.273	0.214	0 - 1.52
Hake	9	0.062	0	0 - 0.48
Haddock	23	0.056	0.053	0 - 0.14
Fish sticks	16	0.008	0.008	0 - .03
Blue crab - Atlantic	20	0.021	0.018	0.006 - 0.059
Cod	17	0.099	0.1	0 - 0.17
Canned tuna	361	0.166	0.13	0 - 0.852
Blue mussel	269	0.144	0.108	0 - 0.909
Atlantic croaker	202	0.044	0.015	0 - 0.529
Flounder	39	0.047	0.029	0 - 0.43
White croaker	15	0.258	0.252	0.162 - 0.369

Source: Environmental Working Group.

Appendix D: State Survey Results

Results of state survey of fish advisory systems.

State	NUMBER OF ADVISORIES	STATEWIDE ADVISORY DUE TO MERCURY CONTAMINATION	THRESHOLD-GENERAL POPULATION (PPM)	THRESHOLD-SENSITIVE POPULATION (PPM)	CONSUMPTION RECOMMENDATION - SENSITIVE POPULATIONS	ROUTINE MONITORING FOR MERCURY
Alabama	4	Coastal marine	1.00	1.0*	No consumption; statewide advisory recommends no consumption of one species	YES
Alaska	0	NO	No system	No system	No system in place	SOMEWHAT
Arizona	2	NO	No set threshold	No set threshold	Case-by-case approach, existing advisories recommend no consumption	NO
Arkansas	19	NO	1.00	0.5	Ranges from two 8-ounce meals per month to no consumption	NO
California	12	NO	No set threshold	No set threshold	Case-by-case approach, ranges from four 8-ounce meals per month to no consumption	SOMEWHAT
Colorado	8	NO	0.50	0.5	Advisories triggered at 0.5 ppm, state performs additional testing and issues more advisories starting at 0.2 ppm	NO
Connecticut	6	Lake and river	0.20	0.2*	No consumption; statewide advisory recommends one 8-ounce meal per month	NO
Delaware	5	NO	0.22***	0.12***	Case-by-case approach, limits vary, 0.12 ppm triggers further testing	YES
Florida	97	Coastal marine	0.50	0.5*	One 8-ounce meal per month, no consumption at 1.5 ppm; statewide recommends one 8-ounce meal per month of one species and no consumption of one species	YES
Georgia	84	NO	0.23	0.23	Ranges from four 8-ounce meals per month to no consumption (at 2.0 ppm) depending on level of mercury contamination	YES
Hawaii	0	NO	No system	No system	No system in place	NO
Idaho	1	NO	0.50	0.5*	One 4-ounce meal per month for three species, one 7-ounce meal per month of two species	NO
Illinois	2	NO	0.50	0.5	No consumption	YES
Indiana	136	Lake and river	0.16	0	Ranges from four 8-ounce meals per month to no consumption (at 0.65 ppm) depending on level of mercury contamination; statewide advisory recommends one 8-ounce meal per month (all freshwaters not under a specific advisory)	YES
Iowa	0	NO	1.00	1.0	Consumption limits not defined	YES

** consumption limits more stringent for sensitive populations*
*** not recognized by EPA*
**** triggers further study*

Source: The State PIRGs.

Results of state survey of fish advisory systems - continued.

