American Fisheries Society

US Environmental Protection Agency

National Forum on Contaminants in Fish

October 20-22, 2002

Burlington Vermont

Proceedings

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The following Steering Committee members and other individuals contributed their time and expertise to develop the agenda for the 2002 Forum program, identify and recruit speakers, determine priorities, and facilitate discussions:

Jeffrey Bigler, EPA, Office of Water, Co-Chair

Betsy Fritz, AFS, Co-Chair

Robert Brodberg, California Environmental Protection Agency

Eric Frohmberg, Maine Bureau of Health

Razelle Hoffman-Contois, Vermont Department of Health

Barbara Knuth, Past President, AFS Water Quality Section, Cornell University

Janet E. Lubeck, American Fisheries Society

Randall Manning, Georgia Department of Natural Resources

Patricia McCann, Minnesota Department of Health

John Persell, Minnesota Chippewa Tribe

Andy E. Smith, Maine Bureau of Health

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Introduction

Representatives of 47 states, 30 tribes, 6 federal agencies, several Canadian provinces and other interested organizations attended the 2002 Forum on Contaminants in Fish sponsored by the US Environmental Protection Agency and convened by the American Fisheries Society in Burlington Vermont.

The agenda was developed by a steering committee with representatives of states, tribes, federal agencies and the AFS. The steering committee developed an agenda that presents a variety of perspectives and approaches to the difficult issues facing states and tribes, including how to address cumulative risks and mixtures; risks to those most exposed; and the need to integrate perspectives and responsibilities of health and environment agencies. The Forum also included topical breakout sessions for more in-depth presentations and discussion on Sunday, along with the regional breakouts that have been customary. The forum also included a poster and information exchange session.

This document presents the proceedings of the Forum. It includes summaries of all presentations in the plenary session, copies of slides presented, a list of participants, and other information about the forum. Additional copies are available from the American Fisheries Society in Bethesda, Maryland.

Summary of Conference Presentations

At the 2002 forum, 33 speakers presented technical information, perspectives on policy development, and experiences in developing and implementing advisory programs. Biosketches for the speakers are included in the appendix, as are black and white copies of slides presented.

The presentations were organized into nine sessions:

- Welcome and Introductions
- Guest Speaker
- Update on Activities Related to the 2001 Forum
- Reports from the Weekend Sessions
- Advisories for Commercial Fish: Federal, State, and Tribal Approaches
- Hot Topics – Chemicals of Concern
- Approaches to State and Tribal Advisories
- Approaches to Considering Benefits in Advisory Programs
- Current Science on the Benefits of Fish Consumption

Moderators for the panels offered additional comments and perspectives. In addition, forum participants had an opportunity to ask questions and make comments after most of the presentations.

Seven additional presentations were made during workshops held on Sunday October 20. While these presentations are not summarized in this document, slides from these talks are included in the Appendix.

This section provides short summaries of the presentations.

I. Welcome and Introductions

Jeffrey Bigler, US Environmental Protection Agency

Good morning, and welcome to the 2002 National Forum on Contaminants in Fish, sponsored by the American Fisheries Society, US EPA, and the Vermont Department of Health. My name is Jeff Bigler and I will serve as the overall moderator for this year's Forum.

This year, we have a full house - and then some. More than 240 have registered, making this a banner year for the Forum. We had originally planned on accommodating up to 120 registrants and we obtained rooms based on this estimate. Therefore, two weeks ago AFS found it necessary to close registration as the participation list approach 250. Fortunately, in the end, AFS was able to accommodate all who registered for the Forum - but don't be surprised if you wind up sharing a donut during the breaks.

Attending the Forum this year are representatives from 47 states, 30 tribes, 6 federal agencies, several Canadian Provinces, and scores of others from various agencies and organizations. We have some of the nation's experts on the occurrence of chemical pollutants in fish and the potential health risks and benefits associated with fish consumption. Many experts are on the agenda, while others are here to join in discussion over the next two days. I urge you all to take advantage of the opportunity provided by the Forum to share your experiences and thoughts, successes and failures. Whether you interact in the Plenary, in the halls during breaks, or perhaps after hours at a local watering hole, please use this opportunity to meet others and share your work with them. After all, we all share a common goal; that is the goal of ensuring that decisions regarding the issuance of fish consumption advisories are based on sound science and sound public health policy.

Let's now move on to the agenda. As in the past, the agenda for the Forum was developed by a joint state/tribal/AFS/EPA steering committee. This year's steering committee members include:

Betsy Fritz, American Fisheries Society, Co-Chair
Jan Lubeck, American Fisheries Society
Robert Brodberg, California Environmental Protection Agency
Razelle Hoffman-Contois, Vermont Department of Health
Barbara Knuth, Cornell University; Past President, AFS Water Quality Section
Randall Manning, Georgia Department of Natural Resources
Pat McCann, Minnesota Department of Health
John Persell, Minnesota Chippewa Tribe
Andrew E. Smith/Eric Frohmberg, Maine Bureau of Health
Amy D. Kyle, University of California Berkeley and Consultant to AFS

The Forum has always been driven by the participants – states and increasingly tribes. The steering committee decided to take on some challenging issues at the Forum, such as how to assess cumulative risks and mixtures; issues for those at the upper end of the distribution for exposure; ways of thinking about risks and benefits for people who are traditional users of fish. These are tough and important issues. The agenda also reflects the need to integrate both "health" and "environmental" agency perspectives and responsibilities: both play an important role.

On behalf of the entire Forum, I would like to thank the committee members for participating in six months of conference calls, reviews and endless phone calls to potential speakers in order to ensure that this year's Forum provides a balanced, stimulating, and thought-provoking agenda. I have no doubt that, at the end of the day, you will agree that the steering committee succeeded in developing such an agenda. Please join me now in thanking the steering committee for all of their hard work.

Gus Rassam, Executive Director, American Fisheries Society

Welcome. Since the first forum in this series in 1990, the American Fisheries Society has been pleased to co-sponsor this important venue for exchanging information on an extremely important topic, with the Environmental Protection Agency. Aside from one previous forum held in Chicago, AFS and EPA have been partners in bringing the best each organization has to offer to the benefit of all the community. AFS brings its long track record in arranging and holding scientific meetings, and EPA provides the capability to bring together various state programs, federal agencies, tribal programs, and other stakeholders, all working toward common goals of helping protect the public from effects of contaminants contained in fish.

Since 1990, much progress has been achieved. Fish consumption advisories are now common in most of the states, and these advisories are underlain by the best scientific data available. Aside from such an increase in awareness, the major discernible changes that came from previous fora can be summarized as follows:

- There is an increasing awareness of the need for community involvement in both setting standards and communicating advisories to target groups.
- Increased collaboration among neighboring states to achieve consistency of approach.
- Public awareness of the health problems associated with mercury levels in waters, especially in most of the eastern, Midwestern, and southern United States.
- Assessment of "emerging" contaminants such as flame retardants or pharmaceuticals.
- Creation of Web-based communication tools such as the National Listing of Advisories.

The total knowledge-base on contaminants, their levels in both water and the fish swimming in it, and their effects on health of target demographics, has expanded tremendously during that time period, thanks mainly to the diligent efforts by scientists working in EPA and university laboratories.

On the other hand, all this knowledge still needs to reach people—and reach them in the right way and at the right time. Integrating the information in the popular culture and making sure that people understand it and act on it is still a major challenge. This is especially true since no one wants to turn people away from a healthy, fish-based diet.

This forum will allow the spirit of cooperation among State, Federal, and Tribal agencies to expand. It will increase our common understanding of the scientific database of contaminants and will certainly lead to better ways of communicating that scientific information to the public.

Thank you for contributing to these goals.

G. Tracy Mehan III, Assistant Administrator for Water, US EPA

Congratulations are due to AFS on the program for the forum and partnerships they have fostered through their sponsorship and organization of the forum.

My experience, including working in the Great Lakes, has given me a first hand awareness of persistent, bioaccumulative, toxic pollutants, which are very important. The problems of such contaminants in fish raise serious risk management and risk communication issues. What we see in terms of contaminants in fish is an indicator of success in other programs that control releases of pollutants to the environment and clean up past releases.

I want to emphasize how important it is that you continue your great work to identify risks from contaminants in fish and communicate them to people at risk, especially women and children. I urge you to keep the issue in the forefront. I also recognize that we need to address current air pollution issues as well as continuing, or "legacy," contamination releases from sites of past disposal.

It is important for all of us to note the successes that we have achieved. One important success for EPA relates to mercury, which is widespread in fish but primarily comes from air deposition. EPA is closing in on 50% reduction in mercury releases to air due to development and implementation of technology-based standards limiting mercury releases in industry sectors (known as "MACT" standards.) We also hope to achieve international efforts in cooperation with the United Nations. EPA is working on strategies to address releases of multiple pollutants using a new approach to air pollution control known as "clear skies." We hope to make progress in remediation to reduce concentrations of pollutants in fish tissue. Thank you for the opportunity to address your gathering.

Note: these remarks were presented by video.

II. Guest Speaker

Trends in Chemical Pollutants in Fish.
Usha Varanasi, Northwest Fisheries Science Center

The National Oceanic and Atmospheric Administration (NOAA) manages living marine resources, including fish, marine mammals, and sea turtles, in all federal waters off the U.S. coast. This is a huge area, 3.4 million square nautical miles, spans a variety of ecosystems from arctic to tropical, and is home to over 900 species of fish and invertebrates that are caught for commercial, recreational, and/or subsistence purposes.

Fish are an important source of food, employment, and revenue, and are critical components of marine ecosystems. As a food source, fish are particularly important and unique; they are the primary source of animal protein for over 1 billion people and are largely harvested from the wild. While there are many benefits of eating fish, accumulation of pollutants, toxic chemicals as well as natural toxicants (e.g., harmful algal blooms) in fish can pose some risks to consumers.

NOAA is concerned about the health of living marine resources, as well as consumers of these valuable resources. As a result, NOAA conducts research on the accumulation and impact of pollutants, toxic chemicals as well as natural toxicants, on fishery resources.

Thousands of chemicals are produced and used routinely in industrialized and developing nations. Many of these chemicals eventually find their way into the ocean. Studying toxic chemicals is important because they affect both the safety of seafood that we eat and fish development, diseases, reproduction, and survival. Science can provide the information we need to assess benefits and risks associated with these pollutants and make critical management decisions (e.g., when to close or open a fishery, post a health advisory, or modify effluent discharge guidelines).

When investigating these pollutants, it is critical to determine the specific properties of key compounds and how they interact with species of interest. For example, research in the late 1970s at NOAA's Northwest Fisheries Science Center found that polycyclic aromatic hydrocarbons (PAHs) accumulate in the tissues of invertebrates (e.g., mollusks and crabs) but not fish; this is in contrast to organochlorines and many metals that do accumulate in fish. Fish, like other vertebrates, metabolize PAHs quickly and efficiently in the liver to detoxify them. They readily convert most hydrocarbons to metabolites that are eliminated into bile and out of their bodies.

It is also critical to develop and use methods that provide sufficient information, but that are not unnecessarily sophisticated. This enables techniques to be readily transferred and applied quickly to consumer safety issues (e.g., impacts of oil spills or harmful algal blooms on fishery resources).

While contaminants exist to some degree in all of our nation's waters, specific trends tend to vary by region due to various physical, biological, and human use characteristics. Nationally and regionally, federal, state, and tribal agencies are conducting monitoring programs to determine the extent and impact of contaminants on coastal and estuarine areas. Results from NOAA's national benthic surveillance program, indicate that, in general, legacy pollutants (e.g., DDT and PCBs) are decreasing, trace metals are more or less constant, and many chemicals, particularly those that are human-made, are highly concentrated near cities. Data also indicate that PAHs and other non-point source pollutants are increasing in a number of areas.

Long-term monitoring of contaminant levels and investigation into the impacts of non-point source pollutants on fishery resources are key. Data from these programs are used to determine trends in our nation's waters and fishery resources. Historically, however, it has been difficult for agencies to commit to consistent long-term monitoring programs. As part of long-term monitoring programs, it has become increasingly important to investigate the full suite of non-point source pollutants, such as PAHs and pharmaceuticals, as well as mixtures of pollutants and their cumulative affect on species.

Credible, rigorous, and objective science; long-term monitoring of legacy and non-point source pollutants; the development of testing methods that provide accurate and quick results; and efficient and effective communication of information to fisheries users will help ensure that the appropriate balance of benefits and risks is made with regard to the consumption of valuable fish and invertebrate resources. Continued research to better understand pollutants and their impacts on living marine resources is critical to the sustainability of the nation's fisheries.

References:

National Oceanic and Atmospheric Administration's National Status and Trends Program.
Puget Sound Ambient Monitoring Program
NOAA's Northwest Fisheries Science Center Environmental Conservation Division

Andy Smith: What is NOAA doing to look at pharmaceutics in fish?

Response: NOAA is currently investigating a number of non-point source pollutants, including agricultural pesticides and certain pharmaceuticals. Some compounds, such as caffeine, are of particular concern because of the high volume and frequency with which they are released into the environment.

III. Updates to the Forum

New Version of the Risk Communication Guidance.

Barbara A. Knuth, Cornell University

EPA is sponsoring a revision to the current guidance for risk communication, which was entitled *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories*, *Volume IV – Risk Communication,* EPA 823-R-95-001 and issued in March 1995.

The 1995guidance was written largely for an agency audience. In recent years, more attention has been focused on the needs of other groups in risk communication. For example, the last Forum focused on risk communication. Also, the National Environmental Justice Advisory Committee (NEJAC), which advises EPA, has been discussing contaminants in fish. Such initiatives and groups have contributed to an interest in updating and expanding the guidance.

Several issues are being addressed in the revisions. It is important to ensure that risk communication is culturally appropriate. It is important to ensure that all partners are involved and to assess messages based on needs identified. It is important to help the partners take actions that can include eliminating the problem. We know it is important to acknowledge that contamination is not "acceptable." The Guidance should not be perceived as condoning pollution or seeing warnings alone as an acceptable solution.

The document is being coordinated by Tetra Tech, Inc. as the lead technical consultant. Other consultants are John Hesse (retired from the Michigan Health Department), Judy Sheeshka, Barbara A. Knuth, Patrick West, and Amy D. Kyle. A group of stakeholders identified by Tetra Tech and EPA have reviewed the work plan and provided input.

The approach for the revised guidance includes an effort to produce targeted modules that communities can use. Community partners have different needs. Risk communication modules can be targeted to help address these specific needs.

The guidance will emphasize community involvement and also better explain links to other phases of the risk analysis process. The product will continue to enhance the user-friendly set of risk communication outreach materials under development by the National Fish and Wildlife Contamination Program.

The final product will be web-based, rather than a paper report, to encourage tailored use of guidance appropriate to community needs. This should allow people to find helpful tools with a few clicks.

A current prototype is shown below.

The stakeholders advised us to keep the concise risk communication framework while adding case studies to illustrate important points. These can draw on real situations. They also requested that the product provide techniques for applying the framework to different situations and that it be realistic in its assumptions about funding, time, and staffing. All phases of the process are limited by resources and staffing. The stakeholders also wanted a discussion of fish consumption benefits. The consultants are working on a design.

The advantages of a web-based approach are that the guidance is more accessible and it may be less daunting than a large document. Moreover, materials may be developed for specific type of audiences. The materials can be modified and updated easily. This allows the format to become issue-oriented, based on the path a user takes, rather than process-oriented. There are some possible disadvantages, including accessibility only to those with web access. Stakeholders felt that this is a diminishing concern. Also, the document will need to be updated.

The next steps will be to complete all sections, links, information boxes, etc. The stakeholder work group will review the results and be involved in developing case studies.

Update on TMDLs and Fish Consumption Advisories.
Jim Pendergast, US EPA

This presentation focuses primarily on total maximum daily loads for methyl mercury; the water quality criterion for methyl mercury and how this is related to total maximum daily loads (TMDLs); the relationship between fish consumption advisories and TMDLs; and US EPA's new TMDL Rule.

The water quality criterion for methyl mercury that was adopted by EPA in January 2001 specified levels in fish tissue, rather than water, for the first time. This was because, to protect people, it makes more sense to measure mercury in the fish that people eat than in the water. However, this approach raises technical issues. How do states use this new criterion for permitting and TMDLs? Because the new criterion is above the level of detection, this could lead to more permits and TMDLs, which presents a resource issue.

US EPA has decided not to require states to start updating their own standards to reflect the new water quality criterion for five years from the date of publication of the criterion. This would allow time to publish guidance for implementing the criterion. Though EPA is not pushing them to do so, some states are interested in adopting the criterion now.

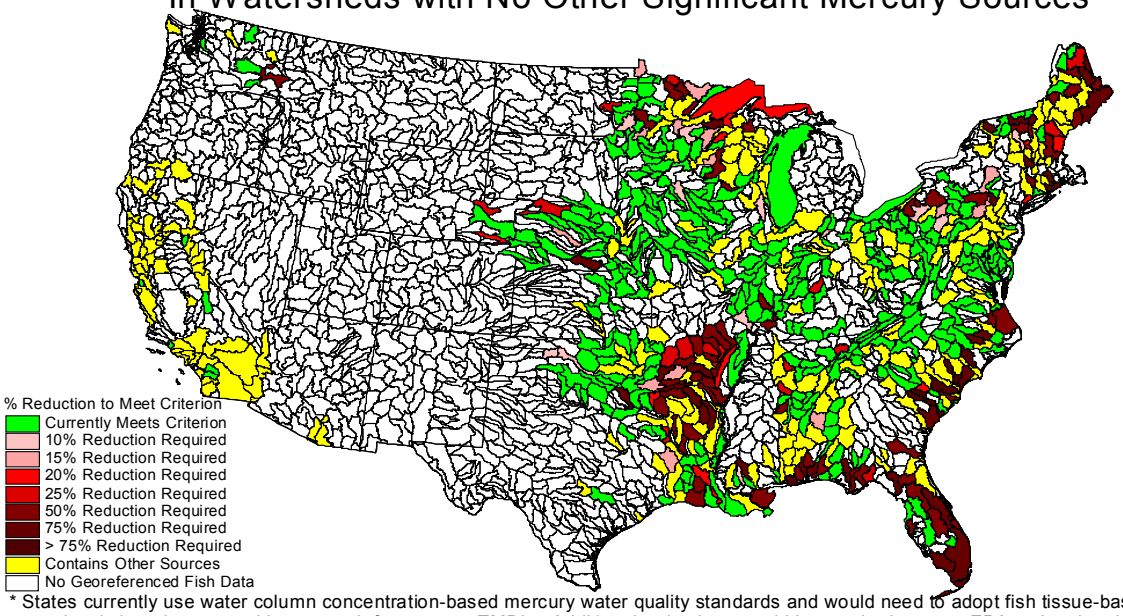
The key elements and issues to be addressed in the methyl mercury water criterion implementation guidance are:

- Water quality standards – translating methyl mercury to total mercury; flexibility for site specific criteria, expression of criterion (tissue or water); variances and use attainability analyses. Site-specific flexibility for criteria may be appropriate in cases where states may have watersheds where people eat considerably more or less fish than the consumption rate for the EPA criterion.
- Defining impairment – It will be important to define "impairment." What does this mean? Do you include all tropic levels; does size of fish matter; what are appropriate analytical methods?
- Approaches to TMDLs.
- Permitting, especially for small sources.

US EPA has also been asked whether they will allow states to convert the tissue-based criterion to a water-based number.

A lot of mercury in fish today has probably come from air deposition; there could be a statewide or national analysis for sources in some watersheds. The map below shows the estimated percent reductions in air deposition load necessary to meet new criterion. Reductions to be obtained through imposition of the MACT (maximum achievable control technology) standards required under Section 112 of the Clean Air Act can be overlaid with this. US EPA is now working on calculating the reductions in air deposition for each watershed so that it can determine where the MACT standards are sufficient.

Estimated Percent Reductions in Air Deposition Load
Necessary to Meet New Methylmercury Criterion*
In Watersheds with No Other Significant Mercury Sources



* States currently use water column concentration-based mercury water quality standards and would need to adopt fish tissue-based target levels in order to use this approach for mercury TMDLs. Additional reductions would be required to meet EPA national and most state fish advisory levels, which are often set below the methyl-mercury criterion.
Note: Watersheds highlighted yellow have "significant" mercury sources other than deposition, defined as where the total estimated load from Publicly Owned Treatment Works (POTWs) and pulp and paper mills is greater than 5% of estimated waterbody delivered mercury at a typical air deposition load (10 g/km2/yr), and/or where mercury cell chlor-alkali facilities, mercury mines, or significant past producer gold mines are present. See text of report for data sources for point source dischargers and mines.
Source: National Listing of Fish and Wildlife Advisories (NLFWA) Mercury Fish Tissue Database (June, 2001).

EPA issued guidance in 2000 that provides that states must list as impaired water bodies that have risk-based fish advisories based on water body specific data where the advisory uses the same the same risk basis as the WQS. This means that the advisory and WQS use the same type of data collection and same threshold value.

The guidance does not require states to list water bodies with advisories that were issued without site specific data. Statewide advisories do not by themselves trigger listings of water bodies as impaired.

If the threshold for an advisory is based on a 0.3 parts per million level of methyl mercury that the state had adopted as a WQS, then any time there was an advisory based on site specific data, this would be considered to be an exceedance of water quality standards, and the state would be expected to list this as an impaired water. But if state developed a statewide advisory as a precaution, based on limited data, then US EPA would not require that all of the water bodies included under the statewide advisory be considered to be impaired.

The 2000 guidance also shows a cross-walk between water body listings and the National Shellfish Sanitation Program growing area classifications.

The bottom line is that advisories are not always impairments. Impairments occur when a population is exposed to a greater than acceptable risk, considering mixtures and range of species and ages.

Advisories are issued to protect individuals including people who have higher consumption. They can be water body specific. Some are regional or statewide, some are size specific, and some are species specific. A state could meet the water quality standards and still have advisories for some people.

The water quality standards are based on certain assumptions – people who consume more fish than this could still have risk but not be in impaired water bodies.

More information is available at the TMDL home page at http://www.epa.gov/owow/tmdl

Question: Barry Moore, Maine. What is the basis for estimates on percent reductions? How does this map differ from mercury map program map?

Response: It is the same mercury map. Paul Cocca developed it. Reductions were based on comparing average fish tissue values in watersheds to 0.3 ppm and calculating percent reduction to achieve this, assuming a linear relationship between the mercury concentration in fish and the atmospheric deposition of mercury.

Barry Moore: Is a linear relationship realistic? We don't think so.

Response: A Florida Everglades study showed linear relationships between atmospheric loadings and concentrations in fish tissue once reductions reached steady state, using a model developed for the power industry. Other models give pretty much the same result. Some data coming out of Canada suggests that the reduction may be much faster but still linear.

Don Axelrad, Florida: The model was developed by EPA and Florida Department of Environmental Protection as well as EPRI. If you consider the relative source contribution from marine fish based on national numbers, in Florida where there is a great deal of consumption of marine fish, we may calculate a 0 criterion for fresh water fish.

Response: We haven't considered this, but it is possible to occur.

IV. Reports from the Weekend Sessions

Methyl Mercury Contamination in Fish: Human Exposures and Case Reports.

Henry A. Anderson, Wisconsin Division of Public Health

You may remember that in the early days of the PCB advisories, one of the issues that came up with regard to the medical community was whether breastfeeding was advised.

We have, in other sessions, discussed asking physicians to tell patients about advisories, but when people come back with mercury values we are silent.

Now we have a biomarker for methyl mercury and the medical community is beginning to see patients who are ill and who have mercury measurements from hair, urine or blood. The question is, what does it mean and what do they do about it? The impetus for the workshop was to address how we can partner with the medical community to address these issues.

The workshop held on Saturday was sponsored by the US EPA, AFS, American Academy of Pediatrics, American College of Obstetricians and Gynecologists, Association of Occupational and Environmental Clinics, and Centers for Disease Control and Prevention.

The goal was to learn about the distribution of blood methyl mercury in the general population, including clinical experience. There is some published literature and some cases that have been

evaluated. We wanted to start to look at neuropsychological or neurological testing. How do we assess low exposures?

The group began with discussions of risks and benefits, toxicokinetics, available biomarkers, and which tests should be run for which types of exposures. There are elemental mercury and inorganic mercury exposures as well as methyl mercury, and it is important to physicians to know which test to order depending on route and source of exposure. There were presentations on chelation, where the issue is whether it is appropriate and when is it appropriate. The group discussed exposure assessment methodologies and heard reports from physicians including Dr. Jane Hightower and others from Boston, Wisconsin, and New Jersey. There was an evening presentation on German approaches and the results coming from the biomonitoring being conducted in the National Health and Nutrition Examination Survey (NHANES). The group discussed neuropsychological and neurological assessments. These have been the most sensitive endpoints. How do we gather information? What are appropriate risk communication and outreach methods?

Regarding the distribution of blood methyl mercury concentrations in the general US population, national data available are from the Centers for Disease Control NHANES study. The 1999-2000 NHANES only covers women (16-49) and children (1-5) for mercury (e.g., blood, hair, urine). This is a significant limitation. The blood mercury data indicate 7.8% of women are above EPA's reference dose (for blood) of 5.8 µg/L [1]. It is not surprising, but the study found that fish consumption correlated well with blood mercury (For women who ate less than one fish meal a week, only 2% were above 5.8 while 15% of those who ate two meals a week were above.)

The group recommends that mercury become a core biomarker measured for all populations. The NHANES group reported that they are moving toward analyzing all blood samples collected for lead for mercury as well. The group also felt it would be important to look at the health status information and relate it to the mercury biomarkers

The group discussed cases of elevated methyl mercury exposures. There are reports of fish consumption that are related to blood mercury exceeding 50 µg/l. If people start looking, we may well find more of these. Now we need to address what this means. We need to define advice for folks with elevated levels. In the past, we have focused on subsistence users as an at risk population. We now need to consider high end consumers who have no cost boundaries and don't like bones in their fish, who purchase steak type fish. In Dr. Hightower's study, people were frequently eating sushi, tuna, swordfish, and other finfish with known high levels of mercury. We need to get together clinical guidelines and treatment guidelines from the professional associations. Targeted outreach for at risk populations is also needed.

With regard to neuropsychological impacts, though mercury is likely to cause effects, there is no signature neurological effect pattern to define toxicity and no simple test to run. Protocols need to be developed. What does a physician do? What kinds of tests are most likely to be useful? Guidance on these questions also needs to come from professional associations.

Next steps are to build effective partnerships, including consortia between governmental and non-governmental entities. More research is needed on cardiovascular effects in adults. Greater public and professional communication of mercury exposures hazards and prevention methods are needed. It would be important to better integrate fish consumption advice (between the states and the federal agencies) to speak with a single voice. Funding is a key issue.

Advisories for Methyl Mercury: Approaches.

Amy D. Kyle, University of California Berkeley

The conference steering committee developed a short work sheet including information about how states and tribes develop advisories for methyl mercury. Program managers for 39 states and four tribes completed the worksheet before or during the forum.

The worksheet included four types of advisories:

> Advisories for no fish consumption that apply to the general population (not including any identified sensitive subpopulations);
>
> Advisories for restricted fish consumption that apply to the general population (not including any identified sensitive subpopulations);
>
> Advisories for no fish consumption that apply to an identified sensitive subpopulation(s);
>
> Advisories for restricted fish consumption that apply to an identified sensitive subpopulation(s).

Mercury concentrations in fish that trigger advisories for no fish consumption for the general population ranged from 0.5 to 2.88 parts per million (ppm). Fifteen states and three tribes reported issuing advisories of this type.

Mercury concentrations in fish that trigger advisories for no fish consumption for an identified sensitive population ranged from 0.25 to 1.5 parts per million (ppm). Twenty three states reported issuing advisories of this type.

Mercury concentrations in fish that trigger advisories for restricted fish consumption for the general population ranged from 0.59 to 1 parts per million (ppm). Twenty eight states and two tribes reported issuing advisories of this type. The provisions varied considerably, with the allowable number of meals varying from 12 to 96 and the allowable meal size varying from 3 to 16 ounces. The total allowable methyl mercury that could be consumed following this type of advisory ranged from 0.48 to 7.7 milligrams per year.

Mercury concentrations in fish that trigger advisories for restricted fish consumption for an identified sensitive population ranged from 0.25 to 1.5 parts per million (ppm) and were issued by 23 states. The allowable number of meals ranged from 12 to 104. The allowable total amount of methyl mercury ranged from 1.37 to 47.4 milligrams per year.

V. Advisories for Commercial Fish

Report on the Advisory Panel to the Food and Drug Administration on Mercury Advisories.

H. Vasken Aposhian, University of Arizona

The talk addresses the discussions of the Food and Drug Administration Food Advisory Committee on Methyl Mercury, held July 23-25, 2002.

The charge to committee was to evaluate in light of all the relevant information about potential consumption exposures, population body burdens, hazard, and consumer measures whether the advisory for commercial fish is protective of the general public. Put more simply, does the FDA advisory provide adequate protection for pregnant women?

Question No. 1 was: Has the agency adequacy addressed and appropriately considered all the relevant actors and information that bear upon the elaboration of a consumer advisory on fish consumption? Answer: No. Are any factors not relevant? Answer: No. Are there additional factors that would be relevant? Answer: Yes.

There was some concern about a lack of transparency about the data that the FDA has used in the past. A statement from the chairman was that, "The FDA should publish its risk assessment in peer reviewed literature and indeed other organizations that have competing models ought to do the same and let the scientific community evaluate it." The group was also concerned about exposure of children to canned tuna fish and exposure of women.

Question No. 2: Should the FDA advisory have specifically advised pregnant women to avoid any other fish species not specifically mentioned and, if so, what would be the scientific rationale?

Consensus response was: Yes. The panel was surprised to learn that 27% of seafood consumed by American people is canned tuna. There was a concern about how to transfer information to women and children at risk. The information pamphlets by the states of Wisconsin, Minnesota, and Maine were very simple and clear. The Committee wanted to see better communication with people at risk for canned tuna.

Question 3: Should the agency issue a fish listing as an adjunct to the advisory to clarify what is meant? Answer: Yes

Should the agency revise its consumer advisory to make explicit that the 12 ounce per week includes all sources of fish, both recreational and commercial? Answer: Yes.

Should the agency increase its monitoring of methyl mercury in commercial fish in order to keep this advice current? Answer: Yes. FDA has not done much monitoring of canned tuna, which they say is because there isn't enough money. Other data are available. The American Tuna Association said every batch that is processed has a methyl mercury determination done and records are kept. The FDA has apparently never asked to see those records.

The state of Florida has performed some testing and reported results that exceed one ppm. The FDA action level is 1 ppm. One value of 1.238 was from a low sodium can of a type that should be eaten by those with high blood pressure. This presents a concern.

The reference levels used by various agencies continue to differ.

His involvement began in 1995 during interagency discussions. EPA via act of Congress got a study by the National Academy of Sciences (NAS) to determine which the appropriate level was, and the NAS concluded that it should be at the level set by EPA, at 0.1 [2]. This was two to three years ago. No one on committee felt people should not eat fish. Fish is good for people. It is very important that FDA communicate with women about how much canned tuna they should eat. Children are the future of this country.

FDA Consumer Advisory for Methyl Mercury.

Philip Spiller, US Food and Drug Administration

FDA has issued one advisory for seafood and that is for methyl mercury. It is still a work in progress. The federal advisory is national and uniform in scope. The mission of FDA is to address food in interstate commerce, not recreational/subsistence uses of fish.

Three major decisions are needed to devise an advisory: Who to target? What outcome are we seeking in the target population? How do we structure advisory to achieve the desired outcome?

For adults, the threshold for effects is 50 ppm in hair. Recent studies in the Seychelles and Faroe Islands show levels of 5 to 7 ppm. In the United States, the average adult hair concentration is 0.2 ppm. Some people may be consuming more mercury than recommended under the FDA acceptable daily intake level, but so far they have been too few to detect through biomonitoring such as that conducted in NHANES (National Health and Nutritional Examination Survey by CDC.) Based on these factors, FDA did not see adult population as urgent priority for action at national level. This does not mean they cannot re-think this based on new data. It also does not mean that on a regional basis, the adult population would not be an appropriate target for an advisory.

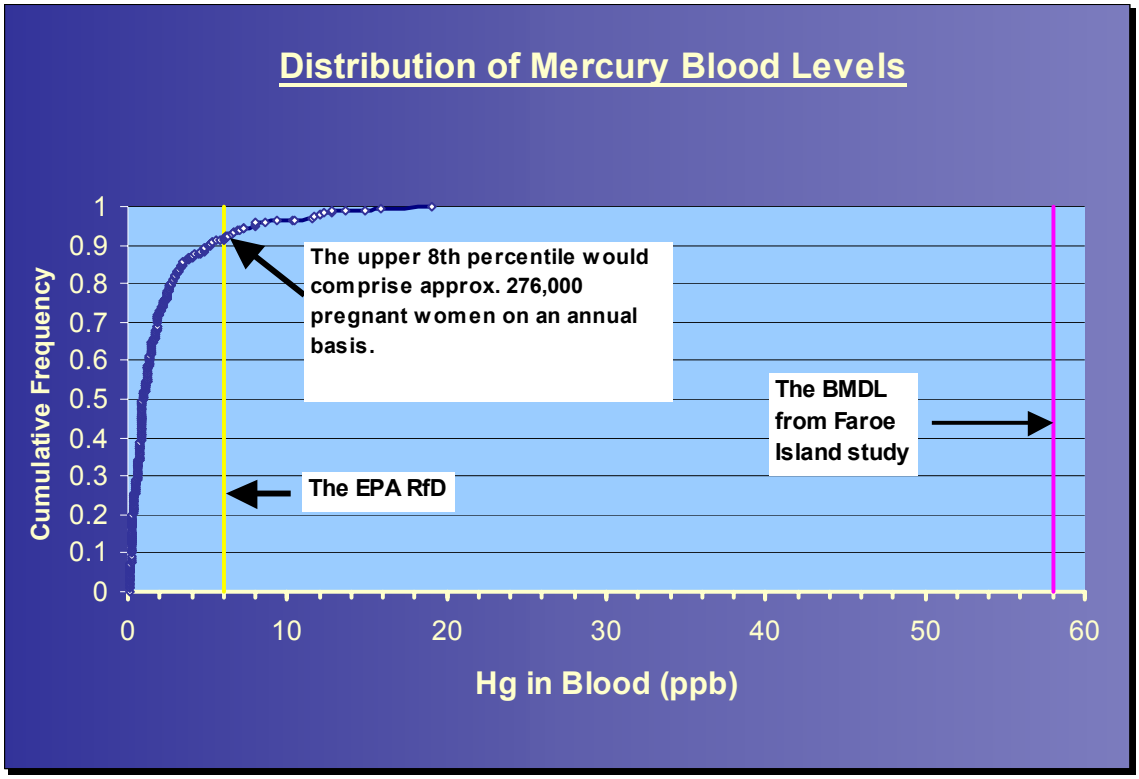
FDA decided to target the fetus. The Seychelles Island study did not detect effects [3, 4] [5] [6] [7], while the Faroe Islands study did [8-13]. The Faroe Island study did report effects at levels lower than those known to cause effects in adults. US EPA has used this study. Both have been questioned. ATSDR relied on the Seychelles study.

In July 2000, after a review, the National Academy of Sciences said that the Faroe Islands study should be used because of questions about Seychelles [2]. Other countries appear to be hedging bets and take into account both studies.

Faced with this ambiguity, FDA decided to take a prudent course and issue a consumer advisory to protect the fetus as a target population. The next question was what outcome should be sought via the advisory. One option would be to set a goal of keeping exposure below highest no effect level from Seychelles and Faroe Islands. That level of exposure is hard to reach, even without an advisory and would be the equivalent of one fish meal per day with fish containing five times the amount in commercial fish average. This is a 98th percentile consumer.

Another option would be to keep exposure below a worst case acceptable daily intake (ADI)-type level. The acceptable daily intake was developed by the FDA before the Seychelles or Faroe Islands studies were available. It is still applicable to general population but would not be relevant to the fetus if the fetus was more sensitive than the adult. ATSDR developed a daily

intake level, the Minimal Risk Level (MRL), which would be relevant for the fetus. The EPA reference dose is also relevant to pre-natal exposures and is more conservative, representing the worst case. According to the most recent data available from NHANES, eight percent of women of child bearing age are consuming above the worst case.



FDA decided to issue a single advisory that would be simple to follow and that would minimize impact on the majority whose consumption is not at issue. If advisory is followed, FDA calculated that everyone within the target population would have margin of safety of at least 10. It would move everyone to left of yellow line (on the previous graph). Most people do not need to modify behavior. It creates as little disruption as possible and targets as few fish as possible. The message is to avoid highest species, which are named; that it is acceptable to eat up to 12 oz per week of a variety of fish; and that one should check local advisories for recreational and subsistence advisories.

Michael Bender, Vermont: Why is FDA's level of safety less than EPA? Why does FDA not test tuna?

Response: We keep hearing a steady concern over the years that it is a bad thing that FDA's ADI differs from EPA's RfD. The idea of having different numbers for adults and fetus is not necessarily bad. We need to have a strategy for sensitive populations.

Kory Groetsch, Great Lakes Indian Fish and Wildlife Commission: People are aware of mercury issue but can't tell which fish will have higher v. lower levels of mercury. Has FDA considered labeling to allow consumer to choose?

Response: yes – nothing has been ruled out. The standards for requiring labeling are strict. It is a challenge to make sure an advisory becomes well known. The FDA advisory has been out since the mid 1990s and been published in sources such as magazines.

H. Vasken Aposian: When you buy a candy bar – you can look at the number of calories. FDA now insists on labeling of calories on foodstuffs – why not put on some kind of notice for mercury?

Reponses: Nutritional labeling is covered by a different law; other labeling has more rigorous studies mandated.

Eric Uram, Sierra Club. The ADI places significant weight on the recommendation for two fish meals or more per week from the American Heart Association. It now appears that eating less fish will get you same benefit. Has FDA tried to quantify benefits for seafood and resolve this issue?

Question: The data for the tile fish came from two quadrants along the Texas Louisiana border – probably golden tilefish. Other data collected was 0.1 ppm total Hg in survey collected along Atlantic coast. Would you consider de-listing this and looking at data?

Response: We would be receptive to this.

Dan Kusnierz, Penobscot Indian Nation. Tribes are struggling with message of benefits and risks from fish including cultural benefits. For subsistence fishing – people are going out there and catching fish themselves. A new at-risk population is people buying fish from grocery stores because of messages that eating fish is good for you. Now we are finding high levels of mercury in blood of these people. The communication strategy does not seem to be working for at least some people. There are also implications for people who stop eating traditional foods and buy fish.

Response – one of the recommendations was to do a better job of extending advisory beyond commercial fish because people do not necessarily distinguish between these and to build in messages about subsistence and recreational fish.

Elaine Krueger – Massachusetts issued an updated advisory last year that included advice from the federal level and included advice on tuna. We can appreciate good work done by federal agencies but have to give advice on the phone to people and can't always wait on the federal response. States have issued advisories regarding commercial fish. How many states have commercial advisories?

Response: About four.

Integrated Public Health Messages for Sport Fish and Commercial Seafood.
Henry A. Anderson, Wisconsin Division of Public Health

Understandably, it is confusing to see advice about mercury in fish on one side (the state or recreational side) but not the other (the federal or commercial side.) Communication is a local activity. We need to communicate at local level.

A survey was conducted in 12 states as a joint effort of the states of Wisconsin and Maine, using random digit dialing. Other states included California, Montana, Minnesota, New Mexico, Louisiana, Arkansas, Florida, North Carolina, New Jersey, and Connecticut. Respondents were asked about their fish consumption.

For women, average sport fish consumption was about 4 fish meals a year; 11 for shellfish; and 28 for fish fillets and tuna (combined). Even as few as 4 meals can be critical for PCBs, which are low in commercial fish. Concentrations of mercury in sport fish can be comparable to commercial.

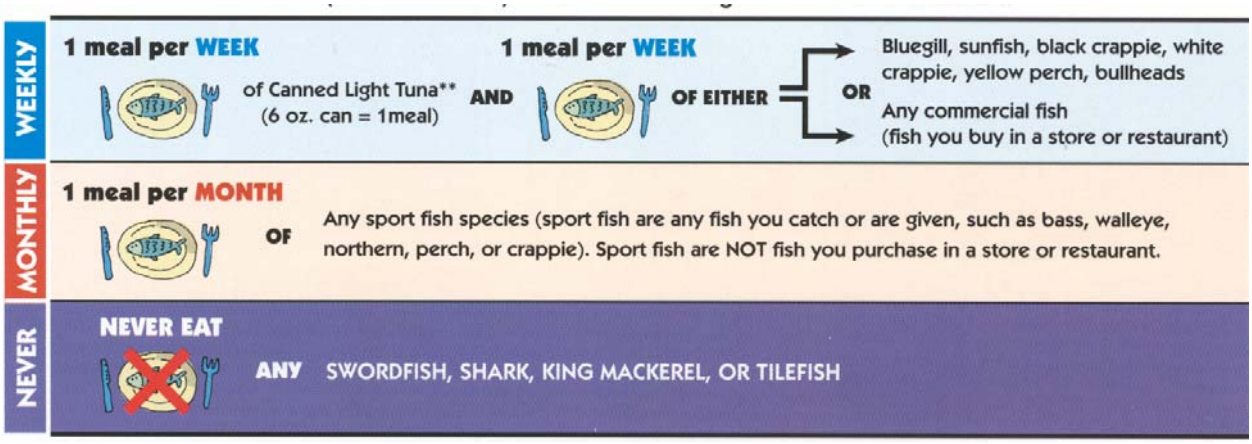
Hair mercury was sampled, and 410 samples were obtained. The amount of mercury in hair was related to fish consumption.

Wisconsin has a complex system of advisories. In 2000, 1200 water segments were tested, and advisories were issued for 340. The states moved to general statewide guidelines plus site specific advice for 92 hot spots where more stringent advice is needed, and the advice addresses both commercial and sport caught fish.

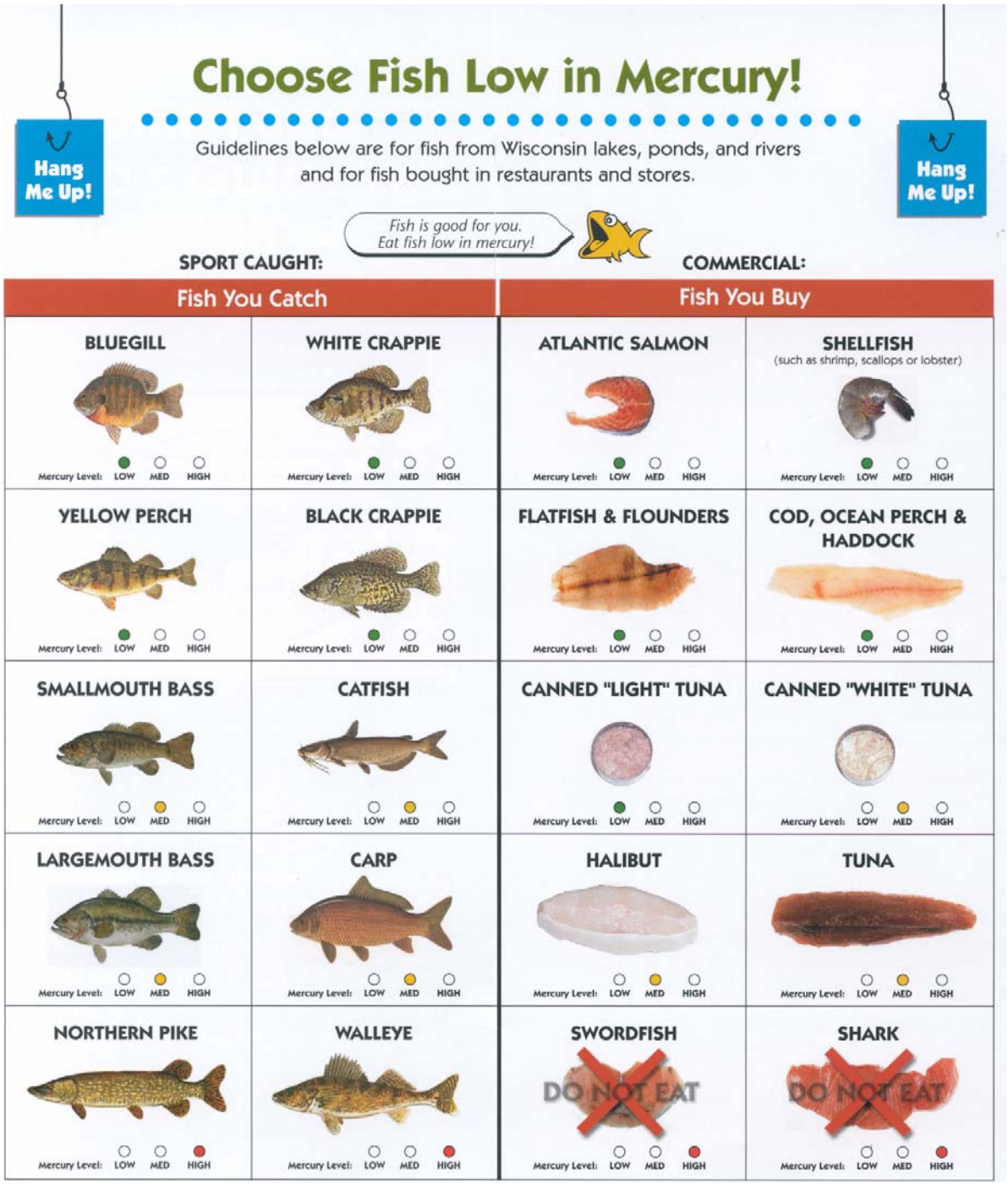
The guide to eating fish from Wisconsin suggests:

- One meal per week of canned light tuna and one meal per week of either key sport caught fish or any commercial fish;
- One meal per month of higher mercury sport caught fish;
- No consumption for the list of commercial fish on the FDA advisory to never eat.

A Woman and Child's Guide to Eating Fish from Wisconsin (2002) – Includes sport and commercial fish.



The advisory includes additional information about ocean species and provides pictures of both sport caught fish and commercial fish that are low in mercury.



People like to have pictures of what it looks like when they buy it in the store.

Any successful program has to be a joint activity between state health and environment agencies. The environmental agency was responsible for comprehensive sport fish monitoring species, size, and location. The health agency was responsible for human biomonitoring, heath outcomes, and advisory evaluation. There are little state general revenues for this, so the work was largely supported by federal sources.

The survey also asked about awareness of mercury. Awareness varied considerably by state but averaged about 20% with a high of 32% in Maine and a low of 8 to 9% in Montana, New Mexico, and California. States with longer established programs have higher awareness.

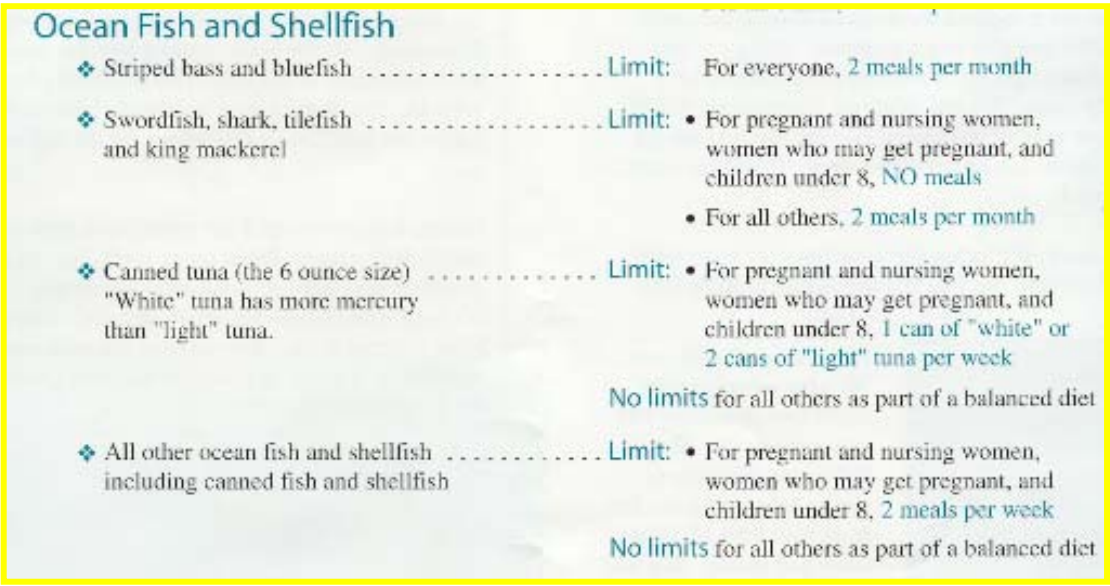
The group concludes that increased commercial fish monitored designed to assist in advisory development is needed, as is increased human biomonitoring and continued health effects research, particularly for cardio vascular effects.