State	NUMBER OF ADVISORIES	STATEWIDE ADVISORY DUE TO MERCURY CONTAMINATION	THRESHOLD-GENERAL POPULATION (PPM)	THRESHOLD-SENSITIVE POPULATION (PPM)	CONSUMPTION RECOMMENDATION - SENSITIVE POPULATIONS	ROUTINE MONITORING FOR MERCURY
Kansas	0	NO	No system	No system	No system in place	YES
Kentucky	1	All waters**	None	0.12	Statewide advisory recommends four 8-ounce meals per month, no consumption at 1.0 ppm	YES
Louisiana	17	Coastal marine	0.50	0.5*	Case-by-case approach, limits vary; statewide advisory recommends between one 8-ounce meal per month and no consumption of one species	YES
Maine	2	Lake, river, coastal marine	0.60	0.2	One 8-ounce meal per month of two species, consumption of all other species not recommended	YES
Maryland	0	NO	0.40	0.26	Would range from four 8-ounce meals per month to one 8-ounce meal per month, no consumption at 0.7 ppm	YES
Massachusetts	84	Lake and river	1.00	0.5*	Ranges from no consumption to two 8-ounce meals per month; statewide advisory recommends no consumption	SOMEWHAT
Michigan	71	Lake	0.50	0.5	One 8-ounce meal per month, no consumption at 1.5 ppm; statewide advisory recommends one 8-ounce meal per month of eight species from all inland lakes	YES
Minnesota	850	Lake	0.16	0.038	Ranges from unlimited consumption to no consumption (at 2.8 ppm) depending on level of mercury contamination; statewide advisory recommends same range	YES
Mississippi	8	Coastal marine	1.00	1.0*	One 4-ounce meal per month, no consumption at 1.5 ppm; statewide advisory recommends between one 4-ounce meal per month and no consumption of one species	YES
Missouri	0	NO	1.00	1.0*	If less than half of samples tested exceed 1.0 ppm, advisory would recommend four 8-ounce meals per month, if greater than half of samples tested exceed 1.0 ppm, no consumption would be recommended	YES
Montana	22	NO	0.16	0.0	Ranges from unlimited consumption to no consumption (at 2.8 ppm) depending on level of mercury contamination	SOMEWHAT
Nebraska	13	NO	0.35	0.25	Four 5-ounce meals per month, no upper limit for no consumption	YES
Nevada	2	Carson River watershed below Dayton**	1.00	No set threshold	Case-by-case, no consumption at 1.0 ppm, current advisory recommends no consumption	NO
New Hampshire	2	Lake and river	0.50	0.2	One 8-ounce meal per month, no consumption at 0.85 ppm; statewide advisory recommends one 8-ounce meal per month	YES
New Jersey	30	Lake and river	0.35	0.08	Ranges from four 8-ounce meals per month to no consumption (at 0.55 ppm) depending on level of mercury contamination; statewide advisory recommends one 8-ounce meal per month of two species	NO
New Mexico	26	NO	0.50	0.25	One 4-ounce meal per month, no consumption at 0.5 ppm	SOMEWHAT
New York	18	Freshwaters, portion of New York City Harbor**	1.00	1.0*	No consumption; statewide advisory recommends four 8-ounce meals per month	YES
North Carolina	10	Lake and river	1.00	1.0*	No consumption; statewide advisory recommends no consumption of two species and limits consumption to one 8-ounce meal per month of one species	YES
North Dakota	1	All tested waters**	no set threshold	no set threshold	Statewide advisory recommends eight 8-ounce meals per month to no consumption of eight species depending on species and type of sensitive population (woman or child)	NO

** consumption limits more stringent for sensitive populations*
*** not recognized by EPA*
**** triggers further study*

Source: The State PIRGs.

Results of state survey of fish advisory systems - continued.

State	NUMBER OF ADVISORIES	STATEWIDE ADVISORY DUE TO MERCURY CONTAMINATION	THRESHOLD-GENERAL POPULATION (PPM)	THRESHOLD-SENSITIVE POPULATION (PPM)	CONSUMPTION RECOMMENDATION - SENSITIVE POPULATIONS	ROUTINE MONITORING FOR MERCURY
Ohio	22	All freshwaters	0.05	0.05	Ranges from four 8-ounce meals per month to no consumption (at 1.0 ppm) depending on level of mercury contamination; statewide advisory recommends four 8-ounce meals per month for waters not under a specific advisory	YES
Oklahoma	0	NO	1.50	1.0	No consumption would be recommended	YES
Oregon	9	NO	0.35	0.35*	Case-by-case approach, ranges from four 8-ounce meals per month to no consumption, no upper limit for no consumption	NO
Pennsylvania	1	NO	0.13	0.13	Ranges from four 8-ounce meals per month to no consumption (at 1.9 ppm) depending on level of mercury contamination	YES
Rhode Island	1	NO	1.00	1.0*	No consumption	NO
South Carolina	58	Coastal marine**	0.25	0.25	No consumption; statewide advisory recommends between one 8-ounce meal per month and no consumption of one species	YES
South Dakota	1	NO	0.30	0.3*	One 7-ounce meal per month of two species, no upper limit for no consumption	YES
Tennessee	2	NO	1.00	0.5	No consumption	YES
Texas	9	Coastal marine	Approx. 0.7	Approx. 0.7	Case-by case approach, limits vary	NO
Utah	0	NO	No system	No system	No system in place	NO
Vermont	3	Lake and river	No set threshold	No set threshold	Case-by-case approach, ranges from two 8-ounce meals per month to no consumption; statewide advisories limits different species at varying levels from four 8-ounce meals per month to no consumption	YES
Virginia	3	NO	1.00	1.0*	No consumption	YES
Washington	1	NO	No set threshold	No set threshold	Case-by-case approach, ranges from four 8-ounce meals per month to 2 8-ounce meals per month	NO
West Virginia	0	NO	0.028	0.028	Would range from four 8-ounce meals per month to no consumption (at 1.036 ppm) depending on level of mercury contamination	NO
Wisconsin	approx. 140	All waters**	Not applicable	Not applicable	Statewide advisory recommends four 8-ounce meals per month of six species and one 8-ounce meal per month of other sport fish, no consumption at 1.0 ppm	YES
Wyoming	0	NO	No system	No system	No system in place	NO

** consumption limits more stringent for sensitive populations*
*** not recognized by EPA*
**** triggers further study*

Source: The State PIRGs.