Consumer Advisory for Commercial Fish.

Andy Smith, Maine Department of Human Services

The first question is, why issue advisories for commercial fish? The main reason is that commercial fish are most commonly consumed. Women want to know about the commercial fish they were eating. Only about 20% of women in Maine reported eating sport caught fish. The limited data available for Maine suggest that higher hair mercury levels were largely associated with eating commercial fish.

A guiding principle was to avoid confusion and increase consistency. It is difficult to inform people and gain behavior change with differing messages. To gain buy-in from medical folks, the message needs to be clear. A second objective was to redirect fish consumption toward fish lower in mercury.



Ocean Fish and Shellfish

- Striped bass and bluefish ..... Limit: For everyone, 2 meals per month
- Swordfish, shark, tilefish and king mackerel ..... Limit:
  - For pregnant and nursing women, women who may get pregnant, and children under 8, NO meals
  - For all others, 2 meals per month
- Canned tuna (the 6 ounce size) "White" tuna has more mercury than "light" tuna. ..... Limit:
  - For pregnant and nursing women, women who may get pregnant, and children under 8, 1 can of "white" or 2 cans of "light" tuna per week

  No limits for all others as part of a balanced diet
- All other ocean fish and shellfish including canned fish and shellfish ..... Limit:
  - For pregnant and nursing women, women who may get pregnant, and children under 8, 2 meals per week

  No limits for all others as part of a balanced diet

The advisory differs from FDA's advice in certain ways. It addresses canned tuna and separates out light compared to white canned tuna, as the latter is about twice as high in mercury, and suggests no more than 1 can of white or two cans of light tuna a week for women or children under eight. (The FDA advisory does not include canned tuna.)

The advisory also provides information for the general population (in addition to women and children) and recommends no more than two meals per month of swordfish, shark, tilefish, and king mackerel for the general public.

The strategy for risk communication focused on developing a brochure using focus groups and a health literacy expert and posters for waiting rooms and exam rooms at clinics. It shows commercial fish in forms found in the market and the sport fish in forms brought out of the water. (So, commercial fish are depicted in a cleaned and packaged form and sport fish are depicted in a whole form.) Maine is targeting women through WIC (woman infant children) programs and clinics. The strategy also targets fishing households with kids by matching birth certificates and fishing licenses.

Next steps involve continuing to improve materials. The ultimate measure of effectiveness would be increased awareness of safe eating guidelines, changed consumption behavior and decreased hair mercury levels. (It would be a failure to reduce both hair mercury levels and consumption.)

The Context for Connecticut's Seafood Advisory.

Gary Ginsberg, State of Connecticut

The State had been issuing recreational advisories since 1980s. The principal sampling for mercury in lakes occurred in 1996-1997. This resulted in a statewide freshwater advisory. Four water bodies were particularly high, with average concentrations in bass above 1 ppm.

People would ask about commercial fish, so Connecticut developed an advisory to respond to questions. They decided to look at concentrations in commercial fish and how these compared to sport caught fish. Swordfish and shark were greater than 1 ppm; tuna steak was generally from 0.3 to 0.5 ppm. Published results for canned tuna [14] reported 0.1 ppm in chunk or chunk light and 0.3 ppm in chunk white or solid white tuna.

The point of departure is around 0.2 ppm, and these numbers were in the same ballpark. This convinced the administration that it was appropriate to move forward. Infrequent consumption of swordfish/shark (once per month) is in the range of the methyl mercury RfD. This leads to a do-not-eat category. They do not have a category for consumption less frequent than once per month. Frequent consumption of canned tuna (e.g., 2 or more times per week) is in the range of the RfD and would lead to an advisory of one to two meals per week for the high risk population only.

They considered whether consumption of commercial fish could be contributing to mercury concentrations found in hair. In NHANES for 1999 (702 women), the 90th percentile is at 1.4 ppm, which is around the range of the RfD.

A simulation of seafood consumption by FDA [15] matched consumption rates and mercury concentrations based only on 24 species (which suggests that others are not important). The

study shows tuna is around 30% on average, which is by far the largest single species. Swordfish and shark contribute much less overall. Pollock and cod are also contributors.

A New Jersey study measured mercury in pregnant women [16] and found that 9.5% were between 1 and 2 ppm in hair. 10-15% ingested more than the RfD. Fish consumption patterns were only weakly correlated with Hg.

A Connecticut mercury biomonitoring data study (EPA Mercury Advisory Awareness Study, 2000) found that the results for hair mercury were higher than other states and may be influenced by small numbers. The study included 17 women from Connecticut, 18-45 yrs old, and found a mean hair mercury level of 1.0 ppm (+/- 0.8 ppm.) The fish intake data was sketchy, but commercial fish consumption was much more common than sport fish.

The Connecticut Commercial Advisory says that high risk groups should avoid swordfish and shark, while others can eat 1 to 2 meals per month. For canned tuna and other commercial fish the recommended consumption is 1-2 meals per week for high risk groups and unlimited for others. Species identified as being low in mercury and PCBs include haddock, cod, flounder, and salmon.

A question to consider is whether there should be a commercial advisory for PCBs. Striped bass and bluefish have elevated PCBs. Connecticut has recreational but no commercial advisory for these species. They are uncommon in marketplace in Connecticut.

LuAnne Williams, North Carolina: Would like to thanks folks from Wisconsin and Maine for initiating the multi state survey, which North Carolina benefited from. This led to changes in approach, leading to more focus on health care providers. They have advice statements that recommend two meals a week of fish and provide a list of safer species. They recommend that people avoid seven types of fish.

Roseanne Lorenzana, EPA Region X: There has been a study funded by EPA of fish consumption in Asian Americans in 1999 that show high level of consumption of commercial fish, though species are not primarily tuna fish or pollock. What is the monitoring of these kinds of fish? Are there state advisories that focus on these populations?

Response: Henry Anderson: if people are purchasing fish there is probably little testing. Wisconsin does have outreach to growing Asian populations. There are difficulties in defining species in common terms. They are also emphasizing cooking approaches.

VI. Chemicals of Concern

A. Mercury

Methylmercury: Ongoing Research on Toxicology.

Kathryn R. Mahaffey, US EPA

Fish and shellfish virtually all contain mercury, though both concentrations and consumption vary widely.

Key results to review here include the NRC 2000 report [2]; the US EPA's 2001 reference dose [17, 18]; biomonitoring measures; and current research findings.

EPA's 2001 RfD was based on a benchmark dose (BMDL) [19]. This was based on neuropsychological tests reflecting children's ability to learn and process information. Methyl mercury exposure doubled the risk of scores in a range considered subnormal. The BMDL that EPA used was based on doubling of the prevalence of scores in a range recognized as subnormal on tests of developmental function.

Biomarkers are used to represent exposure. One key issue is the relationship between mercury concentrations in umbilical cord blood in the developing child and in the mother.

Both US EPA and the National Academy of Sciences selected a BMDL of about 58 µg/L of mercury measured in the umbilical cord. The cord blood was assumed to have the same amount of mercury as the mother's blood. This is a common assumption.

More recent results suggest that this assumption may be incorrect and that cord blood is on average 1.7 times **higher** in mercury than maternal blood. This would mean that, if the level of mercury in the umbilical cord blood was 58 µg/L, the level of mercury in the mother's blood would be expected to be about 34 µg/L. The reasons for this difference are likely to be due to differences in the way the mercury is distributed and processed in the body of the mother and child. Differences in the mean ratio of cord blood to maternal blood varied in one study from 2.17 to 1.09 [20].

In developing the RfD, the uncertainty factors were set based on the assumption that the ratio was 1. This did not take account of this difference.

As noted in other talks, according to NHANES data, about 8% of women in the US exceed the EPA RfD of 5.8 µg/L. The 90th percentile is 4.84 µg/L.

Effects of methylmercury in adults are also a concern. Are there cardiovascular effects in adults of low dose exposure to methyl mercury? Some results suggest that this may be the case. Salonen studied 1983 men living in Eastern Finland aged 42 to 60 years [21, 22]. This study reports that mercury is a risk factor for coronary and fatal cardiovascular disease. Dietary intake of fish and mercury were associated with significantly increased risk of acute myocardial infarction (AMI) and with death from coronary heart disease (CHD), cardiovascular disease and from any cause. Men in the highest tertile (2 ppm and higher hair mercury) had a 2-fold age- and CHD-adjusted risk of AMI (95% CI 1.2 to 3.1; P=0.005) and a 2.9-fold higher adjusted risk of cardiovascular death (95% CI, 1.2 to 6.6; P=0.014). This is a dramatic number.

Carotid intima-media thickness increased with increases in hair mercury concentration. This suggests that mercury accumulation in the human body is associated with accelerated progress of carotid atherosclerosis. This has been viewed as just one population. There is a multi center European trial on coronary heart disease that also measured heart disease, and results have been accepted for publication. Additional information should be available soon.

Setting a Methyl Mercury Reference Dose for Adults.

Alan H. Stern, New Jersey Department of Environmental Protection

The policy of the U.S. EPA is to derive a single reference dose (RfD) per chemical based on goal of protecting most sensitive group. Generally, members of the sensitive group are not known, or cannot control their exposure (e.g., air or drinking water). Therefore, protection of sensitive groups results in overprotection of general population.

However, for methyl mercury (MeHg), the sensitive population is well characterized and is women of childbearing age, pregnant women, and young children. Individuals have reasonable control over exposure in that they control their fish consumption. They can consume fish with lower mercury concentrations, at least in theory.

In principle, this lends itself to a two-tiered advisory structure for the sensitive population and general population. The general population is not overly protected and has less potential limitations on obtaining nutritional value from fish. The sensitive population is protected at more stringent level.

The two-tiered approach is based on two RfDs. The current RfD is based on neurodevelopmental effects for the sensitive population.

The previous RfD, which is applied to the general population, is based on neurological effects for general population and is specifically protective against the occurrence of paraesthesia. This was the basis for the previous US EPA methyl mercury RfD, which was based on studies from Iraq [1] and Minamata. It is appropriate to consider whether this is still an appropriate endpoint when more subtle health endpoints are considered.

Currently, 12-13 states follow a two-tiered approach. The appropriateness of this approach is predicated on the assumption that the reference dose for the general population will be less than that for a sensitive population ($Rfd_{gen} > RfD_{sens}$). The current RfD is 0.1 µg/kg/day, while the old RfD (for the general population) was 0.3 µg/kg/day. This difference is small, but significant for fish advisories and allows for two different consumption rates for fish advisories.

Is the assumption that the RfD for the general population will be greater than the RfD for the sensitive population ($Rfd_{gen} > RfD_{sens}$) correct? The NRC report highlights several areas of uncertainty for a general ("adult") RfD, particularly cardiovascular effects and immunotoxic effects [2]. Currently lacking is a lifetime exposure assessment that addresses in *utero* plus adult exposures, as effects may be due to the combination of developmental as well as adult-stage health impacts.

The NRC committee felt that there was not enough information in the literature or enough time to peer review all of the studies that were available and to derive reference dose for these endpoints. Their recommendation was to add an uncertainty factor of 3 (half a log unit) to deal with this, for database uncertainties related to adult effects.

Researchers have reported some findings for cardiovascular endpoints for MeHg. Salonen et al. [22] looked at middle aged Finnish men. The mean hair mercury was 1.92 ppm, approximately 2.3 times the New Jersey general population mean. For men with hair mercury greater than 2 ppm, the adjusted relative risk for AMI, CHD, and CVD were 1.7 to 2.1. In New Jersey, about 20% of general population has hair concentrations greater than 2 ppm.

The Salonen study [21] included a 4 year follow-up assessing hair Hg, and atherosclerosis progression. They used ultrasound determination of carotid artery thickness, which is a major advance in assessing pre-clinical effects. After adjustment for co-variates, men in upper quintile of hair mercury (2.8 ppm in hair) had a 40% increase in arterial wall thickness.

If the RfD for the general population is higher than the RfD for sensitive populations, we would retain the two tier structure. Currently they are separated by only 0.2 µg/kg/day. If the RfD for the general population decreases by 0.1 µg/kg/day, will the difference in advisories be significant? If the RfD for the general population is lower than that for the "sensitive" populations, would we just have one advisory? Does the cardiovascular endpoint apply to women?

EPA has sponsored a project to look at these issues, to be investigated by Dr. Alan H. Stern with Dr. Andy E. Smith of Maine as the co-principal investigator. Other participants include state toxicologists, epidemiologists, risk assessors. The project will also include independent consultants in statistics and cardio-epidemiology.

Note: Dr. Stern was a member of the NRC panel.

Henry Anderson, Wisconsin: Because of benefits of fish consumption, maybe you would want to call this something other than an RfD?

Response: Any integrated analysis that looks at mercury exposure and health effects should integrate competing processes of beneficial omega three fatty acids. The trick is to see to what extent this is actually occurring. Another paper suggests that when mercury is present, benefits of omega three fatty acids are lost.

Kate Mahaffey: There is a big literature about omega 3 and omega 6 in various fish. They are associated with fat in fish. We can have fish that are high in omega 3's but not high in mercury. It is misleading to think that just because you select fish lower in mercury that you are winding up with fish lower in these fatty acids.

Andy Smith: this will be addressed by a speaker on the fish oils issues

Kate Mahaffey: Going from the benchmark dose (BMDL) to the reference dose has an uncertainty factor of ten, which has several components, but it assumed that cord blood and maternal blood are equal. Some of this factor is eroded by what we know so far.

Deb Rice: The NAS panel used the critical study/critical endpoint approach to choose a point of departure for calculating an RfD, in accordance with typical practice. They chose the Faroe Islands study as the critical study, and the Boston Naming Test as the critical endpoint. However, they also performed an integrative analysis of all three studies combined, to encourage better use of all the available data. EPA considered the RfD to be based on a number of endpoints from the Faroe Islands and New Zealand studies, as well as the integrative analysis. Most of these endpoints yield an RfD of 0.1 µg/kg/day. The BMDL from the Boston Naming Test is 58 ppm in blood; however, any one of a number of other endpoints could have been chosen as representative of the RfD. For example, the BMDL for the integrative analysis is 32 µg/kg/day.

Alan Stern: They did an integrated analysis in a less formal sense with the Faroe Islands data. I agree with you. The intent on the committee was to come up with the test that gave the lowest BMDL that was clearly defensible. They did not pick the lowest one, which was the continuous performance test, but the test giving the most sensitive mercury effect (the Boston naming test) because they thought it was a more robust test. 58 µg/kg/day was one of several numbers within a fairly narrow range that could have been chosen, but it was not the lowest number that could have been shown.

B. Brominated Flame Retardants

Occurrence of PBDE Flame Retardants in Fish.

Robert C. Hale, Virginia Institute of Marine Science

The term "brominated flame retardants" is often used interchangeably with "polybrominated diphenyl ethers." In reality, PBDEs are a subclass of BFRs, which are chemicals added to products up to reduce fire hazards. Products can contain up to 30% of them by weight.

BFRs have differing chemical structures. However, PBDEs and PBBs (poly brominated biphenyls) have very similar chemical structures, which differ only in that the PBDEs have an ether linkage not found in the PBBs. Both resemble the highly toxic and persistent PCBs.

In 1973, PBBs were inadvertently introduced into livestock feed in Michigan and subsequently into people. As a result, a large number of animals had to be destroyed, but many people still carry body burdens. Following this incident, PBB use in the US was suspended.

There are three commercial PBDE mixtures now in use in the US, referred to as "Deca," "Penta," and "Octa." Deca-BDE is used in thermoplastics and textiles. Penta BDE is used in polyurethane foam, and Americans use 98% of the world's total production. Octa-BDE is less common and mostly used in thermoplastics. They are mixtures that are numbered just like PCB congeners.

These mixtures consist of individual congeners, which have been assigned numbers like PCB congeners, to reflect the number of halogens and their position.

Deca (BDE-209) strongly partitions to sediments and does not represent as much of a bioconcentration hazard as some other forms. The congeners that comprise the "Penta" product tend to partition similarly to PCBs. Bioaccumulation is high and probably occurs to a greater degree for these compounds than for PCBs.

PBDEs are resistant to environmental degradation and subject to long range transport. Those with less than seven bromines have higher vapor pressure and appear to be subject to long range transport. Accumulation in fish is a major pathway for human exposure, as per PCBs.

European researchers have conducted more research in this area than researchers in the US. Their work suggests that the less brominated congeners have already reached remote areas.

Levels in breast milk measured in North America are increasing logarithmically, in proportion to our relatively higher use.

The European Union has issued a ban on the penta mixes, scheduled to go into effect in 2003.

It has been suggested that Deca (BDE-209) may be vulnerable to debromination in some conditions, perhaps including the presence of UV light. However, there is no currently published literature showing that degradation of BDE-209 is responsible for the distribution of tetra- and penta-brominated congeners in the environment.

To date, the US has no regulations restricting the use or disposal of these compounds.

The Mussel Watch program (which routinely monitors concentrations of contaminants in sediments and shellfish) is expected to add the PBDEs to its surveillance program.

The first documentation of PBDE concentrations in North American aquatic organisms was from 1987 and reported about 200 ppb in lipids of dolphins. Marine mammals seem to be very high accumulators. Levels in San Francisco Bay seals increased 65-fold from 1988 to 2000 [23]. The values in the US are increasing over time, and tetra-brominated compounds are being found in virtually all samples.

A case study from Virginia, published in Environmental Science and Technology, was conducted in 1998-9 in the Roanoke Basin [24]. It found BDE-47, the most commonly reported congener and a major component of the Penta- mixture, in 89% of Roanoke basin fish fillets. Other congeners were present as well. The detection of PBDEs in rivers surrounded by dams debunks the idea that it comes from historical uses of drilling muds or marine sponges. Sources are likely to be local. There is a history of textile mill and furniture manufacturers in the area. While there is some statistical correlation between PCBs and PBDE concentrations, there were also outliers. This suggests that the original sources may differ.

Major PBDE commercial products in use in North America in 1999.

Commercial PBDE Mixture	1999 North American demand (tons)	Percent of 1999 Global Demand	Major component PBDE congeners
Penta-	8290	97.5%	BDE-47, 99, 100, 153, 154, 85
Octa-	1375	35.9%	BDE-183, 153, unknown octa- and nona-BDEs
Deca-	24300	44.3%	BDE-209, unknown nona-BDEs
Total	33965	50.6%	

PBDEs: Toxicology and Human Exposure.

Linda S. Birnbaum, US Environmental Protection Agency

The brominated flame retardants are major industrial products (~67 metric tons/year). There are several forms.

The “deca” compounds are produced in the largest volume (75% of what is produced in the European Union.) They are used in polymers, electronic equipment, and textiles.

The “octa” compounds are used as polymers, especially in office equipment.

The PeBDEs are most problematic. They are used in textiles and polyurethane foams (up to 30%). A ban has been recommended in the European Union for these compounds, allowing no production, only import. Essentially they are not being used except in North America

The mixes of congeners vary by medium.

In air: 47>99>100>153=154.

The pattern in sludge looks like the pattern in foam, as you see less 47 than 99.

In sediments, concentrations of congener 99 are higher than 47. This pattern reflects commercial PeBDEs along with some also some nona and deca forms.

In biota, 47>99=100 except in locations near a manufacturing site. This pattern does not reflect commercial mixtures. In a commercial mixture you have more 99 than 47

For concentrations in biota, marine mammals have much higher concentrations than other organisms. Fish are lower and invertebrates about the same or slightly lower.

For ecotoxicity, PeBDEs are much worse than OBDEs which are worse than DBDEs. They are highly toxic to invertebrates (For larval development, the lethal effects levels are in the low μg/L range.)

DBDEs and OBDEs may be low risk to surface water organisms and top predators. There are concerns for waste water, sediment, and soil organisms. The presence of lower brominated congeners in OBDE, which could lead to penta forms, is a concern. Photolytic and/or anaerobic debromination can also give us penta forms.

For mammals, concerns are liver effects, enzyme induction. DBDE is a hepatocarcinogen at high doses. There are also neurotoxic effects. More recent studies show more subtle effects. Changes seen would be associated with learning issues in adults and could lead to permanent changes in brain function. Moreover, developmental exposure may lead to increased susceptibility of adults exposed to low doses of PBDEs. *In vitro* studies show changes in signaling pathways

Endocrine disrupting effects include AhR effects, thyroid effects, and estrogenic effects. For thyroid the real concern has to do with ability to disrupt thyroid homeostasis. Some forms are estrogenic.

PBDEs are readily absorbed except for DBDE, which is poorly absorbed. Lipid binding is important. In fat, 47>99>>>209. In the liver, you see covalent binding from 99 and 209. Metabolism is through hydroxylation, debromination, and O-methylation. Excretion is primarily in feces.

Trends of BDEs in human milk pose an important concern. In Sweden, results show an exponential rise that peaked in about 1997 and then went down after they stopped using it in 1994. Levels in Europe are much lower than what we are starting to see here in North America; levels of use are 10 times higher here than there and they have stopped using the penta formulation. Our levels are much higher; some people are far above the range of any other people and highly exposed.

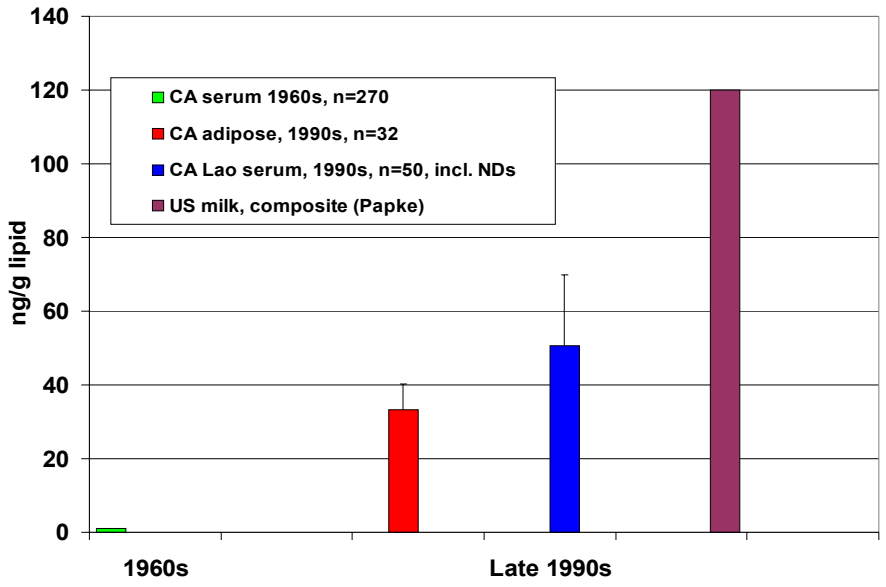
Total BDEs in contemporary human milk (ng/g lipid) [25]

Country	Number of samples	Year	Median	Mean
Sweden	93	1996-1999	3.2	4.0
Japan	12	2000?	1.4	1.3
Canada	50	2001-02	25	64
USA (adipose)	23	1998	41	86

Measurements of PBDEs in human samples in the US [23] show that 47 is about 40% of total; 153 is about 20%, 154 is about 17% and 99 and 100 are about 10%. There is little 99 compared to what is present in a commercial mixture. Possible explanations are that these may be more persistent or perhaps they are coming from octa mixtures or debromination of deca mixtures. The mix measured is totally unlike the original formulation of the products.

Though limited data are available, it appears that concentrations have increased dramatically in measurements made in California.

Fig. 2 PBDE 47 in California women



Source: [26]

Measurements made in Canada show that the sum of eight congeners in breast milk has increased greatly since around 1992 and is largely driven by 47. The pattern of congeners is different from commercial mixtures (and food). In the US and Europe, 47 is higher than 99 (others: 100, 153, 183, and 209?). In Japan, 99 and 153 are higher than 47. There are also large interindividual differences.

Concentrations are doubling every 2-5 years. PBDE and PCB levels are not correlated. In most samples today, PCBs are greater than PBDEs. There are likely to be different sources and/or a different time sequence.

The key question is whether levels are high enough to see effects. To determine this, we need more toxicology data. We also need:

- More systematic human and environmental monitoring;
- More information on fate and transport – are commercial products breaking down? And into what?
- More toxicology data that focus on congeners present in people and wildlife, not commercial products since they are altered in the environment.

Polybrominated Diphenyl Ethers (BDEs).

Khizar Wasti, Virginia Department of Health

In view of BDES being detected in fish at 1-2 milligrams per kilogram (mg/kg) range, the state of Virginia developed guidance levels for the issuance of a fish consumption advisory for BDEs. To date, information available in the literature regarding the toxicity of BDEs is very limited.

For deca-BDE, the acute toxicity in experimental animals is low. The oral LD50 in rats is greater than 5 mg/kg. No adverse effects were noted in rats fed at doses of up to 800 mg/kg body weight for 30 days. There is no evidence of carcinogenic, reproductive, teratogenic, or mutagenic effects. Epidemiological studies in occupationally exposed workers did not indicate any symptoms attributable to BDE exposure. In the U.S. Environmental Protection Agency's (EPA) Integrated Risk Information System (IRIS) database, the oral reference dose (RfD) is reported as 0.01 mg/kg/day.

For octa-BDE, the acute toxicity in experimental animals is low. The oral LD50 in rats is greater than 5,000 to 28,000 mg/kg. Teratogenicity was seen at doses of 25 and 50 mg/kg body weight; resorptions or delayed ossification of different bones and fetal malformations were noted in rats. These changes were not seen at 15 mg/kg dose or less. In rabbits there was no teratogenicity, but fetotoxicity was seen at a maternally toxic dose of 15 mg/kg. A no-effect level was 2.5 mg/kg. Assays for mutagenicity were negative. For carcinogenicity, no data are available to date. The oral RfD in the IRIS database is reported to be 0.003 mg/kg/day.

For penta-BDE, acute oral toxicity is low with an LD50 in rats of 6,000 to 7,000 mg/kg. Rats given a diet containing 100 mg/kg for 90 days showed no clinical effects. It was not found to be mutagenic, and there are no data on its carcinogenicity. In the IRIS Database, the oral RfD is reported as 0.002 mg/kg/day.

For tetra-BDE, no human or animal data are available. Toxicity may be assumed to be similar to commercial penta-BDE since it contains significant amount of tetra-isomer.

Since very little toxicity information was available in the literature, Virginia sought assistance from various federal and state agencies. A task force was formed comprising staff from health and environmental agencies in Virginia and North Carolina, and two federal agencies which included EPA and the Centers for Disease Control and Prevention (CDC). To derive an allowable BDE level in fish, the oral RfD values of penta-isomer (0.002 mg/kg/day); octa-isomer (0.003 mg/kg/day); and deca-isomer (0.01 mg/kg/day) were compared. The task force members concurred with the approach of selecting the RfD of the most toxic isomer to be used in deriving guidance levels for BDEs in fish. The task force considered the option of using the RfD value for penta-isomer, 0.002 mg/kg/day. EPA suggested using an interim RfD for tetra-isomer, 0.001 mg/kg/day. This RfD value was based on the assumption that tetra-BDE is twice as toxic as the penta-isomer. Virginia used this RfD and a consumption rate of two 8-ounce meals per month to derive a trigger level for the issuance of a fish consumption advisory.

The equation used for deriving the trigger level is as follows:

$$\frac{0.001 \text{ mg/kg/day} \times 70 \text{ kg} \times 30 \text{ days/month}}{0.227 \text{ kg/meal} \times 2 \text{ meals/month}} = 4.62 \sim 5.0 \text{ mg/kg or parts per million (ppm)}$$

Using this equation, the allowable meals per month at various BDE concentrations can be calculated and are shown in the table.

Concentration (mg/kg or ppm)	# of Meals per month
1	9.3
1.47	6.3
2	4.6
3	3.1
4	2.3
5	1.9
9	1
10	0.9

Based on the calculations above, Virginia uses the following trigger levels for the issuance of a fish consumption advisory when fish is contaminated with BDEs.

- Below 5 mg/kg or ppm - no advisory
- 5 to below 10 mg/kg or ppm - two eight ounce meals per month
- Above 10 mg/kg or ppm – no consumption

Because data are limited and reproductive or developmental effects of BDEs have not yet been evaluated, the state concluded that it would be prudent for pregnant women, nursing mothers, and young children to avoid consumption of fish contaminated with BDEs above 5 mg/kg or ppm. Since reported concentrations in fish were below the trigger level, no advisory was issued. In issuing advisories Virginia tries to give the message that not every concentration is harmful.

Gary Ginsburg: Given the similarities between these compounds and PBBs, did you look at toxicological data for PCBs?

Response: There was no information on PBBs either.

Luanne: This was one reason EPA recommended an additional safety factor of 2. New RfDs are pending

Linda Birnbaum: If neurodevelopmental effects were addressed, it would lower the number by three orders of magnitude.

C. Dioxins and Coplanar PCBs

Emerging Science of the Dioxin Reassessment.

Dwain Winters, US EPA

A number of things have happened with the US EPA's reassessment of dioxin assessment in the last year.

Dioxin-like compounds include dioxins, furans and PCBs. There are 75 dioxin congeners, and we consider seven of them to be highly toxic. There are 135 furan congeners, and we consider 10 of them to be highly toxic. There are 209 PCB congeners and we consider 12 to be highly toxic.

We use TEQs to compare congeners of different toxicity. (The TEQs reflects the relative toxicity of each congener.) These are fundamental to the evaluation of these compounds. They are based on multiple endpoints or on the binding of the compound to a receptor. The TEQs developed by the World Health Organization are accepted internationally and have the most comprehensive discussion.

Five compounds make up about 80% of the total TEQ in human tissues. Four of these are dioxin/furan compounds and one is a PCB. They are: 2,3,7,9-TCDD, 1,2,3,7,8-PCDD, 1,2,3,6,7,8-HxCDD, 2,3,4,7,8-PCDF, and PCB 126.

The current human exposure to dioxin TEQ for adults in the US is about 1 pg TEQ/kg/d (one picogram of dioxin TEQ per kilogram of body weight per day). Populations that may have higher intake include nursing infants, people with a fatty diet, subsistence fishers, and farmers in proximity to contamination.

EPA has concluded that for dioxin, unlike many other chemicals, the body burden is the best dose metric. It accounts for differences in half life and results in strong agreement between human and animal data. This approach has been adopted by the World Health Organization, European Union, and the US. The metric is ng/kg BW (nanograms of dioxin TEQ per kilogram of body weight.)

2,3,7,8-TCDD is considered to be a known carcinogen for humans, while other dioxin-like compounds and complex environmental mixtures of these compounds are considered likely to be carcinogenic. This based on unequivocal animal data studies demonstrating carcinogenicity and limited human studies.

Cancer potency estimates are primarily based on recently published human epidemiological studies. EPA's potency value has been revised upward by a factor of six compared to a value published by EPA in 1985 based on a rat study. Cancer risks to the general population may

exceed 1 per 1,000 from normal (dietary) exposure. This is not the upper bound, though risks may be less.

Non-cancer toxic effects of concern include developmental toxicity (affecting the immune system, nervous system and reproductive system), immunotoxicity, endocrine effects, chloracne and others.

Information about non-cancer effects in animals and humans is sufficient to generate a level of concern similar to that for cancer. It is likely that part of the general population is at or near exposure levels where adverse effects can be anticipated.

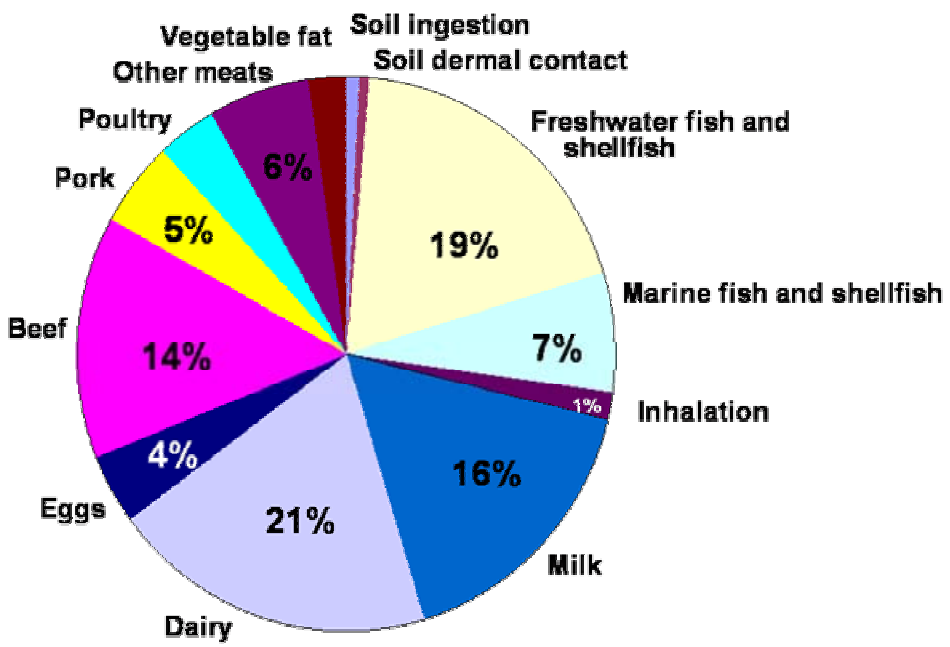
This table summarizes the body burdens associated with adverse effects. The margins between current average body burden (5 nanograms per kilogram - ng/kg) and these effect levels are mostly less than an order of magnitude, so some people are at levels likely to result in adverse effects. Consequently, EPA will not develop an RfD for dioxin.

Adverse Effects	**Body Burden (Ng/Kg)**
Developmental neurotoxicity:	22
Developmental/reproductive toxicity:	0.7 - 42
Developmental immunotoxicity:	50
Adult immunotoxicity:	1.6 - 12
Endometriosis:	22
Biochemical Effects	
CYP1A1 Induction:	0.6 - 33
CYP1A2 Induction	2.1 - 83

Most exposure is from the diet, but no one component dominates. Statistically based surveys of beef, pork, and poultry were done in 1994-95 and 1996-97. These are being re-sampled now, so some time trend data will be available. Fish data are more problematic because they do not lend themselves to statistical analysis. EPA is compiling data on dioxins in fish and welcomes submittal of relevant data.

Pathways for dioxin exposure include ingestion of soil, meats, dairy products, and fish; inhalation of vapors and particulates; and dermal contact with the soil. Sources include combustion, metals processing, chemical manufacturing, biological and photochemical processes, and reservoir sources.

The sources of US adult daily intake of dioxins, furans, and dioxin-like PCBs are shown in this chart:



The sources and pathways involve discharges to air and water, transport through the air, deposition from the air, and re-entrainment to soil particles. The compounds bind to leaves that are consumed and then get into food supply.

Releases have been greatly reduced in the last ten years. Municipal and medical waste incinerators have been greatly reduced. A major source remains backyard barrel burning. Some sources are poorly characterized. Reservoir sources are past releases of dioxin that are "stored" in the environment but that can be reintroduced. About 50% of population exposure is related to these sources. Most incorporation into food supply is in the corn belt, dairy states, and west. These are mostly upwind from major emission sources. Major reductions in emissions will not see proportional reduction in exposure because we are looking at complex exchanges between compartments. These need to be better understood.

D. Lead

Application of the Lead IEUBK Model to Assess Spokane River Fish Consumption Risks.

Lon Kissinger, US EPA

The Spokane River is down river from the Bunker Hill Superfund Site and the Coeur d'Alene mining district, which are sources of lead in Idaho.

The goal of the project was to assess lead risks and develop fish advisories using models that predict blood lead concentrations. Such approaches integrate lead risk for all exposure routes. Two models were used. The first model, the Integrated Exposure Uptake Biokinetic Model (IEUBK) assesses risk for children age 0 to 84 months. The IEUBK model output is a probability distribution of blood lead concentrations. EPA currently uses a criterion that lead

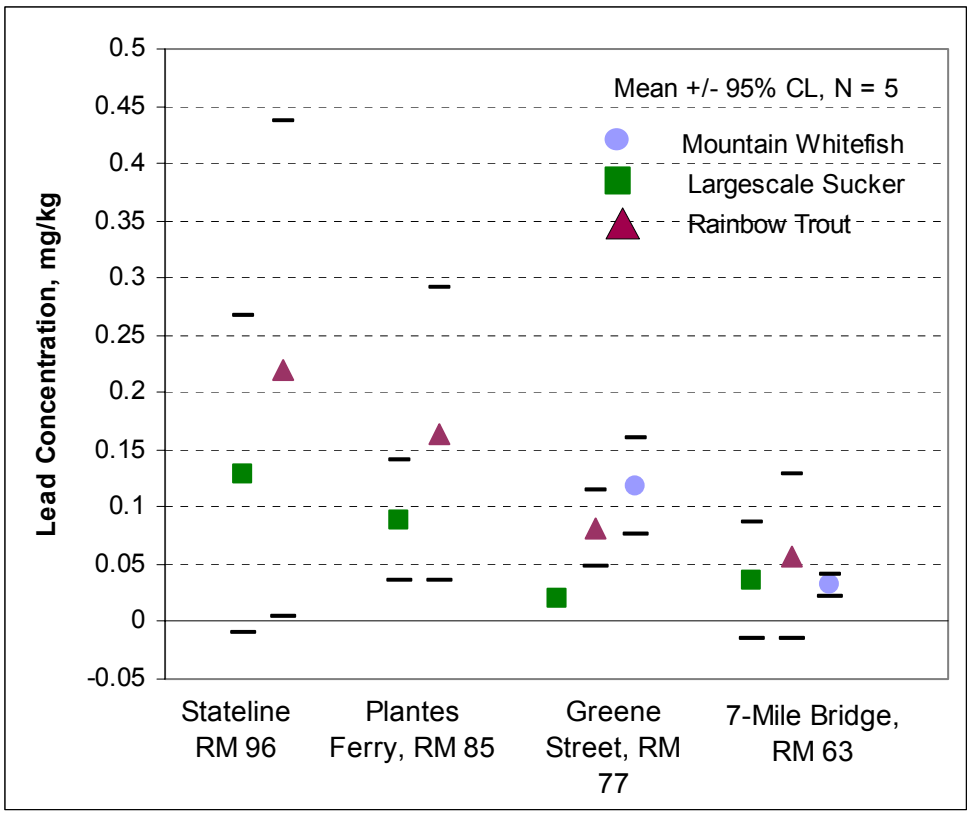
risks are tolerable if no more than 5% of predicted blood lead concentrations exceed 10 micrograms per deciliter (ug/dL). The 10 microgram per deciliter cutoff is supported by the CDC. The second model, the adult lead model, is used to assess risks to the developing fetus. This model assumes that if you maintain the mother's blood lead level within an acceptable range, then the risks to the developing fetus will be tolerable.

Information on the models is available at EPA's Lead Technical Review Workgroup web site: `http://www.epa.gov/superfund/programs/lead/`

The IEUBK model, as used for the assessment of lead risks from Spokane River fish, incorporates a number of parameters, which include the fraction of meat consumption that consists of locally caught fish, the concentration of lead in fish tissue, and lead concentrations and intake rates for other media. Fish tissue and sediments were sampled and analyzed for lead at a number of locations. In general, fish tissue and sediment lead concentrations were positively correlated.

One issue for this study was that there were no site specific, quantitative information about fish consumption for children. In the absence of such data, a children's tribal fish consumption rate, developed by the Columbia River Intertribal Fish Commission, was used. The 65th percentile consumption rate of 16.2 grams per day was considered to be health protective.

Spokane River Fish Fillet Lead Concentrations



Species tested for lead included mountain whitefish, largescale sucker, and rainbow trout. The mean levels in rainbow trout were 0.82 mg/kg and in largescale sucker 2.8 mg/kg. These levels were substantially higher than background values in fish (Schmitt and Brumbaugh, 1990.) Whole fish had much higher lead concentrations than filets.

IEUBK parameter values were: a state line trout fillet lead concentration of 0.22 mg/kg; a soil concentration of 230 mg/kg; other parameters at model defaults.

The model predicted that 3.7% of children consuming fillets would have blood lead levels above 10 µg/dL. This was less than 5%, so the risk was judged to be tolerable.

For those who ate whole fish, the percentage exceeding 10 µg/dl was much higher. Using the maximum observed lead concentration, 62% would be above a blood lead level of 10 µg/dl if they consumed whole large scale sucker; 15% for rainbow trout; and 6% for mountain whitefish.

The model results were used to compute meal limits for children and adults. The results can also be used to see the effect of percent of meat consumed as fish.

In employing the IEUBK model to assess lead fish consumption risks, it is important to take soil lead exposure into account. High soil lead exposures will reduce the allowable levels in fish.

Editor's note: There is no known safe exposure to lead and effects have been found for children with blood lead concentrations below 10 µg/dL.

Occurrence of Lead in Fish: Examples from Georgia, Maine, and California.

Robert K. Brodberg, California Environmental Protection Agency

Lead has not been widely monitored in fish advisory programs. It is not one of the target analytes recommended by U.S. EPA to assess chemical contaminants in fish [27]. A few advisories have been issued for lead contamination in fish. Is there evidence that lead bioaccumulation in fish is a problem that is being missed due to lack of monitoring? This presentation summarizes preliminary data from Georgia, Maine, and California showing the occurrence of lead in sport fish in these states. Randy Manning summarized data from Georgia and Eric Frohmberg contributed the data from Maine.

Georgia

Georgia summarizes its monitoring data by water basin and hydrologic unit. Over 1700 fish fillet samples have been analyzed for lead using a detection limit of 1 ppm. Lead above 1 ppm has only been detected in about 4% of the samples. Lead has been detected most often in largemouth bass and channel catfish. It has also been detected in hog suckers, trout and sunfish. The highest levels have been found in the Upper Ocmulgee hydrologic unit (largemouth bass, 11.5 ppm; channel catfish, 15.5 ppm). This could indicate that there is a regional source of lead in this area. Or, it might indicate a local problem with clean preparation techniques or cross-contamination because samples are prepared in local jurisdictions. In either case, closer investigation is warranted.

Maine

Maine's summary of lead data includes over 300 fish samples. Maine used a lower detection level (0.02-0.05 ppm), and lead was detected in about 70% of the samples. The average lead

concentration in these samples was between 0.05 and 0.6 ppm. In only one case did the average lead concentration exceed the Maine action level of 0.6 ppm. Maximum values in some fillet samples of brook trout and smallmouth bass reached about 1 ppm. Lead concentrations in whole fish samples were generally low with the exception of white sucker (maximum concentration about 0.7 ppm), which has intramuscular bones. Some data were available to compare lead concentrations in the same species, prepared and analyzed whole body versus as fillets. Brook trout and smallmouth bass had higher concentrations in fillet samples than in whole body samples. However, lead concentrations in fillet and whole body samples of landlocked salmon and white perch were about equal.

California

In California, lead measurements were available for about 250 composite fillet, whole body or liver samples from the Toxic Substances Monitoring Program. The lead concentration in greater than 80% of all samples was less than the detection limit (0.001 ppm). Levels in whole body samples (maximum concentration 0.5 ppm) tended to be higher than in fillet samples (maximum concentration 0.2 ppm). The highest lead concentration was measured in white croaker liver. Overall there was not a noticeable difference in concentrations between inland and marine species.

Conclusions

Lead concentrations in sport fish varied between the states. Comparison is limited by differences in methods and detection limits, but the data show that a potential for bioaccumulation exists. Still, in most cases, results were below the Maine action level (0.6 ppm), and many samples were at or below detection limits.

This limited summary suggests that while lead may bioaccumulate in fish, it is not accumulating to levels that indicate a wide-spread problem. Nonetheless, screening level monitoring should be considered in areas of known or suspected high lead contamination.

One potential problem that should be considered when sampling fish for lead bioaccumulation is internal and external contamination. In a study of fish from streams in the Missouri lead belt, Schmitt and Finger [28] showed that differences in preparation can result in up to a ten fold difference in lead concentrations. Most laboratories now use “clean metal” techniques, which reduce external contamination. However, additional caution is needed because lead can accumulate in bone, scales and skin (e.g., by adhering to the skin surface). This might account for cases in which whole fish show higher lead concentration than fillet samples. And this can increase the apparent concentration in fish with intramuscular bones that are not removed in fillets. Lead can also be introduced from scales, skin and mucus, especially during field preparations. Differential inclusion of these non-muscle sources can also increase sample heterogeneity and consequently variation in reported lead concentration.

E. Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic Aromatic Hydrocarbons (PAHs) in Fish and Invertebrates.

Usha Varanasi, National Oceanic and Atmospheric Administration

Polycyclic aromatic hydrocarbons (PAHs) are toxic compounds that are released from a variety of natural (e.g., oil seeps and fires) and anthropogenic (e.g., oil spills, combustion engines, coal burning, and wood preservative) sources. PAHs enter our nation's waterways and oceans through both point and non-point mechanisms, exposing valuable fish and invertebrate resources to toxic PAH compounds.

Once fish and invertebrates are exposed to PAHs, they readily absorb the compounds into their bodies. Key questions then become "is seafood safe to eat?" and "are there adverse effects on the organisms?" The answers for these questions are different for fish and invertebrates.

Vertebrates, including fish, metabolize (body processes that transform substances) PAHs quickly and efficiently in their liver to detoxify their systems. They readily convert most hydrocarbons to metabolites that are eliminated into bile and out of their bodies. High molecular weight PAH compounds, however, can be converted to reactive intermediates that bind to intracellular targets (e.g., DNA) and alter their function. Because vertebrates metabolize PAHs so quickly and efficiently, very little toxic product is found in their edible tissues; however, toxic products and byproducts can have a number of adverse effects on the fish themselves.

Invertebrates (e.g., mollusks and crabs), on the other hand, metabolize PAHs slowly and inefficiently (or not at all); they are unable to readily convert hydrocarbons to metabolites and eliminate them from their bodies. Because invertebrates metabolize PAHs so slowly and inefficiently, they accumulate toxic PAH compounds in their tissues, which can cause acute effects to the organisms, as well as a seafood safety concern.

PAH compounds are fluorescent, enabling scientists to screen for them using high pressure liquid chromatography or Gas Chromatography/Mass Spectrometry analysis. These methods can be used to look for metabolites in bile (vertebrates) and aromatics in tissues (invertebrates).

In responding to PAH contamination to determine its impact on fish and invertebrate resources, it is critical to ask and answer a series of questions, such as "What is the chemical composition of the source?" "What is the fate and toxicity of the source?" and "What are the resources at risk?" In conducting analyses, it is often most appropriate to take a tiered approach that uses both screening methods and detailed analyses. Screening methods are rapid, cost-effective, provide a semi-quantitative estimate of contamination, and allow priority selection of a subset of samples for detailed analysis. Detailed analyses provide confirmation of screening results and quantitative information about individual contaminants. A tiered approach enables rapid processing of a high volume of samples, which is critical during oil spills where information about impacts to fisheries is needed quickly.

During the *Exxon Valdez* oil spill, NOAA scientists sampled a variety of fish and invertebrate species and compared PAH levels in edible tissues to a nearby, non-impacted reference site. Scientists then used screening methods to analyze metabolites in pink salmon bile in several Alaska villages where seafood safety was a particular concern; they found that metabolites in pink salmon bile were considerably higher than the reference value, but that concentrations of

PAHs in edible tissues were close to reference values. In contrast, PAHs in edible tissues of mussels, butter clams, and littleneck clams were highly elevated compared to reference values. This information was quickly relayed to fish and shellfish consumers, helping to minimize economic and subsistence impacts.

PAHs appear to be increasing in many areas where population levels are increasing. From a seafood safety standpoint, PAHs are a concern for invertebrates, but not fish. From a biological effects standpoint, however, PAHs are a concern for both invertebrates and fish. Reducing the input of PAHs into the environment and continued monitoring of PAH effects on fish and invertebrate reproduction, growth, and survival are critical to ensuring sustainability and health of the nation's fishery resources.

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VII. State and Tribal Approaches to Advisories

Setting Statewide Advisories based on Upper Percentile Lake Averages.

Eric Frohmberg, Maine Bureau of Health

A key issue for developing advisories in Maine is that there are more than 3,000 lakes and ponds, and the state does not have the resources to sample them all. The question becomes, how can we develop advisories based on limited sampling data, and what kind of statistics should we use to evaluate the data we do have?

Two options are to use a mean concentration for contaminants in fish or to use an upper percentile estimate. The mean lake concentration gives you a good average population weighted exposure. This might make sense if you are addressing people who fish at different lakes in a somewhat random way. However, we don't think this is how people behave.

An upper percentile estimate of lake concentrations reflects uncertainty. We have many lakes in Maine and limited data. More importantly, it matches our hypothesis for how people fish. Many people have summer cabins and fish at a particular lake. Hence, we are concerned about someone on a high mercury lake, eating fish exclusively from that lake. Using the average value from a lake at an upper percentile, while over protective for many lakes, will protect people eating fish from these high mercury lakes.