References

Ache, BW, Boyle, JD, and Morse, CE. 2000. A Survey of the Occurrence of Mercury in the Fishery Resources of the Gulf of Mexico. Prepared by Battelle for the U.S. EPA Gulf of Mexico Program, Stennis Space Center, MS. January 2000.

Browner, C. 2000. EPA decides mercury emissions from power plants must be reduced. Released December 14, 2000. Press release online at *http://www.epa.gov/mercury/actions.htm*.

Brune, D, GF Nordberg, et al. 1991. A review of normal concentration of mercury in human blood. *Sci. Total Environ*. 100: 235-282.

Centers for Disease Control and Prevention (CDC). 2001. Blood and hair mercury levels in young children and women of childbearing age – United States, 1999. *Morbidity and Mortality Weekly*. 50(08):140-3.

CDC National Health and Nutrition Examination Survey (NHANES) IV. 2001. Available online at *http://www.cdc.gov/nchs/nhanes.htm*.

Cramer, GM. 1994. Exposure of U.S. consumers to methylmercury from fish. FDA Office of Seafood. In DOE/FDA/EPA Workshop on Methylmercury and Human Health. March 22-23, 1994. Bethesda, Maryland. Ed Moskowitz, PD, L Saroff, M Bolger, J Cicmanec, and S Durkee.

Ginsberg GL and Toal BE. 2000. Development of a single-meal fish consumption advisory for methyl mercury. *Risk Analysis*. 20(1): 41-47.

Glass, GE and JA Sorensen. 1999. Six-year trend (1990-1995) of wet mercury deposition in the upper Midwest, U.S.A. *Environ. Sci. Technol*. 33: 3303-3312.

Golden, AL, G Berkowitz, MS Wolff, JH Godbold, A Afilaka, SN Chillrud, RF Bopp, HJ Simpson, PJ Landrigan. 2001. Body burdens of persistent pollutants in Hudson River anglers. Submitted to *Environmental Health Perspectives*.

Grandjean, P, E Budtz-Jorgensen, RF White, P Weihe, F Debes, and N Keiding. 1999. Methylmercury exposure biomarkers as indicators of neurotoxicity in children aged 7 years. *Am. J. Epidemiol*. 150(3): 301-305.

Grandjean, P, P Weihe, RF White, F Debes, S Araki, K Yokoyama, K Murata, N Sorensen, R Dahl, and PJ Jorgensen. 1997. Cognitive deficits in 7-year-old children with prenatal exposure to methylmercury. *Neurotoxicol. Teratol*. 19(6):417-428.

Grandjean, P, P Weihe, RF White, N Keiding, E Budtz-Jorgensen, K Murato, and L Needham. 1998. Prenatal exposure to methylmercury in the Faroe Islands and neurobehavioral performance at age seven years. Response to workgroup questions for presentation on 18-20 November, 1998. In: Sicentific Issues Relevant to Assessment of Health Effects from Exposure to Methylmercury. Appendix II-B. – Faroe Islands Studies. National Institute for Environmental Health Sciences. Available online at *http://ntp-server.niehs.nih.gov/Main_Pages/PUBS/MethMercWkshpRpt.html*.

Greenwood, MR. 1985. Methylmercury poisoning in Iraq: an epidemiological study of the 1971-72 outbreak. *J. Applied Toxicology*. 5(3): 148-159.

Gulf of Mexico Program (GulfChem). 2001. Occurrence of Mercury in the Fishery Resources of the Gulf of Mexico Data. Available online at *http://pelican.gmpo.gov/spotlite.html*.

Harada, M. 1995. Minamata disease: methylmercury poisoning in Japan caused by environmental pollution. *Crit. Rev. Toxicology*. 25(1): 1-24.

Johnson, H.M. 2000. Annual Report on the United States Seafood Industry. Eighth Edition.

Kosatsky, T and P Foran. 1996. Do historic studies of fish consumers support the widely accepted LOEL for methylmercury in adults. *Neurotoxicology*. 17(1),:177-186.

Leong, CCW, NL Syed, and FL Lorscheider. 2001. Retrograde degeneration of neurite membrane structural integrity of nerve growth cones following *in vitro* exposure to mercury. *NeuroReport*. 12(4): 733-737.

National Academy of Sciences (NAS), National Research Council. 2000. *Toxicological Effects of Methylmercury*. National Academy Press, Washington, DC.