The best data source of data about contaminants in fish in Maine is REMAP, an EPA-funded study conducted in 1993 of a random sample of 120 lakes. It looked at many parameters, including mercury. Based on the results from this sampling program, the first advisory was developed and a second monitoring program (SWAT) was established. SWAT provided data for 80 more lakes between 1994 and the present.

We have looked at the distribution of mercury values for various species across lakes. Our objective is to develop distributions of species-specific lake average mercury concentrations for 50 lakes per species. This will give us reasonable confidence in the upper percentile estimates of mercury concentration by species. The mean values for lakes average vary from about 0.3 to 0.7 ppm.

Maine has two-tiered advisories, for the general population and sensitive populations. For each species, we look at the percentage of lakes above the action level. The sensitive population action level for one meal per month is 0.8 ppm. We use this as an action level because if you cannot eat one meal per month for a non-cancer pollutant, we advise people not to eat any. If 95% of the lakes are below an action level, we do not issue an advisory.

The percentage of lakes above an action level varies. For brook trout, we found no values above the action level of 0.8 ppm. For landlocked salmon, a few lakes were above the action level. For white perch, smallmouth bass, and chain pickerel, a significant percentage of lakes were above the action level. The advisory recommends that pregnant and nursing women, women who may become pregnant, and children under eight limit their consumption of brook trout and landlocked salmon to one meal per month and that these groups eat no other fresh water fish from Maine.

For all populations, one meal per week of brook trout and landlocked salmon and two meals per month of other species are recommended limits in the safe eating guidelines.

This approach reflects our understanding of exposure. It reflects uncertainty. It provides an incentive for additional testing, as more data could lead to a better understanding of distribution. The principal disadvantage is that it is over protective for the vast majority of lakes.

Use of Maine's Statewide Advisory in a Tribal Setting.

Susan M. Peterson, Aroostook Band of Micmacs

The Aroostook Band of Micmacs is the only band of Micmacs in the US. There are about 8500 enrolled members. The tribe owns about 1000 acres in Maine and additional acres in Canada and is acquiring land. The tribe does not own the lakes in which their members fish.

The State of Maine's fish consumption warnings are included in the state's book of fishing regulations. The tribe was concerned that tribal members would not read the warnings. The tribe adopted the advisories and issued its own publication called Keeping Our Traditions and Our Families Alive. It includes the advisories for freshwater and salt water fish, as well as tribe and agency contact information. It also includes guidelines for how to select, clean, and cook fish.

The Tribe adopted the Maine advisory not because they feel it is fully protective but because they do not have enough data to adopt something more protective. The meal size consumed by tribal members is probably higher than that used to develop the advisory.

The Tribe plans to develop its own advisory and to research how advisories are perceived. One approach may involve anthropological research combined with elements of a consumption survey. This would look at what was consumed in the past, what is consumed now, and whether advisories have had any effect. This would be done through interviews with tribal elders. They will also evaluate particular risks for tribal members, including increased caloric demands or increased respiration, as well as possible genetic susceptibility. This will be done in cooperation with state and federal counterparts.

North Dakota's Fish Consumption Advisory: Based on Average Concentration.

Michael Ell, North Dakota Department of Health

This presentation will describe North Dakota's experience in developing fish advisories based on average concentrations of contaminants in fish.

Fish were first collected for analysis of mercury concentrations in 1991, with a focus on Devils Lake. An advisory was issued that summer. In the spring of 1992, the state issued a broader advisory, which included ten lakes and reservoirs and two rivers.

Sampling has continued since that time, reaching a peak in the mid 1990s, when more than 30 lakes and 20 species of fish were included. In the late 1990s, the state was not able to collect fish for as many lakes, so several lakes were de-listed due to lack of data and an analysis suggesting that bioaccumulation was decreasing. The focus changed to particular lakes with a lot of fishing.

In January 2001, the state issued the first statewide advisory, which remains in effect. The rationale for the advisory was that mercury occurs in all lakes, reservoirs, rivers and streams in the state. For advice to be useful, it has to be simple. The earlier advisories had 20 species of fish and 30 water bodies and were too complicated. The new statewide advisory was based on

existing data and standard assumptions. It used a reference dose of 0.1 µg/kg/d for sensitive populations.

We pooled all data available and looked at the relationship between length of fish and mercury concentration. The relationship varied between lakes. We also look at the curve to select the appropriate fish size for the statewide advisory. The lengths were converted into three categories – small, medium, and large.

NORTH DAKOTA ADVISORY FOR HUMAN CONSUMPTION OF FISH

The chart applies to fisheries of the state; data for crappie, trout and white sucker are incomplete, and the fish in many lakes, reservoirs and rivers have not been sampled. It does not consider other human exposures of methylmercury (as mercury), such as eating ocean or other inland fish.

Meal frequencies:
- none -- no consumption advised
- occasional -- occasional consumption, 1 to 2 meals per month, avoid eating whoppers
- moderate -- moderate consumption, 2 to 4 meals per month
- frequent -- frequent consumption, 4 to 8 meals per month

Summary: "children 5 & younger," pregnant women and nursing women can occasionally eat only smaller fish; and children over age 5 and all other adults can frequently eat smaller fish while limiting the meals of medium and larger fish.

		----------		Fish Size		----------
Fish Species		Smaller	or	Medium	or	Larger
BASS, largemouth smallmouth	Children 5 & younger	occasional		none		none
	Pregnant &nursing women	occasional		occasional		none
smaller sizes are less than 16 inches	Children over 5 & under 15	moderate		moderate		moderate
	All other people	frequent		moderate		moderate
BASS, white	Children 5 & younger	occasional		none		none
smaller sizes are less than 12 inches	Pregnant & nursing women	moderate		moderate		occasional
	Children over 5 & under 15	frequent		moderate		occasional
	All other people	frequent		moderate		moderate
CHINOOK SALMON	Children 5 & younger	moderate		occasional		occasional
smaller sizes are less than 19 inches	Pregnant & nursing women	moderate		moderate		occasional
	Children over 5 & under 15	frequent		moderate		moderate
	All other people	frequent		frequent		moderate
NORTHERN PIKE	Children 5 & younger	moderate		occasional		occasional
smaller sizes are less than 28 inches	Pregnant & nursing women	moderate		moderate		occasional
	Children over 5 & under 15	frequent		moderate		occasional
	All other people	frequent		moderate		moderate
WALLEYE CHANNEL CATFISH	Children 5 & younger	moderate		occasional		occasional
	Pregnant & nursing women	moderate		moderate		occasional
smaller sizes are less than 22 inches	Children over 5 & under 15	frequent		moderate		moderate
	All other people	frequent		moderate		moderate
YELLOW PERCH	Children 5 & younger	moderate		moderate		occasional
smaller sizes are less than 11 inches	Pregnant & nursing women	moderate		moderate		occasional
	Children over 5 & under 15	frequent		moderate		moderate
	All other people	frequent		frequent		frequent

The reason to use the mean concentrations to develop a statewide advisory is that we are using individual fish concentrations rather than lake averages. These are composite data. It also provides more flexibility to the consuming public by giving people more opportunity to keep and eat fish. We conclude that this provides an adequate level of protection and that 75% of fish will be below the consumption level anyway. By contrast, the 95th percentile would recommend that people only consume walleye of 13 inches or smaller.

Mercury Advisories in the State of Pennsylvania.

Bob Frey, State of Pennsylvania

The presentation will address the development of site specific advisories and a statewide advisory for mercury.

In April 2001, Pennsylvania issued a large number of site and species specific mercury advisories. The technical group had wanted to issue advisories before that but was asked by the management to wait until the release of the National Academy of Sciences analysis of the EPA RfD. They used the EPA RfD and meal-specific advisory groups based on EPA's fact sheet (EPA 823-F99-016, September 1999) but adjusted the trigger levels a bit. They issued nearly 80 new advisories.

The advisory triggers used were modified slightly from those recommended by EPA, as shown in this table:

Category of Advice	**Pennsylvania (Hg ppm)**	**US EPA (Hg ppm)**
Unrestricted	0 – 0.12	> 0.08 – 0.12*
One meal per month	0.13 – 0.25	> 0.12 – 0.24
Two meals per month	0.26 – 0.50	> 0.32 – 0.48
One meal per month	0.51 – 1.0	> 0.48 – 0.97
Six meals per year	1.01 – 1.9	> 0.97 – 1.9
Do not eat	> 1.9	> 1.0

* Eight meals per month

The distribution of mercury concentrations by the advisory type is shown in this table, which summarizes ten years of data and 551 mercury data points.

Category of Advice	Number	Percent of samples
Unrestricted	222	40
One meal per month	169	31
Two meals per month	118	21
One meal per month	37	7
Six meals per year	5	> 1
Do not eat	0	0

Values for key species were walleye (n = 44) 0.069 to 1.56 ppm; largemouth bass (n = 54) 0.078 to 0.99 ppm; smallmouth bass (n = 97) 0.06 to 0.73 ppm; brown trout (n = 75) 0.007 to 0.86 ppm; carp (n = 50) 0.04 to 0.58 ppm; and channel catfish (n = 37) 0.027 to 0.78 ppm.

Species fell out differently into advisory groups. Walleye had 7% unrestricted; 30% one meal per week; 41% two meals per month; 11% one meal per month; 5% six meals per year; none at do not eat. Substantially more largemouth and smallmouth bass were in the unrestricted category.

The state also issued a statewide advisory recommending consumption of no more than one meal per week of recreationally caught sport fish, in response to questions from anglers who asked about water bodies and species not covered in the site specific advisories. The reasons include the fact that many waters and species are not tested and there could be additional contaminants.

As a result of this, they no longer issue site specific one meal per week advice.

The Total Maximum Daily Load (TMDL) regulations have implications in Pennsylvania. The state has listed water bodies with advisories on the 303(d) of impaired water bodies, which puts them in line for a TMDL. Things changed when they issued the statewide advisory, as they had eliminated one of the advisory categories. How to handle a statewide advisory for 303(d) purposes is an important question. Any place with actual fish tissue data that would result in an advisory should be listed for 303(d) purposes. Once you have a statewide advisory, you have two options. You could list only water bodies with an advisory of two meals per month (or more restrictive advice.) A second option would be to include waters where actual data fall into the one meal per week group. There are varying opinions about the best option, but the 303(d) list was recently submitted, and we will see how this falls out.

Minnesota Statewide Fish Consumption Advice.

Pat McCann, Minnesota Department of Health

Minnesota is famous for being the land of 10,000 fish advisories.

We now have a statewide advisory, but also still issue site specific advice.

The reasons to issue a statewide advisory were because, while the state cannot test every species and every water body, we observe that every fish we do test has some mercury in it. Because of the widespread mercury, we have concluded that some advice should be available for every water body. Previously, some had the misconception that all of the water bodies on the advisory list were bad, while everything else was clean. This is not true. It is important to have advice that applies everywhere, particularly for sensitive populations. This will also simplify communication to the public.

A key question is whether the available data can be used to predict mercury concentrations in untested water bodies. We have concluded that they can be, in a general sense, though not in a rigorous sense. There is high variability in production of methyl mercury between water bodies for reasons that are not well understood. Our sampling is not designed for predictive purposes, and there are issues of selection bias and sample type consistency.

The approach used to develop advisories is a "weight of evidence" approach. We analyze data by species and geographic location, look at harvest rates, and get input from other agencies. Consistency with nearby states is also a consideration.

In 2001, we developed a new brochure to communicate a simple message and provide statewide advice. We hoped it would help people decide whether they were at risk and needed more detailed information.

For the general population, consumption is unlimited for panfish fish caught in Minnesota for (sunfish, crappie, perch and bullheads.) For all other fish, the recommended limit is one meal per week.

Safe Eating Guidelines: *General Population*

For adults who eat fish all year long*

Kind of fish	How often can you eat it?
Fish caught in Minnesota:	
Sunfish, crappie, yellow perch, bullheads	unlimited amount
Walleyes, northern pike, smallmouth bass, largemouth bass, channel catfish, flathead catfish white sucker, drum, burbot, sauger, carp, white bass, rock bass, other species	1 meal a week
Commercial fish:	
Limit the following species: shark, swordfish, tile fish, king mackerel	1 meal a month

* In general, adults who eat fish just during vacation or one season can eat fish twice as often as recommended in these guidelines.

For sensitive populations, the panfish meal limit is now one per week; for most fish, one meal per month; for walleyes over 20 inches and some others we recommend no consumption.

Safe Eating Guidelines: *Special Populations*

For pregnant women, women who may become pregnant and children under age 15*

Kind of fish	How often can you eat it?
Fish caught in Minnesota:	
Sunfish, crappie, yellow perch, bullheads	1 meal a week
Walleyes shorter than 20 inches, northern pike shorter than 30 inches, smallmouth bass, largemouth bass, channel catfish, flathead catfish white sucker, drum, burbot, sauger, carp, white bass, rock bass, other species	1 meal a month
Walleyes longer than 20 inches, northern pike longer than 30 inches, muskellunge	**Do not eat.**
Commercial fish:	
• Shark, swordfish, tile fish, king mackerel	**Do not eat.**
• Other commercial species, including canned tuna	See MDH's brochure, *"An Expectant Mother's Guide to Eating Minnesota Fish,"* for guidelines.

Special Note:

Please see the two tables on page 6 for exceptions to these guidelines. These exceptions are for eating fish from certain Minnesota waters known to have higher levels of contaminants.

* There is no change in these guidelines for eating fish just during vacation or one season.

The materials also show waters with more restrictive advice.

Other agencies provided input. The Department of Natural Resources wanted to continue to provide site specific advice and point out less contaminated water bodies. They were concerned about developing lists of "bad" waters. Future funding for monitoring became a problem, as money was cut from the budget due to the statewide advisory. The pollution control agency has concerns about implications for the TMDL listing process. They had listed any lake or water body with an advisory. Now they use a cutoff of 0.2 ppm. They were also concerned about future monitoring funding. Statewide advice fell more in line with their work on trends. The tourism agency was concerned about impacts on tourism.

The meal advice categories for women and children for mercury provide for unlimited consumption at less than 0.05 ppm; one meal per week from 0.06 to 0.2 ppm; one meal per month from 0.21 to 1.0 ppm; and no consumption above 1.0 ppm.

There are more than 3,500 data points for mercury in fish in Minnesota. We looked at means, which do not differ that much from the upper 95% confidence interval. Both are in the same advice category. We decided to do a length cutoff because otherwise many waters would be on the do not eat list. We also wanted to emphasize that bigger fish tend to be more contaminated. A regression analysis did not help pick a cutoff.

Communication strategies for the general statewide advice include a brochure called "Eat Fish Often," a guide for mothers, on-line resources, and a page in the fishing regulations. Site specific advice is provided on the agency web site and on DNR lake reports.

Regional Fish Advisory for the Mississippi Delta.

Henry Folmar, Mississippi Department of Environmental Quality

The Mississippi Delta is very southern but also different from the rest of the south. It is highly productive but has low biological diversity. People have a deep and abiding respect for the Mississippi River. Fishing is an important part of life, and most people eat what they catch.

DDT is not a new problem in the Delta. It was heavily used after World War II. It lasts a long time, even though banned in 1972. Use of DDT led to the decline in fish eating species like the bald eagle and brown pelican. Fish advisories were issued for certain Delta lakes in the 1970s.

Recent studies show that the Mississippi has some of the highest DDT levels in the country. Whole carp had the highest levels of any 112 sites monitored by the US Geological Survey. Yazoo Refuge was closed to fishing due to DDT. Levels were also found to be extremely elevated in the delta.

Levels of DDT in fish are declining. Data show a three-fold decline since 1984 at the Yazoo River at Redwood Mississippi in both DDT and toxaphene. Some data show a greater decrease since the 1970s.

Concerns remain because the levels considered to be safe have also changed. The Food and Drug Administration rescinded its action level in 1993. States were encouraged to use guidance from US EPA that was more protective.

The Mississippi Fish Advisory Task Force developed new criteria for DDT and toxaphene in fish. The task force included several agencies, followed EPA guidance and also sought advice from experts from outside the government. The criteria are shown in this table.

Mississippi Fish Advisory Criteria for DDT and Toxaphene

Consumption Advice	Fish Concentration of DDT in ppm	Fish Concentration of Toxaphene in ppm
No limit	< 1.0	< 0.4
Two meals per month	1.0 to 5.9	0.4 to 1.9
No consumption	≥ 6.0	≥ 2.0

A Mississippi Delta fish tissue study was conducted to evaluate DDT and toxaphene in edible fish tissue at ten sampling sites. These data were used to evaluate human health risks and to develop an approach to future monitoring.

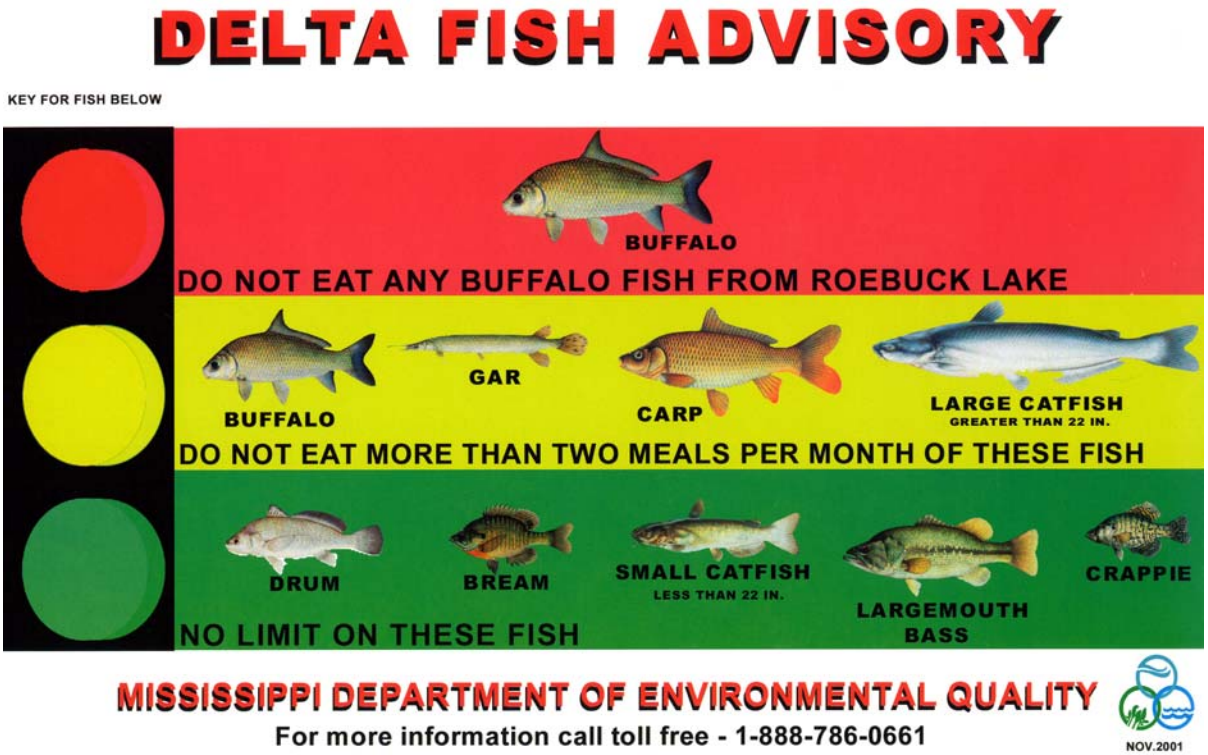
The study was conducted in 2000. All largemouth bass, bream, crappie, freshwater drum and all catfish less than 3 pounds were below the criteria. 66% of samples were below the criterion for DDT; 73% for toxaphene. Farm raised catfish were below the criteria for both pollutants.

All ten sites had at least two samples above the consumption criteria. Some form of advisory was warranted at each site.

The group developed Mississippi's first regional advisory. For buffalo, gar, carp, and catfish over 22 inches, recommended consumption was two meals per month. No limit was adopted for drum, bream, small catfish, largemouth bass, and crappie.

The advisory applies to the Delta from Memphis to Vicksburg but not to the Mississippi River or oxbow lakes connected to the river.

In addition, for one lake, Roebuck Lake, they recommended no consumption of buffalo. The Mississippi Department of Wildlife Fisheries and Parks also issued a commercial fishing ban for Roebuck Lake.



There was a public media campaign that included news conferences, new releases, staged sampling demonstration photo-ops, radio and TV spots on morning shows, call in shows on gospel and blues radio stations, distribution of letters and posters to stores, door to door canvassing in some communities, and signs at boat ramps. Letters and brochures were mailed to 1400 churches; 16,000 coloring books were distributed; and posters and brochures were placed at WIC offices. The materials were also translated into Spanish.

Next steps are to continue monitoring for both hot spots and areas that can be removed from the advisory, to continue outreach efforts, and to develop TMDLs.

Advisories Based on Eight Meals per Month.

Joe Beaman, Maryland Department of the Environment

Maryland provides guidance for three populations: the general population, women of child-bearing age, and young children. The state uses three meal sizes (eight ounces for the general population; six ounces for women; and three ounces for children to age six).

Advisory recommendations are provided for the following consumption rates: less than 1 meal per month (4-11 meals per year), 1 meal per month, 2 meals per month, 4 meals per month, and 8 meals per month. The decision to provide recommendations for up to 8 meals per month was a policy decision focused on protecting frequent fish consumer groups based on anecdotal knowledge about these populations in Baltimore City, urban Maryland near the Potomac, and the Eastern Shore. It was not based on a formal exposure assessment.

What does eight meals per month mean?

For carcinogens (PCBs for example), the resulting threshold ranges are 20 to 39 ppb for general population and 17 to 33 ppb for women of child-bearing age. This corresponds to a 1 per 10,000 risk level. Maryland assumes 30% cooking loss for carcinogenic compounds.

For non-carcinogens (methyl mercury), the threshold for eight meals per month are 59 to 117 ppb for the general population, 54 to 107 ppb for women of child bearing age; 13 to 26 ppb of PCBs for children to age six; and 32 to 64 ppb of mercury for children to age six. This is based on an RfD of 0.1 µg/kg/d for mercury and 0.05 for PCBs.

Decision rules establishing data sufficiency thresholds state that an advisory may be developed for a minimum of 5 fish. Decision rules for temporal relevance allowed data from 1995 - 2001 to be used to establish advisories released in 2001.

The data supporting the statewide mercury advisories came from the Department of Natural Resources, which sampled 20 lakes of 80 acres or more. Maryland has about 372 lakes or impoundments. Species collected were largemouth bass, smallmouth bass, bluegill, sunfish, and black crappie. About 59% of the lakes greater than 50 acres had sufficient data for advisories for bass, bluegill and/or crappie. For each species, a geometric mean was calculated for each lake and then the average of the geometric means for the lakes was used as the threshold to set the advisory. Three lakes had higher values than all others and were separated out and given special advisories.

PCBs advisories for eight meals a month were issued for white perch for rivers on the lower Eastern Shore, including the Choptank, Nanticoke, and Pocomoke. The average PCB level in these tidal tributaries was 27 ppb.

The advantage of issuing an advisory based on consumption of eight meals per month is that it provides information to fish consumers including low-level subsistence users about locations and species of fish that can be consumed frequently (2 times per week) without concern about health effects. The disadvantage is that any advisory may discourage fish consumption, even of relatively clean fish.

A key outstanding issue is that data on exposure are lacking. The state is currently conducing mail surveys among licensed anglers and interviews in urban areas. They will use this information in tailoring the advisory recommendations to the populations of concern based on their specific consumption habits.

Bob Brodberg: question for Henry Folmar on the risk communication. What did this cost?

Henry Folmar: I don't know. There was no budget for it, and we just bootlegged it out of other programs. We have not put a pencil to this.

Bob Brodberg: Did you look at mercury?

Henry Folmar: We did not look at mercury in these fish but have not previously found mercury in the fish. Sediment conditions do not appear to be favorable to methylation.

Andy Smith: Tell us what sort of mercury levels you have seen? I am also very impressed with the risk communication program. Are you doing any assessment or evaluation?

Henry Folmar: For mercury, they are still using an action level of 1 ppm. The levels they are seeing in largemouth bass are around 0.2 or 0.3. As far as outreach, there is nothing on the books to target evaluation. There is a guy who is doing a consumption survey and they are going to try to persuade him to repeat it.

Andy Smith: How did you actually develop materials? Did you use focus groups?

Henry Folmar: We did not officially call it a focus group but had citizen input from people on the Delta.

Question: I want to turn Andy's question back to him. What is the response in Maine to the advisories in general? Are people following them?

Eric Frohmberg: We do have a follow up program to look at awareness of advisories. Henry presented some of the data yesterday. It is better than it used to be and not what we wish it would be.

Sue Peterson: We have not received any feedback as yet. We may develop a video and use tribal language.

Andy Smith: We will be getting data from pregnant women including hair mercury and survey information. For the general population the advice is not that restrictive. We have some data on angler behavior. Most anglers are not eating enough to be affected by advisory in the first place.

Question: Remember the presentation on PAHs off the coast of Alaska. The salmon there that were smoked were much higher than salmon from oil spill site. Are you thinking about putting advice about smoking in advisories?

Sue Peterson: We could consider that in the future.

Jeff Bigler: I don't recall that there was risk information presented. It might be worth looking at risk.

John Persell: We could look at this. But remember that native people have been smoking fish for generations.

Bob Brodberg: In Maine, do you sample marine waters at all? How does this match up with statewide advice?

Eric Frohmberg: We do look at marine waters and shellfish. The big marine species that have been a problem are bluefish and striped bass. Our striped bass and bluefish advisories, however, are driven by PCBs, not mercury.

VIII. Approaches to Considering Benefits in Advisory Programs

Perspectives on Considering Risks from Contaminants in Fish.

John Persell, Minnesota Chippewa Tribe Research Lab

People like good news better than bad news. For high end consumers, people are paying attention to the message that fish is good food.

People may reserve judgment about information they hear. Think of cigarettes and smoking. Science told us that all of those toxics in the body were bad for us, but there were also scientists on the other side that kept things from advancing.

Working with Indian people, the feedback is that they don't trust what we say as scientists, and they will make their judgments based on what they feel is best for them. Our credibility and our ability to communicate results are key. We can do the best science in the world, but if we can't communicate it then we are spinning our wheels. One of the major goals that I have set out is to shine light on the information that we have. Let's communicate risk as best we can. I am pleased to see the outstanding message development presented by the gentleman from Mississippi.

Let's also consider how we got to where we are today and how we can fix the problem. I never go to a meeting with the tribal government to communicate risks without somebody saying, what are we doing about this? The Minnesota Chippewa tribe wants their treaty rights back. They want to be able to eat these resources at a level that would sustain them.

Three years ago the tribe embarked on a project to determine contaminants in nature's food sources and alternatives. They had been measuring contaminants in fish since about 1992. They developed guidance for what might be safely consumed for three groups: women and children, 50 kg adults; 70 kg adults. They have been looking lake by lake and looking at multiple species, trying to inform their decision making process. They are also looking at risk assessment process itself including the assumptions made. Do we consider all contaminants? What about those we are not aware of? If we have information on particular contaminants, that is the easy part. What about those we have no information for? Maybe we need to include a factor for these. Do we consider multiple contaminants? What about endocrine disrupters? Cancer is not the only endpoint of concern.

Fish is good food. It has cultural and spiritual values. It helps to keep culture alive. What does it do to the human spirit when we know that fish is contaminated? What are the ethical concerns? If fish is a gift of the creator, then what does it mean if it is contaminated? What does it mean to people who think that they are the protectors?

We need to consider additional species. It may be important to look at moose, grouse and rabbits. We are looking at wild rice. Dioxin has been found at 0.6 pg/g in rice kernels. In a year or two, the tribe expects to publish their first comprehensive food guidance addressing all food sources including grocery stores and commodity foods. They are going to do some local testing and look at patterns. They want to be accurate with what they are going to put out in guidance. They will be supporting a health and well being paradigm. The hope is that in the future we will be looking at this in a different way and look at restoration of the resource.

Impacts of Fish Contamination on the Columbia River Basin.

Paul Lumley, Yakama Tribe

The Columbia River basin is large. There are four member tribes of the Columbia River Inter Tribal Fish Commission (CRITFC) – the Nez Perce, Umatilla, Warm Springs, and Yakama. There are a total of 14 tribes in the Columbia River basin.

The purpose of the study was to evaluate the likelihood that Native American tribal members may be exposed to high levels of contaminants from eating Columbia River Basin fish.

The first phase was a fish consumption survey, and the second phase a fish contamination study.

The fish consumption survey investigated two questions: are tribal members eating more fish than average and are they being protected by water quality standards based on a national fish consumption rate of 6.5 grams per day?

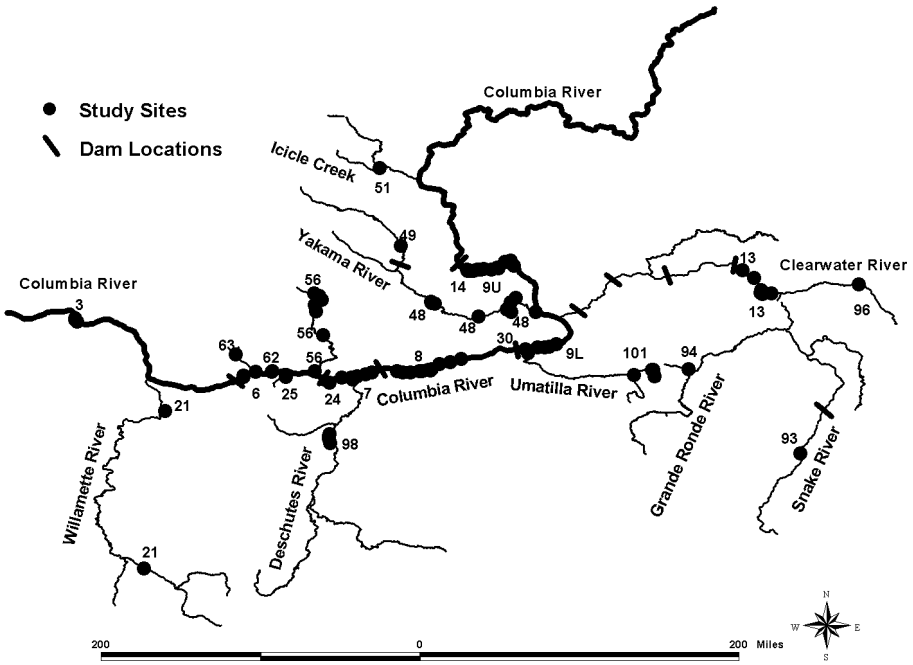
Fish species identified as important for the basin include salmon, rainbow trout, mountain whitefish, eulachon, lamprey, walleye, white sturgeon, and largescale sucker. A hypothetical diet was constructed with these species. The fish consumption survey found tribal members with average consumption rates ate two meals per week and those with high consumption rates ate 12 meals per week. Tribal member eat about nine times the amount of the general public. Children eat about three times the national average. Adults eat 58.7 grams per day on average. They are probably not protected by the water quality standards based on lower rates.

The goals of the fish contamination study were to determine whether fish were contaminated, whether there were differences in concentrations between species and locations, and whether tribal members face a higher risk. The study was not designed to evaluate people's health, intergenerational risks, rates of disease, or sources of chemicals.

The study sites were not random and were mostly on the Columbia River main stem at places where tribal members catch fish. 300 samples were obtained from tribal fishers and hatcheries, with three replicates per site. The resident species included white sturgeon, mountain whitefish, rainbow trout, walleye, bridgelip, and largescale sucker. Some are commercial species. The anadromous species included Chinook salmon, coho salmon, steelhead, eulachon (smelt), and Pacific lamprey. Samples were analyzed in various ways because people eat fish in various ways. The samples were analyzed for 132 chemicals.

The resident fish were found to have considerably higher concentrations of many contaminants than the anadromous fish. For aroclors, resident fish were higher, but Pacific lampreys also showed 100 ppb. Mercury showed up in both at similar amounts.

The total cancer risk was calculated to be 4×10^{-4} for tribal members. This is for the average consumer. Some are higher consumers. The pollutants contributing the greatest risk varied by species, though PCBs, mercury, dioxins, DDT, and arsenic seemed to be most important overall. The hazard index for non-cancer effects was above three, when hazard indices for all types of effects were added.



The most contaminated fish were found in upper parts of the basin. There is some contamination from Lake Roosevelt. They will be bringing in more tribes to discuss these results.

The conclusions of the study were that the fish were contaminated; that there are differences between species and locations, and that tribal members are exposed to a higher risk. Tribal members eat a lot more salmon (anadromous species) than resident fish.

US EPA has concluded that the Columbia River basin results are similar to other large river basins in the US in terms of contamination. Industrial groups seem to be honing in on this as a reason to avoid addressing the critical issues. This is a significant issue for the Columbia River tribes.

The four member tribes do not have advisories. The report received considerable news coverage. If they issued fish advisories, they would have to be careful and be scientifically credible.

Some of the issues to consider include the following.

Salmon is very important from a cultural perspective. It is the first food placed on the table at a long house ceremony.

The tribes have treaty rights. Treaties of 1885 guarantee the "right of taking fish at all usual and accustomed places." They take this very seriously. Some sites have been covered up by the dams. The Columbia River basin used to produce more salmon than any other basin in the world, and now it produces more electricity. When the tribes signed the treaties they never envisioned the fish would become toxic.

The organization's primary mission is to restore the fisheries, not human health. The tribes are struggling with the report because they are trying to get people to return to a traditional diet

because of other health problems. People are demanding answers from leaders about cleaning up contaminants. People see health as embodying physical, mental, spiritual, and cultural qualities.

Fish preparation methods may be an important issue. Canning has become more popular. Drying salmon is healthier. They are advising people go to back to the more traditional ways. Some traditional methods may not be healthy, however, such as whole fish soup and eating salmon eggs.

There are issues about the health of the fish. Research needs are significant and include pathology, toxicology, etc. The tribes do not have staffing to address fish health. Fish health issues tend to get lost in the shuffle compared to human health. There is a need for more discussion of stewardship of the fish. It is difficult for tribes to do it as well, but we need to consider this.

The economic benefits of the fish in the Columbia River Basin are substantial, amounting to about $2 million for tribal members annually. The tribes are looking at ways to add value to product by smoking, etc. The recent EPA report has impacted tribal ability to market salmon. Farmed fish may be ten times more toxic than wild fish.

Environmental cleanup is important. There are a lot of legal and political issues. The agricultural industry is large. Cleanup would take a major effort. Environmental justice is a concern. Risk assessments need to be done by and for the tribes, but they do not have the staff within their governments to do this at present. There are limitations to tribes addressing these issues. Understanding and communicating results to tribal members are important. EPA is not planning to use report to advise the general public. The tribes have to address it. They are initiating an effort to coordinate tribal efforts.

The tribes do not want to see another study presented to them. They want to see something done about it. The next step is to look at action to clean up the environment.

Dietary Benefits and Risks in Alaskan Villages.

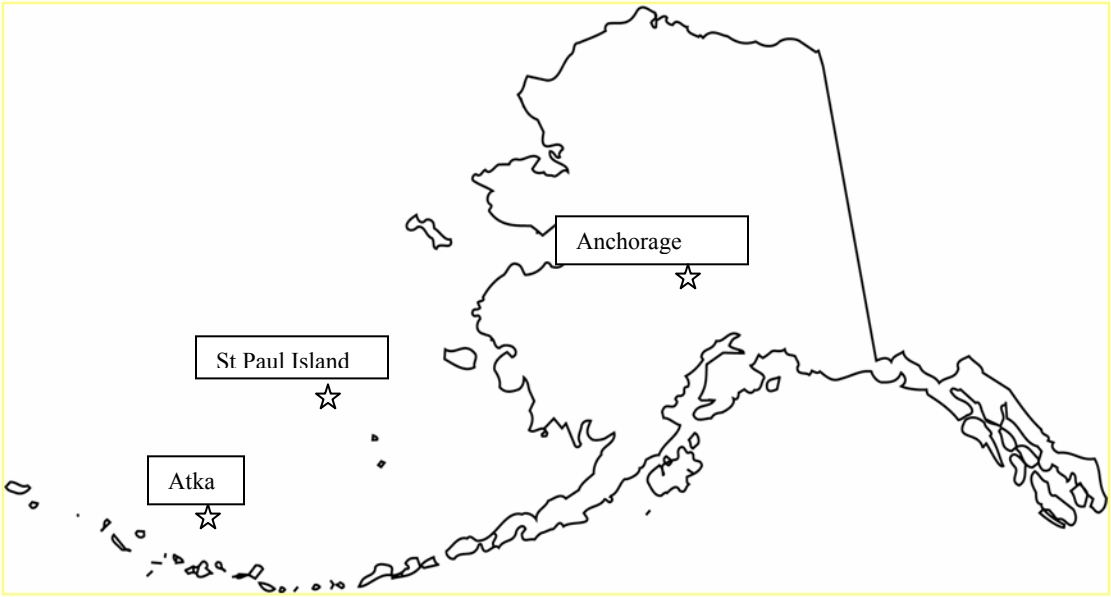
Suanne Unger, Aleutian/Pribilof Islands Association

The focus of the project is on community health issues and community services. There are community-based coordinators in the villages involved in the study.

There are more than 229 tribes in Alaska. In rural Alaska, the subsistence harvest is about 375 pounds of fish, marine and terrestrial mammals per person per year, compared to an average US annual consumption of 255 total pounds of meat, fish, and poultry.

In Alaska, the main subsistence food is fish, at about 65%. Common species are salmon, halibut, herring, whitefish, cod, and Dolly Varden. Subsistence is very important in Alaska. It is not just to supplement the diet.

In the Aleutian/Pribilof region, at St Paul Island, subsistence harvest and use of marine mammals is almost equal to that of fish. The percentage of households that use marine mammals varies among communities, though the highest rates are at Atka, Nikolski, and Akutan, at more than 90%.



The purpose of the study is to encourage healthy dietary choices by raising awareness about the rural diet and the risks and benefits unique to foods consumed at Atka and St. Paul. There are a lot of unique situations in rural Alaska with regard to risks and benefits. The intention is to produce a process that other tribes can replicate.

There is currently no consumption advisory in Alaska except that unlimited consumption is recommended by the state health department due to benefits. This is a confusing message to people. People are concerned about increasing cancer and increasing blights and sores that they observe on fish. Part of the purpose is to help tribes recognize they can start to monitor local species and work at the community level.

Key questions that people have are: Is traditional food safe to eat? What are benefits and risks of traditional foods? What are the benefits and risks of changing from a traditional diet to a more store-bought diet?

The community goal is to restore and maintain healthy lifestyles and cultural connections for this and future generations and to achieve holistic community health in Atka and St. Paul. This is defined as a natural interplay among cultural, physical, environmental, economic, spiritual, social, and emotional forces.

The hypotheses of the study are that: traditional foods are safe to eat and are an important part of a nutritious balanced diet; maintenance of a traditional diet enhances community cohesion, cultural connection and community and individual health; increasing substitution of traditional foods with commercial foods in the diet is resulting in negative health effects; many factors are influencing the collection, use and benefits of traditional foods.

The two communities were chosen for the study because they have high use of subsistence foods and are far removed from the urban center of Anchorage. Foods are expensive and there are limited choices for fresh foods. In St. Paul, testing has shows high levels of persistent organic pollutants in northern fur seals; people have had dramatic changes in their diet; there is a high

rate of diabetes; and there is access to store bought foods. In Atka, some studies have also shown persistent organic pollutants, and the community is in close proximity to Amchitka Island.

Tracey Lynn Alaska Division of Public Health: The presentation made reference to a POPs study that has been conducted in parts of Alaska. It was not a random sample as they tried to encourage certain people to participate.

Question: How do you {tribes} like to be approached by researchers? Particularly one who has never worked with a community before?

Paul Lumley: The best way to work with a tribe is to develop a relationship with someone in the tribe. Each tribal government has a different structure.

Marvin Kline, Fort McPoint Environmental Department: Tribes are at a crossroads. I don't think that going back to traditional ways will help to deal with more powerful culture that we see on TV. Advisories are necessary for elders and for those who want to practice subsistence. For people like me, who decide to be more assimilated, what kind of curriculum are you offering or are you encouraging youth to go to college for natural resources management, etc.

Paul Lumley: A lot of members are focused on cultural practices. In our reservations, the economic conditions are pretty bad, and there is a lot of apathy. It is important to be careful about recommendations to cut back on the use of salmon. You can also make advisories but that does not mean people have to abide by them. High consumers may not change. I will not ask them to reduce salmon use. We need to give them information. If it is true that fish is contaminated, we need to let them know.

Sue Unger: One thing we are hoping to do is to get students involved in parts of the analysis per the laboratory.

John Persell: The tribe has a critical professions program to encourage people to get into critical training.

IX. Looking at Health Benefits of Consuming Fish

Overview of Benefits of Fish Consumption.

Judy Sheeshka, University of Guelph

Consumption of fish has health benefits that depend on the amount consumed, species, and what foods are replaced by fish.

Fish are a good food source because they have high quality protein, "good" fatty acids, and vitamins and minerals. Good quality proteins are those that have all of the essential amino acids and are available to the body. The proteins in animal foods have all nine amino acids, while plant foods do not. This is why vegans need to be careful about combining their plant sources to gain all of the acids. Egg proteins have the highest quality, followed by fish. Sometimes what appear to be big differences in quality disappear when you look at the actual diet. Substituting chicken for fish produces fairly similar result while substituting hot dogs results in what dieticians would consider to be a disaster because of much higher fat concentrations.

Current dietary guidelines recommend 25 to 35% of calories from fat. This is based on benefits of a Mediterranean style diet, with emphasis on low saturated fats. Saturated fats come from meats, baked goods, and high fat dairy products and tend to raise the "bad" cholesterol. Mono and poly unsaturated fats (MUFA and PUFA), in fish, vegetable oils, and nuts, are considered to be good fats. They lower serum LDL (bad cholesterol) and raise HDL (good cholesterol), which lowers the risk of heart disease.

Both lean fish and fatty fish have 75% heart healthy fat. On average, only 25% of fat in fish is the bad kind, compared to 40% in beef. This is pretty consistent across species.

Omega 3 fatty acids are a form of PUFA found in fish and nuts. The two of greatest interest are DHA and EPA. They are not only found in all fish, though the amounts are less in lean fish. The amount of these acids in fish depends on the temperature of the water where the fish live. Examples of amounts found in different types of fish are shown below.

N-3 Fatty Acids in Fish (grams per 100 grams of fish)

	EPA	DHA
Large-mouth bass	0.31	0.45
Coho salmon	0.40	0.66
Rainbow trout	0.47	0.56
Fresh-water drum	0.29	0.37
Channel catfish	0.10	0.14
Northern pike	0.04	0.09
Walleye	0.11	0.29
Yellow perch	0.10	0.22

Fish and mercury and fish and omega acids are another issue. Mercury does not necessarily co-occur with the beneficial fatty acids because the fatty acids go into fat not muscle. A fatty fish

can be either low or high in mercury. Walleye tend to be higher in mercury while perch are low; both have high concentrations of omega 3 acids. Pike has low fatty acids and high mercury.

There is some debate about omega 3 concentrations of farmed fish. The type of feed is important. Farmed fish are higher in total fat than other fish. The percentage of omega 3 acids as a percent of total fat is lower. But the amount of omega 3 acids per gram appears to be similar as in wild fish. It depends on how data are expressed.

Omega 3 fatty acids are important to growth and development and are important during the third trimester up to twelve months of age. The mother's consumption leads to the baby's initial exposure.

There seems to be agreement that one to two fish meals per week will reduce deaths from myocardial infarctions and will also reduce all-cause mortality. The acids reduce triglycerides (which are risk factors for heart disease) in the blood but results for cholesterol are not consistent.

The literature is difficult to interpret because there are different cardiac endpoints. Mechanisms are not known. Some effects do not increase with dose. Lean fish produce the same effects as fatty fish. Addition of 1 gram per day of fatty acid supplement provides improvement but higher doses do not. The benefit plateaus at two fish meals per week. This suggests that something else at play here. Two meals per week of lean fish do not contribute much in the way of omega 3 fatty acids. The studies have only included well educated, relatively wealthy people. The American Heart Association recommends at least two fish meals a week, and the evidence clearly supports 1 to 2 fish meals per week.

There is evidence that fish consumption can protect against cancer especially in the GI tract.

Fish consumption may be beneficial for stroke. Research suggests that some kinds of stroke may be affected and others not. Adding fish to diets designed to lower blood pressure (low salt, etc), along with weight loss and exercise, reduces blood pressure.

To summarize the findings, all fish contain the omega 3 fatty acids, which are highly beneficial during pregnancy and the first year of life and which are found in all fish. The effects of fish on reducing chronic disease may be independent of the effects of fish on blood lipids (including cholesterol). There is complete consistency in the literature that says that having no fish is a health risk.

Use of Quality Adjusted Life Years to Assess Risks and Benefits of Fish Consumption.

Rafael Ponce, University of Washington

The benefits and risks of fish consumption are a key concern. Benefits include high nutritional quality, often inexpensive cost, often ready access, health benefits (cardiovascular disease, neurodevelopmental), social and cultural associations. Risks include health effects of harmful environmental toxicants. There are also issues of risk substitution.

A decision problem is how to develop methods and conduct analysis when disparate health endpoints are at risk.

An ideal policy tool would allow consideration of both risks and benefits; be transparent, rigorous, and theoretically well-founded; allow consideration of uncertainties, correlations; be flexible and allow updating with new information.

The available tools include risk analysis (which compares disease incidence to identify best policy); benefit-cost analysis, (which considers whether the benefits of implementing a policy outweigh the cost); cost-effectiveness analysis (which considers which policy option has the greatest effectiveness per unit cost). In any of these analyses, you need similar "units."

Comparisons of risk are not sufficient for health policy decision making because each risk does not have the same impact or consequences. Economists try to develop ways to define when health endpoints are equivalent. Ways to determine when health endpoints are equivalent could include the following: when an individual is ambivalent between two health effects; when health effects have comparable duration; when health effects have comparable cost; when health effects have comparable population impact.

Use of QALYs (quality adjusted life years) is suggested because it is one way to compare. They divide health impacts into two elements: duration of impact and quality of life. The method assumes that these are independent. Half a year of perfect health equals one year of half-health. This is used for evaluating therapies and screening programs, as well as disease burdens.

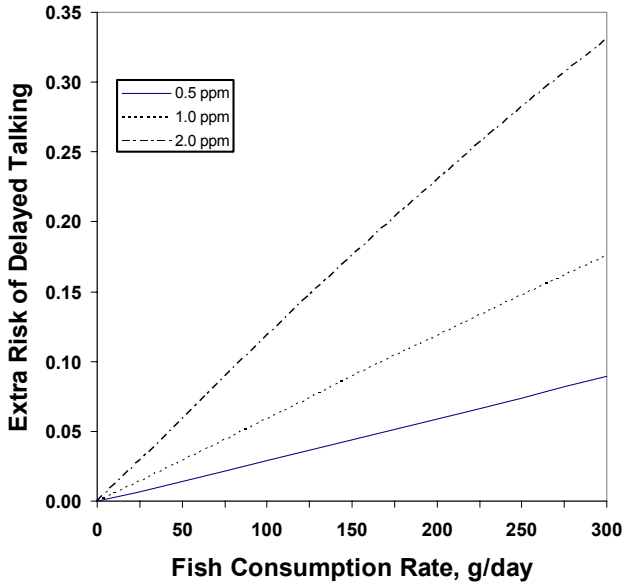
To do this, researchers assess preferences and aversions for different health states and rate them on a scale from 0 to 1, where 0 represents death and 1 represents perfect health. There is some controversy about whether this is an appropriate. Discounting is also a concern; is the value of life at 55 the same as at 23?

To estimate net benefit/risk, one can use QALYs to adjust dose-response functions. Once normalized, dose-response functions can be directly compared and then combined to get a net health impact. This allows for the comparison of endpoints that differ in risk and consequence. The method is presented in more detailed in two papers [29, 30]

This case is presented as an example. It was not intended to be definite. Although realistic data were used in the derivation of this case, it is not intended as a definitive analysis. A number of assumptions need careful consideration. It considers only a single benefit and risk endpoint. The risk is neurodevelopmental delay from prenatal MeHg exposure. The benefit is reduced risk of fatal myocardial infarction with eating fish. The populations modeled are a general population of 100,000 and a population of 100,000 women of child-bearing age and their children. A fish intake of 0 to 300 grams per day of fish was used. This includes 99th percentile of fish consumers for the lower 48 states. The concentration of methyl mercury in fish was assumed to be between 0 and 2 ppm.

To model risks they the Iraqi poisoning data [31] and a Weibull dose-response model from US EPA. They estimated the risk of neurodevelopmental delay from methyl mercury in fish, with a reduction in the quality of life decreased from on the scale from 1 to 0.9. They assumed a lifetime impact of reduced quality of life and used life table to estimate lifespan.