National Marine Fisheries Service (NMFS). 2000. Fisheries of the United States – 1999. Available online at *http://www.st.nmfs.gov/st1/fus/fus99/index.html*.

National Marine Fisheries Service (NMFS). 2000. Top Ten List.

National Rural and Electric Cooperative Association (NRECA). 1998. Letter from Rae E. Cronmiller, Environmental Counsel representing NRECA, to U.S. EPA. June 8, 1998. Available online at *http://www.nreca.org/*.

Nixon DE, GV Mussmann, TP Moyer. 1996. Inorganic, organic, and total mercury in blood and urine: Cold vapor analysis with automated flow injection sample delivery. *J. Analytical Toxicology*. 20: 17-22.

Salonen, JT, K Seppanen, et al. 1995. Intake of mercury from fish, lipid peroxidation, and the risk of myocardial infarction and coronary, cardiovascular, and any death in eastern Finnish men. *Circulation*. 91(3): 645-655.

Santerre, CR, PB Bush, et al. 2001. Metal residues in farm-raised channel catfish, rainbow trout and red swamp crayfish from the Southern U.S. To be published in *J. Food Science – Food Chemistry and Toxicology*. Manuscript No. 2000-0628.

Stern, Alan H. 1997. Estimation of the interindividual variability in the one-compartment pharmacokinetic model for methylmercury: Implications for the derivation of a Reference Dose. *Regulatory Toxicology and Pharmacology*. Vol 25. P 277-288.

Stern, A, M Gochfeld, et al. 2001. Mercury and methylmercury exposure in the New Jersey pregnant population. To be published in *Arch. Environ. Health*.

The Center for Responsive Politics. 2000. Information on campaign and party contributions from electric utilities. Available online at *http://www.opensecrets.org*.

United States Environmental Protection Agency (EPA). 1996. Exposure Factors Handbook. Volume II – Food Ingestion Factors.. Office of Research and Development, National Center for Environmental Assessment, U.S. EPA. August 1997.

United States Environmental Protection Agency (EPA), 1997. Mercury Study Report to Congress. Volume V: Health Effects of Mercury and Mercury Compounds. EPA Office of Air Quality Planning & Standards and Office of Research and Development. EPA-452/R-97-007. December 1997.

United States Environmental Protection Agency (EPA). 1999. The National Survey of Mercury Concentrations in Fish. Data Base Summary 1990-1995. EPA-823-R-99-014. Office of Water. September 1999.

United States Environmental Protection Agency (EPA). 2000. National Listing of Fish and Wildlife Advisories (NLFWA) Database. Available online at *http://www.epa.gov/ost/fish*.

United States Environmental Protection Agency (EPA). Environmental Monitoring and Assessment Program (EMAP). Available online at *http://www.epa.gov/emap/*.

United States Food and Drug Administration (FDA). Seafood Surveillance Program Data.

United States Food and Drug Administration (FDA). 1974. Mercury action level rulemaking. *Federal Register*. 39(236). December 6, 1974.

United States Food and Drug Administration (FDA). 1979. Revisions to the mercury action level. *Federal Register*. 44(14).

United States Food and Drug Administration (FDA). 1991-1999. Total Diet Study. Available online at *http://vm.cfsan.fda.gov/~comm/tds-toc.html*.

United States Food and Drug Administration (FDA). 2001. An important message for pregnant women and women of childbearing age who may become pregnant about the risks of mercury in fish. March 2001. Available online at *http://vm.cfsan.fda.gov/~dms/admehg.html*.

United States General Accounting Office (GAO). 2001. Federal oversight of seafood does not sufficiently protect consumers. Food Safety. Report to the Committee on Agriculture, Nutrition and Forestry, U.S. Senate. GAO-01-204. January 31, 2001.

United States v. Anderson Seafoods, Inc. 1980. 622 F.2d 157 (5th Cir. 1980).

Weiss, B. 1990. The Developmental Neurotoxicity of Methyl Mercury. In *Toxicants Well Studied in Humans*.

Weiss, B. 1996. Long ago and far away: a retrospective on the implications of Minamata. *Neurotoxicology*. 17(1): 257-264.

Wisconsin Electric. 2001. Mercury in the environment. Available online at *http://www.wisconsinelectric.com/pages/p_issues12.html*.

World Health Organisation (WHO). 1990. *Environmental Health Criteria 101: Methylmercury*. Geneva.

Yess, NJ. 1993. US Food and Drug Administration survey of methyl mercury in canned tuna. *J. AOAC Int*. 76(1): 36-38.

The State PIRGs

U.S. PIRG Education Fund
218 D St. SE
Washington, DC 20003

ENVIRONMENTAL WORKING GROUP™

Environmental Working Group
1718 Connecticut Avenue, N.W. Suite 600
Washington, D.C. 20009