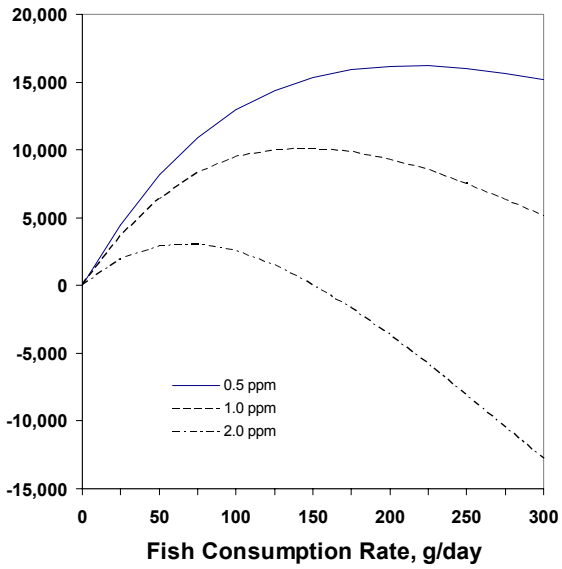
A plot of the extra risk of delayed talking against mercury consumption in fish based on this approach is shown below.

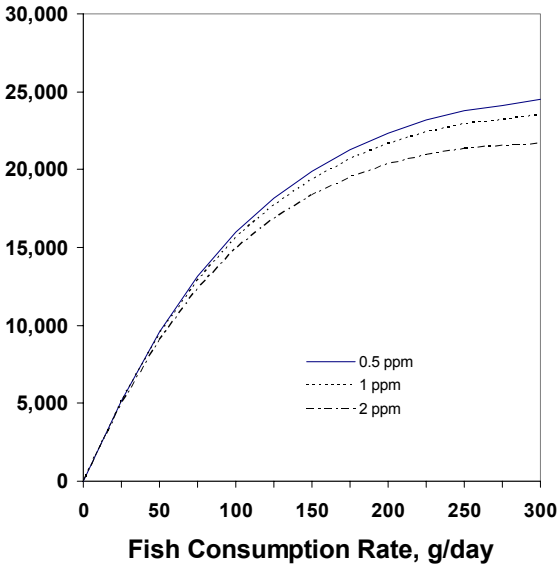


To model benefits they used CDC data to estimate lifespan using mortality rates by all causes and by MI. They estimated benefits of fish consumption [32, 33] and modified the mortality rates, assuming that the male data was applicable to females.

They aggregated risks and benefits. They assumed equivalent health impacts for the two outcomes. This is not an appropriate assumption. There is no discounting of effects. There is an ethical issue here because benefits go to adults and risks to kids. This graph shows the net health impact.

Net health impacts for 100,000 men and women with equal QALY weights (left graph) and unequal QALY weights (right graph).





The conclusion of the analysis is that, depending on the model assumptions, restrictions for the general population to limit fish consumption could do more harm than good. Recommendations to limit fish intake during pregnancy would do more good than harm.

The method is **a**menable to sensitivity and uncertainty analysis. It is possible to adjust the QALY weights and dose-response modeling. It is amenable to discounting; forecasting and can consider multiple benefits/risks. It requires data on health effects (dose-response, age-specific rates, duration of effects). Other issues are that extrapolation of data from animals is uncertain. It requires quality of life weights for each endpoint.

Tracey Lynn: Have you considered further developing model to take into account multiple endpoints? Look at risks and benefits for women, for example.

Response: No

What was the age definition of women and children?

Response: We used life tables; do not specify age. We only looked at the fetus and following the impact over a lifetime

On the second population there was no benefit because low risk of MI – what about benefit of future reduction of MI.

Response: We did not consider that.

Re: risk of not eating fish. What if you replace it with other good nutrition not hot dogs?

Sheeshka – Researchers concluded that a diet high in fish was healthier

Eric Frohmberg – We should be careful about how commercial fish is described across the states. King mackerel is a high mercury fish rarely seen in Maine and another form of mackerel is a poster child for low mercury.

Lynn Tracey, Alaska Division of Public Health: The State of Alaska would like to see salmon included on list of good fish.

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Appendices

Appendix 1: Conference Agenda

Appendix 2: Conference Steering Committee Members

Appendix 3: Biographies of Speakers, Moderators, and Steering Committee Members

Appendix 4: Participants

Appendix 5: Slides from Presentations

Appendix 1: Conference Agenda

Sunday October 20

8:30 – 10:00 AM **Registration** in Lobby, Radisson Hotel, Burlington, Vermont

10:00 AM – Noon **Regional Work Groups.**

Moderators:

Northeast: Razelle Hoffman-Contois, State of Vermont
Chesapeake Bay and Delaware Estuary: Tom Fikslin, State of Delaware
Southern: Tracy Shelley, State of South Carolina
Great Lakes: Pat McCann, State of Minnesota
Western: Bob Brodberg, State of California

2:00 – 3:30 PM **Topical Discussion Sessions**

A. Contaminants in Stocked Fisheries: Potential for contamination, human exposure, and human health risks.
Moderator: Bob Brodberg, State of California

- *PCBs and Hatchery Trout in Pennsylvania—the Good, the Bad and the Ugly!* John Arway, State of Pennsylvania
- *Regulating Contaminants in Feed for Fish*. Frances Pell, US FDA, Center for Veterinary Medicine
- Round Table Discussion

B. The Use of Composite Samples in the Development of Fish Advisories
Moderator: Razelle Hoffman-Contois, State of Vermont

- *Issues in the Use of Composite Samples for Assessing Risks to Highly Exposed Populations*. John Persell, Minnesota Chippewa Tribe Research Lab
- *Composite Sampling Analysis of Fish*. Henry Kahn, US EPA
- Round Table Discussion

3:45 – 5:15 PM **Topical Discussions**

C. Addressing Multiple Pollutants in Fish
Moderator: Eric Frohmberg, State of Maine

- *Current Guidance from EPA on Chemical Mixtures*. Roseanne Lorenzana, US EPA
- *Current Guidance from EPA on Cumulative Risk*. Ed Bender, US EPA
- Round Table Discussion

D. TMDLs (Total Maximum Daily Loads) and the Interplay Between Water Quality Programs and Fish Advisory Programs
Moderator: Randy Manning, State of Georgia

- *TMDLs and Fish Consumption Advisories*. Jim Pendergast, US EPA
- Round Table Discussion

6:00 – 8:00 PM **Displays and Materials from Forum Participants**

Monday October 21

8:00 – 8:15 AM **I. Review of Agenda and Introductions** Jeffrey Bigler, US EPA
Welcome: Gus Rassam, Executive Director, American Fisheries Society

8:15 – 8:30 AM **II. Opening Address**
- *Trends in Chemical Pollutants in Fish***.** Usha Varanasi, NOAA/Northwest Fisheries Science Center

8:30 – 9:15 AM **III. Update on Activities Related to the 2001 Forum**
- *New Version of the Risk Communication Guidance*. Barbara Knuth, Cornell University
- *Relationship of TMDLs to Fish Advisories*. Jim Pendergast, US EPA

9:15 – 9:45 AM **IV. Reports from the Weekend Sessions**
- *Medical Workshop Report*. Henry Anderson, State of Wisconsin
- *Report on mercury advisory worksheets*. Amy D. Kyle, University of California Berkeley

10:15 AM – 12:15 PM **V. Advisories for Commercial Fish: Federal, State, and Tribal Approaches**
Moderator: Elaine Krueger, State of Massachusetts
- *Advisory Panel to the Food and Drug Administration on Mercury Advisories*. H. Vasken Aposhian, University of Arizona
- *FDA National Advisory on Mercury in Commercial Fish*. Phil Spiller, US FDA
- *State and Tribal Advisories on Contaminants in Commercial Fish.*
  - Henry Anderson, State of Wisconsin
  - Andy Smith, State of Maine
  - Gary Ginsberg, State of Connecticut

1:30 – 3:15 PM **VI. Hot Topics—Chemicals of Concern**
Moderator: Luanne Williams, State of North Carolina

- 1:30-2:15 PM **A. Mercury**
  - *Update: On-going Research*. Kate Mahaffey, US EPA
  - *Setting a Reference Dose (RfD) for Adults*. Alan Stern, State of New Jersey
- 2:15-3:15 PM **B. Brominated Flame Retardants (Polybrominated Diphenyl Ethers or PBDEs)**
  - *Occurrence of PBDEs in Fish*. Rob Hale, Virginia Institute of Marine Science
  - *Toxicity of PBDEs in Fish*. Linda Birnbaum, US EPA
  - *Assessing the Risks of PBDEs*. Khizar Wasti, State of Virginia

3:30 – 4:00 PM **C. Dioxins and Coplanar PCBs**
- *Status of the Reassessment*. Dwain Winters, US EPA

4:00 – 4:45 PM **D. Lead**
- *The EPA Lead Model*. Lon Kissinger, US EPA
- *Occurrence of Lead in Fish*. Bob Brodberg, State of California

4:45 – 5:15 PM **E. Polycyclic Aromatic Hydrocarbons**
- *Occurrence in Fish*. Usha Varanasi, Director, NOAA/Northwest Fisheries Science Center

Tuesday October 22

8:00 – 10:00 AM **VII. Approaches to State and Tribal Advisories**

Moderator: Jeff Bigler, US EPA

- *Statewide Advisories Based on the 95th Percentile of Concentrations in Fish*.
  Eric Frohmberg, State of Maine
- *The Use of Maine's Statewide Advisory in a Tribal Setting*
  Susan Peterson, Aroostook Band of Micmacs
- *Statewide Advisories Based on Average Concentrations in Fish*.
  Mike Ell, State of North Dakota
- *Setting Advisories Specific to Named Water bodies Based with a Default Statewide Advisory*
  Bob Frey, State of Pennsylvania
  Pat McCann, State of Minnesota
- *Regional Advisory for DDT for the Mississippi Delta*
  Henry Folmar, State of Mississippi
- *Statewide Advisory Based on 8 Meals per Month*
  Joe Beaman, State of Maryland

10:15 – 11:30 AM **VIII. Approaches to Considering Benefits in Advisory Programs**

Moderator: Dan Kusnierz, Penobscot Nation

- John Persell, Minnesota Chippewa Tribe Research Lab
- Paul Lumley, Yakima Tribe
- Sue Unger, Aleutian-Pribilof Islands Association

11:30 – 12:30 PM **IX. Current Science on the Benefits of Fish Consumption**

Moderator: Andy Smith, State of Maine

- *Overview of Benefits of Fish Consumption*. Judy Sheeshka, University of Guelph
- *Use of Quality-adjusted Life Years to Assess Risks and Benefits of Fish Consumption*. Rafael Ponce, University of Washington
- Questions and comments from participants

12:30 – 1:00 PM **X. Closing Comments**

Appendix 2: Steering Committee Members

- Jeffrey Bigler, US Environmental Protection Agency, co-chair
- Betsy Fritz, American Fisheries Society, co-chair
- Robert K. Brodberg, California
- Eric Frohmberg, Maine
- Razelle Hoffman-Contois, Vermont
- Barbara Knuth, Cornell University
- Jan Lubeck, American Fisheries Society
- Randy Manning, Georgia
- Patricia McCann, Minnesota
- John Persell, Minnesota Chippewa Tribe
- Andy E. Smith, Maine

- Amy D. Kyle, steering committee facilitator

Appendix 3: Biographies of Speakers, Moderators, and Steering Committee Members

Henry A. Anderson, MD

Since 1980 Dr. Anderson has been with the Wisconsin Department of Health and Family Services, division of Public Health as a Chief Medical Officer and State Environmental and Occupational Disease Epidemiologist. He is certified by the American Board of Preventive Medicine with a sub-specialty in occupational and environmental medicine and is a fellow of the American College of Epidemiology. He holds adjunct Professorships at the University of Wisconsin - Madison, Department of Population Health and the UW Institute for Environmental Studies, Center for Human Studies. He has published widely on a broad spectrum of environmental, occupational and public health topics. For the past twenty years he has conducted research on the health impact of contaminants in sport fish and risk communication via fish consumption advisories. He is chair of the Environmental Health Committee of the US EPA Science Advisory Board and serves on the US EPA Science Advisory Board Executive Committee. He is a member of the Director's Advisory Committee, National Center for Environmental Health, Centers for Disease Control and Prevention. He is associate editor of the *American Journal of Industrial Medicine* and serves on the editorial board of *Cancer Prevention International*.

H. Vasken Aposhian, PhD

Dr. Aposhian is Professor of Molecular and Cellular Biology, Professor of Pharmacology and a Member of the Toxicology Center of the University of Arizona. He was a member of the National Academy of Sciences/ National Research Council Committee on Methylmercury Toxicology and its Committee on Arsenic in Drinking Water. His research deals with arsenic metabolism and biotransformation in humans as well as how to remove mercury from the human body. He is very much aware of the problems of the commercial fisherman since he has always spent a month of each year in the town next to Gloucester, Mass, the oldest fishing harbor in the USA.

John Arway

John Arway is a fisheries ecologist and Chief of the Pennsylvania Fish and Boat Commission's Environmental Services Division. John is responsible for the statewide coordination of the Commission's aquatic risk, damage assessment, habitat management and threatened and endangered species programs. He is also the Commission's representative on the Commonwealth's Fish Tissue Contaminants Technical Workgroup. He has worked for over 22 years in the prediction and evaluation of impacts to aquatic resources living in Commonwealth waters.

Edward Bender

Dr. Edward Bender is a Science Administrator on the Science Policy Council staff of the Cross Programs Branch of OSP. Ed supports the meetings and activities of the Science Policy Council of EPA. His current focus is on cumulative and environmental risk assessment, risk management decision making, metals hazard and risk, environmental economics, and foresight analysis. Prior to joining the SPC staff, he served as a Designated Federal Official to several committees of EPA's Science Advisory Board which examined a range of ecological, economic, engineering, and futures issues. He worked as an aquatic biologist and national expert with the Enforcement Division, Office of Water Enforcement and Permits on biological monitoring and water quality assessment for the National Pollutant Discharge Elimination System and Pretreatment Program under the Clean Water Act. He also worked for the U.S. Army to assess the effects of manufacturing and base operations on ecological communities of streams and military lands.

Dr. Bender has more than thirty years experience in environmental monitoring, aquatic ecology and toxicology. His dissertation, entitled "Recovery of a Macroinvertebrate Community from Chronic DDT Contamination," studied the toxic effects of DDT runoff from an abandoned manufacturing facility on fish and aquatic invertebrates in a south-central Arkansas stream. Ed chairs a multi-agency panel that monitors a remedial action on DDT contaminated sediment in Northern Alabama. Ed has a bachelor of science degree in biology from Westminster College, a master of science degree in zoology from the University of Florida, and a doctorate in biology from the Virginia Polytechnic Institute and State University.

Linda S. Birnbaum

Dr. Birnbaum is the Division Director of the Experimental Toxicology Division, National Health and Environmental Effects Laboratory, Office of Research and Development, United States Environmental Protection Agency, in Research Triangle Park, North Carolina.

Dr. Birnbaum received her B.S. in Biology from the University of Rochester, Rochester, New York. She received her M.S. and Ph.D. in Microbiology from the University of Illinois, Urbana, Illinois. After a semester as a Visiting Assistant Professor of Microbiology at the University of Illinois and two years of postdoctoral work at the University of Massachusetts (Amherst), Dr. Birnbaum became an Assistant Professor of Science at Kirkland (Hamilton) College in Clinton, New York. She spent four years at the Masonic Medical Research Laboratory in Utica, New York, first as a Research Associate, then a Research Fellow and a Research Scientist. She next accepted a Senior Staff Fellowship with the National Toxicology Program of the National Institute of Environmental Health Sciences, in Research Triangle Park, North Carolina. Serving next as a Research Microbiologist and then a Supervisory Research Microbiologist, Dr. Birnbaum remained with NIEHS for ten years. After a serving as the Head of the Chemical Disposition Group, NIEHS, she accepted the position of Director, Experimental Toxicology Division with the U.S. EPA, which is responsible for conducting research to determine the health effects of inhaled, ingested, and dermally contacted environmental pollutants, and the cause and effects relationships at pollutant concentrations which mimic those occurring in the environment.

Since going to the EPA, she has served as the Acting Assistant Director for Health for a year and as the Acting Director of the Human Studies Division for another year, returning to her present position.

Dr. Birnbaum is the author of over 600 peer-reviewed publications, book chapters, abstracts, and reports. She is an Adjunct Professor in the Toxicology Curriculum and the Department of Environmental Sciences and Engineering at the University of North Carolina, Chapel Hill, and in the Integrated Toxicology Program at Duke University. She is the former Vice President of the American Aging Association and the Chairperson of the Division of Toxicology of the American Society of Pharmacology and Experimental Therapeutics. She was recently elected to be the Vice President-Elect of the Society of Toxicology and will serve as President in 2004-2005.

Robert K. Brodberg

Dr. Brodberg received a BS from Heidelberg College, and the MS and Ph.D. from Bowling Green State University. Dr. Brodberg is currently a Senior Toxicologist in the Office of Environmental Health Hazard Assessment (OEHHA), which is part of the California Environmental Protection Agency. Dr. Brodberg has worked in the Pesticide and Environmental Toxicology Section of OEHHA since 1992. He is currently the Chief of the Fish and Water Quality Evaluation Unit that is responsible for assessing the potential human health risks of eating chemically contaminated sport fish and seafood and issuing sport fish consumption advisories for California. Dr. Brodberg also consults on projects with units of the State Water Resources Control Board, Regional Water Quality Control Boards, the Department of Fish and Game, and other agencies. He worked on developing sediment quality objectives as part of the Bay Protection and Toxic Clean-up Program and water quality objectives for the Ocean Plan. Dr. Brodberg was awarded a US EPA cooperative agreement to sample and evaluate chemical contamination in fish from two California Lakes. He is a member of the Society of Environmental Toxicology and Chemistry and has authored government reports and journal publications.

Michael J. Ell

I currently administer the Surface Water Quality Management Program in the North Dakota Department of Health′s Division of Water Quality. The Surface Water Quality Management Program has responsibility for lake and reservoir, river and stream, and wetlands monitoring and assessment, including the Section 305(b) reporting; Water Quality Standards; the Section 319 Nonpoint Source Management Program; and TMDL development. The program also supports the state's fish consumption advisory program through the collection and interpretation of mercury and other contaminant data in fish throughout the state.

I was first employed by the Department of Health in 1985 where I worked in the Atmospheric Deposition Program (Acid Rain). I have been in the Division of Water Quality since 1987 and in my current position since May 1991. I graduated from North Dakota State University with a BS in Zoology in 1982 and completed my MS degree at NDSU in 1988 where I studied the effects of weed harvesting on the biota of a small lake in north central North Dakota. I am married and have two children, both teenagers.

Henry Folmar

Mr. Folmer serves as Laboratory Director for the Mississippi Department of Environmental Quality in Pearl, MS. He Received B.S. and M.S. in Fisheries Biology from Auburn University. Began working with fish tissue monitoring in 1979. Helped found Mississippi's Fish Advisory Task Force in 1990, and has served as chairperson for the past 10 years. He is a Charter Member of the Southern States Mercury Task Force.

Robert Frey

Bob is a Water Pollution Biologist with the Division of Water Quality Assessment and Standards in the Bureau of Water Supply and Wastewater Management at DEP. He holds a Bachelor of Science in Education from Bloomsburg University of Pennsylvania. Among other duties, Bob is responsible for preparation of the "Pennsylvania Water Quality Assessment" report for submission to EPA every other year as required by the federal Clean Water Act. He also coordinates rulemakings for stream use redesignations, including High Quality and Exceptional Value designations.

Bob has been involved with Pennsylvania's fish tissue sampling and advisory issuance program since 1980. He is responsible for scheduling the annual fish tissue sampling conducted by DEP regional biologists and PFBC Area Fisheries Managers and coordinating laboratory analysis. He currently serves as Chair of the interagency Pennsylvania Fish Consumption Advisory Technical Workgroup. In this capacity he reviews and summarizes the fish tissue data collected each year and formulates advisory recommendations for the interagency workgroup. After the technical workgroup acts on the advisory recommendations, he forwards the revised advisory listing to an interagency policy workgroup for approval. Following this approval, Bob coordinates issuance of needed advisories, publication in the fishing regulations summary booklet, and posting of advisories on the DEP web site.

Eric J. Frohmberg

Eric Frohmberg is a toxicologist with the Maine Bureau of Health. He has been involved in the development of the fish consumption advisories as well as the Bureau's fish advisory communication program. This has included development of the new brochures, testing efforts with low literacy focus groups, and development of the fish consumption advisory website.

Gary L. Ginsberg

Dr. Ginsberg is currently a toxicologist at the Connecticut Dept. of Public Health within the Division of Environmental Epidemiology and Occupational Health. He has responsibility for human health risk assessments conducted in the state. He is also the project manager for several cooperative agreements with US EPA. One project is researching pharmacokinetic differences between children and adults while the other is exploring the influence of genetic polymorphisms on susceptibility to toxicants and inter-individual variability. Dr. Ginsberg serves as adjunct faculty at the Yale School of Medicine and also at the University of Connecticut School of Public Health. He received a Ph.D. in toxicology from the University of Connecticut (Storrs)

and was a post-doctoral fellow in carcinogenesis/mutagenesis at the Coriell Institute for Medical Research. Dr. Ginsberg's toxicology experience has involved a variety of settings: basic research, teaching, working within the pesticide and consulting industries, and now working in public health. He has published in the areas of toxicology, carcinogenesis, physiologically-based pharmacokinetic modeling, and children's health.

Robert C. Hale

Dr. Hale is Professor, Department of Environmental & Aquatic Animal Health, Virginia Institute of Marine Science, College of William & Mary. He received a B.S. in Biology and a B.A. in Chemistry from Wayne State University (MI) and a Ph.D. from the College of William & Mary (VA) in 1983. He subsequently joined Mobil Corporation's Environmental & Health Sciences Laboratory in Princeton as a Research Environmental Chemist. In 1987 he joined the faculty at VIMS, received tenure in 1993, and was promoted to Professor in 2002. Rob has been involved for over 20 years in research examining the analysis, fate and environmental effects of organic pollutants. During this time his research group has authored more than 120 peer-review articles and scientific presentations. While at VIMS, he has worked with the Virginia Department of Environmental Quality, the U.S. EPA and NOAA on a variety of projects, including efforts to characterize pollutants present in tissues of fish. Dr. Hale is particularly interested in the sources, fate, bioavailability and effects of brominated flame retardants and other emerging contaminants. He has recently published papers describing high concentrations of polybrominated diphenyl ethers in land-applied sewage sludge, World Trade Center dust and U.S. fishes in Nature, Chemosphere, Environmental Health Perspectives and Environmental Science & Technology.

Razelle S. Hoffman-Contois

Razelle Hoffman-Contois is the public health risk assessment specialist for the Office of Environmental Health and Toxicology in the Vermont Department of Health in Burlington. She routinely provides toxicology and risk assessment support for various state entities such as the Department of Environmental Conservation and Department of Fish and Wildlife. Ms. Hoffman-Contois was instrumental in the development of Vermont's mercury based fish consumption advisory. She earned both her B.S. and M.S. at the State University of New York College of Environmental Science and Forestry.

Henry D. Kahn

Senior Statistician, Statistics and Analytical Support Branch

Engineering and Analysis Division, Office of Science and Technology, Office of Water

EPA experience: 28 years

Experience in application of statistics to environmental problems including the design and analysis of studies that involve composite sampling. Received his D.Sc. from George Washington University, M. S. from the University of Miami, and B. E. S. from Johns Hopkins University.

Lon Kissinger

Lon Kissinger joined U.S. EPA Region 10 as a risk assessor in 2000, where his main focus has been on contaminated sediment sites. Lon's interests include subsistence fish and shellfish consumption by tribes and other populations, as well as use of geographic information systems to evaluate sediment contamination. Prior to working with EPA, Lon worked for eleven years with the Washington State Department of Ecology, where he dealt with implementation of the Washington State Superfund Regulation, air toxics, data management issues, and contaminated sediment sites. Lon received his master's degree in environmental toxicology from Cornell University and a bachelor's degree from Millersville University in biology and chemistry.

Barbara Knuth

Dr. Barbara Knuth is a Professor of Natural Resource Policy and Management, and Chair of the Department of Natural Resources at Cornell University. She is a Co-leader of the Human Dimensions Research Unit, specializing in inquiry focused on human attitudes, behaviors, and perceptions related to the environment. Her research program includes a focus on risk perception, communication, and management associated with chemical contaminants in fish. She holds a Ph.D. from Virginia Tech, a Masters of Environmental Science (M.En.) from Miami University (Ohio), and undergraduate degrees in Interdisciplinary Studies and Zoology, also from Miami University. Dr. Knuth has served as the President of the Water Quality Section of the American Fisheries Society (AFS), and is currently 1st Vice President of AFS. She has served on numerous scientific and advisory bodies, including the Great Lakes Science Advisory Board of the International Joint Commission, the Board of Technical Experts of the Great Lakes Fishery Commission, and the National Research Council Committee on Improving the Collection and Use of Fisheries Data. She serves currently on the Institute of Medicine/National Research Council Committee on Implications of Reducing Dioxin in the Food Supply. She authored, under contract to US EPA, the first risk communication guidance document for fish consumption health advisory programs.

Daniel H. Kusnierz

Daniel Kusnierz has been the manager of the Penobscot Indian Nation's Water Resources Program since January 1993. Because the Penobscot Reservation consists of the islands and water of the Penobscot River upstream of Old Town, Maine, clean water is extremely important to the Penobscot tribe. In his capacity as manager of the tribe's water program, Dan Kusnierz oversees many water resource related projects conducted by the tribe including a watershed-wide water quality monitoring program; studies of contaminant levels in fish, aquatic wildlife, and sediments; assessments of water quality using aquatic invertebrates; and studies of cumulative impacts. Working jointly with the tribal health department he is involved with establishing consumption advisories for tribal members. The program also participates in many permitting, licensing, and regulatory proceedings that affect the Penobscot Reservation and its aquatic resources. Dan serves as the tribal coordinator for the model water quality monitoring cooperative agreement between Penobscot Nation and ME DEP.

Dan serves on numerous committees including the Technical Advisory Committee for Maine's Surface Waters Ambient Toxics Program and the Maine Dioxin Monitoring Program, the Maine

Council on Environmental Monitoring and Assessment, and participates on EPA's Regional Tribal Operations Committee. He is the Region I tribal representative to the EPA Tribal Science Council. He is also the chairman of the Penobscot County Soil and Water Conservation District.

Dan earned his B.S. degree in Wildlife Biology from the University of Vermont. He is a M.S. candidate in Wildlife Management at the University of Maine, Orono.

Amy D. Kyle

Amy D. Kyle works on issues at the intersection of environmental health science and public policy and to further the links between the realms of "environment" and those of "health." She holds research and teaching appointments at the University of California Berkeley School of Public Health where her work focuses on children's environmental health, policy for persistent pollutants, development of methods to measure net population burdens of pollution, and air pollution. She is a component director for the Berkeley Center on Environmental Public Health Tracking at Berkeley. She is also one of the authors of a national analysis of measures relevant to children's environmental health produced by the US Environmental Protection Agency. She works with a variety of governmental and non-governmental agencies on a variety of policy issues. Recently, she worked with state health and environment agencies to develop a national strategy to address environmental factors that contribute to asthma in children, a ground-breaking project sponsored by the Environmental Council of the States and the Association of State and Territorial Health Officials. As a Switzer Environmental Leadership Fellow, she is developing develop human health indicators to accompany a set of indicators of environmental quality for the San Francisco Bay, rivers, and delta watersheds with the Bay Institute. She serves as an advisor and consultant to organizations including California Communities Against Toxics, the Natural Resources Defense Council, the California Air Resources Board, and the California Department of Health Services. She has an extensive background in public policy and public service at the state level, having served for five years as deputy commissioner for the Alaska Department of Environmental Conservation and in a variety of other positions. She obtained her BA at Harvard College and MPH and PhD at the University of California Berkeley.

Roseanne M. Lorenzana

Roseanne has been a toxicologist in the US EPA Region 10 Office of Environmental Assessment for the past ten years. And, in the last year has also become Region 10's science liaison to the Agency's Office of Research and Development. Prior to EPA, she was with the Oregon Health Division and the Washington Department of Health. She has a Doctorate in Veterinary Medicine, a Ph.D. in toxicology from the University of Illinois and research experience in biochemical mechanisms of toxicity from the Environmental Health Sciences Center at Oregon State University.

Roseanne has been a Diplomate of the American Board of Toxicology since 1992. She holds an adjunct faculty position the University of Washington, and has guided a number of students through projects involving priority scientific issues important to regional programs. Roseanne has extensive experience with risk assessment for the Superfund program and Water program. She has taught the Agency's Risk and Decision-Making class a number of times in Region 10 as

well as abroad. Roseanne also spent several months in Australia assisting the development of their national cancer assessment guidelines for contaminated sites.

Some of Roseanne's other recent activities have focused on toxicology and exposure assessment for arsenic, issues related to contaminants in traditionally harvested, subsistence food of Northwest Native Americans and Native Alaskans and environmental exposure issues for Asian Americans and Pacific Islander Americans.

Paul Lumley

Paul Lumley is the Manager of the Watershed Department at the Columbia River Inter-Tribal Fish Commission. The Commission is composed of four tribal nations: the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon and the Confederated Tribes and Bands of the Yakama Nation. Paul Lumley received his Bachelor of Science degree in Mathematics from Western Washington University in 1986. Mr. Lumley is an enrolled member of the Yakama Nation and was born and raised on the reservation. Mr. Lumley has fished throughout the Yakama Reservation, including on the Columbia River.

Paul Lumley has worked for the Commission since 1987. Mr. Lumley worked within the U.S. v. Oregon forums in fisheries management for 12 years and has testified in federal court on behalf of the tribes on numerous issues related to fisheries management and the use of hatcheries as a salmon-rebuilding tool. Beginning in 1999, he expanded his role to include watershed issues, such as habitat protection, habitat restoration and improving water quality for salmon. The project area for the four CRITFC tribes is the entire Columbia River Basin.

Mr. Lumley is active raising funds and assisting in the implementation of projects that are identified in the tribes' salmon restoration plan: *WY-KAN-USH-MI WA-KISH-WIT* (Spirit of the Salmon*)*. As a means to pursue the tribes' goals, Mr. Lumley participates in the following: numerous processes under the Northwest Power Act as related to the Fish and Wildlife program that mitigates for the development of the federal hydrosystem program (Bonneville Power Administration funding), various water quality programs in cooperation with the U.S. Environmental Protection Agency on numerous water quality issues, and promotes and seeks foundation and corporate sponsorships to fund tribal salmon restoration programs.

Kathryn R. Mahaffey

Dr. Mahaffey's professional career is in exposure assessment and toxicology of metals. She has worked extensively in the area of food safety. Following graduate training in nutritional biochemistry and physiology at Rutgers University, she completed post-doctoral training in neuro-endocrinology at the University of North Carolina School of Medicine. Her research has been on susceptibility to lead toxicity with greatest focus on age and nutritional factors resulting in more than 100 publications in this area. During her long career with the United States Government she has been influential in lowering lead exposures for the United States population through actions to remove lead from foods and beverages, and from gasoline additives during the 1970s and 1980s.

In the past decade, Dr. Mahaffey has been actively involved in risk assessments for mercury. She was the author of the NIH Report to Congress on Mercury, and a primary author of US EPA's *Mercury Study Report to Congress*. These reports emphasized risk of developmental deficits caused by methylmercury exposure during development of the nervous system. Dr. Mahaffey was one of the primary developers of US EPA's *Mercury Research Strategy* which was released in late 2000. Along with other team members, she was responsible for the 2001 EPA/FDA national advisory on fish consumption. Dr. Mahaffey was one of a group of three EPA health scientists who revised the basis for EPA's Reference Dose for Methylmercury which was used in developing the Methylmercury Water Quality Human Health Criterion. In 2002 she received EPA's Science Achievement Award in Health Sciences for this work. This is EPA's highest health sciences award and is presented in conjunction with the Society of Toxicology.

Currently Dr. Mahaffey is the Director of the Division of Exposure Assessment, Coordination and Policy within the Office of Science Coordination and Policy of OPPTS, US EPA. This division runs US EPA's Endocrine Disruptor Screening and Validation Program. Dr. Mahaffey remains active in research and developing US EPA's policies on methylmercury.

Randall O. Manning

Dr. Manning is the Coordinator of the Environmental Toxicology Program in the Georgia Department of Natural Resources, Environmental Protection Division. Dr. Manning received his Ph.D. in 1986 from the University of Georgia (UGA), College of Agriculture where he studied the toxicity and metabolism of mycotoxins. Prior to joining the Georgia Environmental Protection Division (GAEPD) in 1991, Dr. Manning was a Postdoctoral Research Associate (1987-88) and an Assistant Research Scientist (1989-90) in the Department of Pharmacology and Toxicology at UGA, studying the toxicity of volatile organic chemicals and the development of physiologically-based pharmacokinetic models for use in risk assessment. As the Coordinator of the Environmental Toxicology Program at GAEPD, Dr. Manning is responsible for providing the Division with support in toxicology and risk assessment. Dr. Manning's research interests relate to the development of risk-based approaches for evaluation of environmental contamination by regulatory agencies. Dr. Manning is a member of the Society of Toxicology, a Diplomate of the American Board of Toxicology, and an Adjunct Assistant Professor in the Department of Pharmaceutical and Biomedical Sciences, College of Pharmacy, University of Georgia and the Department of Environmental and Occupational Health, Rollins School of Public Health, Emory University.

Patricia McCann

Ms. McCann is Program Manager of the Minnesota Fish Consumption Advisory Program at the Minnesota Department of Health. She researches the toxicological characteristics of contaminants in Minnesota fish and wildlife, evaluates environmental and exposure data, and develops fish and wildlife consumption guidelines and communicates them to the public. She holds a M.S. in Environmental Health from the University of Minnesota School of Public Health and a B.S. in Chemical Engineering from the University of Minnesota Institute of Technology.

G. Tracy Mehan III

G. Tracy Mehan, III, was nominated by President George W. Bush to be Assistant Administrator for Water, U.S. Environmental Protection Agency, and confirmed by the U.S. Senate on August 3, 2001. Mehan has responsibility for implementing the nation's Clean Water Act, as well as the Safe Drinking Water Act, along with other environmental statutes, in collaboration with state and tribal partners.

Since February 1993, Mehan has served as Director of Michigan's Office of the Great Lakes and a member of Governor John Engler's Cabinet, coordinating policy on a variety of issues including toxic contamination, aquatic nuisance species (exotics) and water diversions. He represented Michigan on the Great Lakes commission, an interstate compact organization, and its executive committee. He also served on the board of the Great Lakes Protection Fund, a $140 million endowment established by the governors of the region as well as the Water Quality Board of the International Joint Commission.

Mehan chaired the Michigan Mercury Pollution Prevention Task Force, a public-private body which initiated numerous mercury minimization efforts including the phasing out of 9.8 metric tons, per year, of mercury in convenience light switches previously used by the Big Three auto companies. Mehan was formally Associate Deputy Administrator of the U.S. Environmental Protection Agency (1992), where he coordinated policy issues for the agency and represented the Deputy Administrator in interactions with federal, state, and local agencies.

From 1989 to 1992, he was Director of the Missouri Department of Natural Resources, which included divisions of environmental quality; parks, re-creation and historic preservation; energy; geology; and land survey. He represented the state in the Missouri Basin States Association, the Upper Mississippi River Basin Association, and the Midwest Interstate Low-Level Radioactive Waste Compact Commission.

Mehan holds a Bachelor's Degree in history from St. Louis University, Missouri, and a Juris Doctor from the St. Louis University Law School. He is member of the Missouri Bar Association and the Bar Association of Metropolitan St. Louis. As a practicing attorney for many years, he concentrated in the area of civil litigation.

Mehan was an Adjunct Professor at the Thomas M. Cooley Law School and Michigan State University Detroit College of Law in environmental law. He and his wife, Mary, have seven children.

Fran Pell

Fran graduated with a B.S. from Purdue University in 1982. She started her career with the Federal government in USDA as a food inspector about a year after graduation. Fran transferred to FDA in 1985 as an investigator in Baltimore District Office. She conducted mostly food inspections and tissue residue investigations. She transferred to the Center for Veterinary Medicine in 1988. She issued an information gathering assignment in 1989 to the Field to conduct an inspectional survey of aquaculture producers to determine what their drug use patterns were. This Field assignment spawned an educational campaign from the Center on the regulations of drug use for aquaculture. She transferred to the Tissue Residue Branch in 1994 and maintained her expertise in aquaculture. In 1997, Fran was transferred to the Division of

Compliance she became the Compliance expert in Aquaculture drug use. She handles all regulatory questions related to Aquaculture drug use. She is also the lead for the development of regulations on Import Tolerances.

James F. Pendergast

Jim Pendergast is chief of the Health Protection and Modeling Branch in the Office of Water where he manages EPA's fish and beach advisory programs, and provides technical support for water quality modeling and sediment contamination assessments. He has 26 years of professional experience in environmental engineering, water quality modeling, and regulatory controls. Since moving to EPA Headquarters in 1990, he worked on the revision to the TMDL rule, reauthorization of the Clean Water Act, and as a Section and Branch Chief and later Acting Director of the NPDES Permits Division. He was a principal in leading the Water Protection Task Force where he helped manage EPA's work to support efforts by drinking water and wastewater treatment utilities to understand vulnerable points and to mitigate the threat from terrorist attacks as quickly as possible. He worked for six years in EPA Region 6 in the NPDES permits and Superfund programs. Prior to joining EPA in 1984, he was a project manager at Limno-Tech, Inc., where he developed models of water quality impacts from nonpoint and point sources on rivers, lakes, and estuaries.

Mr. Pendergast received a BS in Environmental Engineering in 1976 and a MS in Water Resources Engineering in 1978, both from the University of Michigan. He is a registered professional engineer. He is a member of the Water Environment Federation, the American Society of Civil Engineers, and the Society of Environmental Toxicology and Chemistry. He has several published papers on water quality modeling in engineering journals and conference proceedings. He is married with one daughter, and spends his non-work time coaching a girls fast pitch softball team and playing golf.

John Persell

John began working for the Minnesota Chippewa Tribe in 1978 as a Water Quality Planner, shortly after graduating from Bemidji State University (Bemidji, MN) with a B.S. in Biology and Chemistry. The Tribe's Water Quality Program grew to become the Tribal Water Research Lab in 1979, achieving Federal drinking water certification in 1987. John has remained Director of the Tribal Government's Lab, which today employs four staff performing drinking water, surface water, and tissue analyses for a wide variety of parameters. John has directed the Tribe's research focus to contaminants in subsistence resources during the last ten years. At the center of this research focus is the St Regis/Wheeler Superfund Site which is located on the Leech Lake Reservation. The toxic cocktail at this former wood preservation company site includes Dioxins and Furans, PCBs, DDT, PAHs, Phenols, Arsenic, Chromium, and Mercury.

John is a six year veteran of the United States Air Force and Army; a father and grandpa, and particularly enjoys family and outdoor activities.

Susan M. Peterson

Susan Peterson is an environmental chemist working for the Aroostook Band of Micmacs for a year and a half. A graduate from the University of Maine at Presque Isle, Susan had a double major receiving a BA in Biology and a BS in Environmental Studies. Since working for the Tribe, she has been exposed to the many environmental issues concerning the Micmacs, such as the substandard Tribal housing units in which members are living in and the various toxics found in natural resources that are utilized by the Tribe for food, medicine, and spiritual purposes. One of her major accomplishments was to finish developing a drinking water laboratory and obtain full certification from the state of Maine for the lab. She is currently working on adding more testing parameters to the lab's certification, developing an arsenic-in-drinking water study with all of the Tribes of Maine, and is taking steps to have the lab NLLAP certified for lead testing.

Rafael Ponce

Rafael's interest in environmental health began during his Master's research investigating methylmercury uptake into rainbow trout. He received his Masters from the School of Fisheries at the University of Washington in 1990, and transferred to the Dept. of Environmental Health where he moved up the food chain to investigate the mechanisms of methylmercury-induced developmental neurotoxicity in rats. Rafael received his doctorate in Environmental Health, Toxicology from the University of Washington in 1995. He moved to Anchorage to work as the toxicologist for the Department of Health and Social Services, conducing health risk assessments and evaluation of subsistence food safety. In 1996, he returned to the University of Washington to perform basic research of heavy metal toxicity and risk assessment. He currently has an affiliate appointment with the University of Washington and works as a toxicologist for a biotechnology company (ZymoGenetics, Inc.) in Seattle, WA.

GUS N. RASSAM

Executive Director and CEO, Treasurer, and Senior Editor (May 1999-present) American Fisheries Society. Staff of 22; annual budget of $3 million.

Director of Program Development and Publications (July 1998-1999) Optical Society of America, Washington, DC. Staff of 45; annual budget of $9 million. Previously he served as Executive Director and CEO (acting) (July 1997-July 1998) Optical Society of America. Member of three-person team acting as Executive Director. Report to Executive Committee and Board of Directors. Before that, as Director of Publications (1995-1997) Optical Society of America, Washington, D.C.

Member, Governing Board of the Renewable Natural Resources Foundation , RNRF (1999-present); chair of Finance Committee, RNRF; chair of Awards Jury Committee, RNRF.

Fulbright Scholar

Philip Spiller

Philip Spiller has been with the Food and Drug Administration since 1981. He spent the first nine years in the Office of Legislative Affairs in the Office of the Commissioner, where he

became the Deputy to the Director of that office. He worked on a wide variety of legislative initiatives and helped prepare FDA officials to testify at numerous hearings in both the House of Representatives and the Senate. At one of them, involving the pesticide Alar in apples, he engaged in a 5 second conversation with the actress Meryl Streep, which he regards to this day as the high point of his career. During 1989 through 1991 seafood safety became a major issue in the Congress and Mr. Spiller became familiar with that subject as a consequence. In 1990 Mr. Spiller became a special assistant to the Commissioner on seafood-related matters. When an Office of Seafood was subsequently created in FDA's Center for Food Safety and Applied Nutrition, Mr. Spiller transferred to that Office as Deputy to the first permanent director, Mr. Thomas Billy. His major responsibility during that time was drafting FDA's seafood HACCP regulations. Mr. Spiller became the director of the Office of Seafood in 1994.

Before coming to FDA, Mr. Spiller worked for the Health Resources Administration, which is now part of the agency known as HRSA. Mr. Spiller has a law degree from Boston College and an undergraduate degree from the University of Virginia.

Alan H. Stern

Alan Stern, PhD DABT, received his doctorate in public health from the Columbia University School of Public Health in 1987. He is Chief of the Bureau for Risk Analysis in the Division of Science and Research of the New Jersey Department of Environmental Protection where he specializes in human health risk and exposure assessment. He is board certified in toxicology, and adjunct associate professor in the School of Public Health, and the Department of Environmental and Community Medicine of the University of Medicine and Dentistry of New Jersey. He served as a member of the National Research Council/National Academy of Sciences Committee on the Toxicological Effects of Methylmercury. His current scientific and research interests include assessment of exposure and risk from methylmercury and other heavy metals, biomonitoring, exposure assessment, interindividual variability in dose-response, and probabilistic approaches to risk assessment.

Andrew E. Smith

Andrew Smith, S.M., Sc.D., is the State Toxicologist and Director of the Environmental Toxicology Program within the Bureau of Health, Maine Department of Human Services. Dr. Smith obtained his master's in environmental health management and doctorate in environmental health sciences from the Harvard School of Public Health. He performed post-doctoral studies at Harvard with joint appointments in the Departments of Environmental Health and Biostatistics. As the State Toxicologist and Director of the Toxicology Program, he is responsible for the development health-based drinking water and ambient air guidelines for toxicants, the issuance of fish consumption advisories due to chemical contamination, the design and conduct environmental exposure and epidemiological studies, and management of the Maine Occupational Disease Registry. Dr. Smith has served on U.S. EPA scientific advisory panels to review the Agency's recently revised reference dose for mercury, guidance for evaluating residential exposure to pesticides, and a preliminary evaluation of the non-dietary hazard and exposure to children from contact with CCA pressure-treated wood.

Judy Sheeshka

Judy Sheeshka is a registered dietitian and an Associate Professor in Applied Human Nutrition at the University of Guelph, in Ontario. For the past 8 years she has been interested in comparing the nutritional benefits and the potential risks of eating sport-caught fish from contaminated waters. She was part of a multi-disciplinary team that received Health Canada funding to investigate fish consumption from 5 Great Lakes Areas of Concern. Over 5,000 people fishing along the Canadian shorelines in these Areas of Concern were surveyed and 91 completed dietary records, tape-recorded long interviews, anthropometric measurements, and provided blood and hair samples for laboratory analyses.

Suanne Unger

Suanne Unger received a BS in Education with a major in biology from the University of Wisconsin- Madison in 1998. In 1993, she received an MS in Environmental Studies from the University of Montana- Missoula. After finishing her masters program, Suanne served as a US Peace Corps Volunteer in Botswana from 1993-1995 in the Wildlife/ Environment Program. Suanne has taught high school and middle school science. In Alaska, she has worked for several tribal non-profit organizations developing community-based environmental assessment tools for tribes in Alaska. Currently, she works for the Aleutian/Pribilof Islands Association, Inc., a non-profit tribal organization of the Aleut people in Alaska. This organization services communities on the Aleutian Islands and Pribilof Islands in western Alaska. Suanne is the Environmental Health Research Coordinator on a project entitled *Dietary Benefits and Risks in Alaskan Villages*. This project is funded by the National Institute for Environmental Health Sciences.

Khizar Wasti

Ph.D. Chemistry, 1976, University of Pennsylvania, Philadelphia

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Smith	Andrew E.	Maine Bureau of	Key Plaza, 8th Floor	11 State House	Augusta	ME	04333	207-287-5189	andy.e.smith@state.me.us

		Health		Station					
Smithson	Janice	West Virginia Dept. of Environmental Protection	1201 Greenbrier Street		Charleston	WV	25311	304-558-2837	jsmithson@dep.state.wv.us
Spiller	Philip	US FDA	5100 Point Branch Parkway	Mail Stop HFS-400	College Park	MD	20740	301-436-1428	pspiller@cfsan.fda.gov
Stahl	Leanne	US EPA	1199 Pennsylvania Avenue, NW	Mail Code 4305T	Washington	DC	20460	202-566-0404	stahl.leanne@epa.gov
Stanfill	John W.	Nez Perce Tribe/ERWM	P.O. Box 365		Lapwai	ID	83540	208-843-7375, x-2369	johns@nezperce.org
Starszak	Robert J.	Louisiana Dept. of Health & Hospitals	325 Loyola Avenue, Suite 210		New Orleans	LA	70112-1824	504-568-8537	rstarsza@dhh.state.la.us
Stern	Alan	New Jersey Dept. of Environmental Protection	P.O. Box 409	401 E. State Street	Trenton	NJ	08625	609-633-2374	astern@dep.state.nj.us
Stewart	Kenneth Lee	West Virginia University/NRCCE	P.O. Box 6064		Morgantown	WV	26506	304-293-2867, x-5472	ken.stewart@mail.wvu.edu
Stone	David	Oregon Dept. of Human Services	State Office Bldg., Suite 608	800 NE Oregon Street	Portland	OR	97232	503-731-4012, x-244	dave.stone@state.or.us
Strom	Stan C.	Montana Dept.of Public Health/Human Services	P.O. Box 202951	1400 Broadway, Suite C-214	Helena	MT	59620-2951	406-444-5306	sstrom@state.mt.us
Tarbell	Barbara	St. Regis Mohawk Tribe	412 State Route 37		Akwesasne	NY	13655	518-358-5937 ext 23	earth3-nrda@northnet.org
Truchon	Stephen	BBL Sciences	100 Cummins Center, Suite 322G		Beverly	MA	01915	508-878-7497	spt@bbl-inc.com
Tunink	Dave	Nebraska Game and Parks Commission	2200 North 33rd Street		Lincoln	NE	68503	402-471-5553	dtunink@ngpc.state.ne.us
Unger	Suanne	Aleutian/Pribilof Islands Association, Inc.	201 E. 3rd Avenue		Anchorage	AK	99501	907-276-2700	sueu@apiai.com
Uram	Eric R.	Sierra Club	214 North Henry street, Suite 203		Madison	WI	53703-2200	608-257-4994	eric.uram@sierraclub.org
Varanasi	Usha	NMFS/NOAA/USDC	2725 Montlake Blvd. E		Seattle	WA	98112-2097	206-860-6795	usha.varanasi@noaa.gov
Wasti	Khizar	Virginia Dept. of Health	P.O. Box 2448	Room 124	Richmond	VA	23218	804-786-1763	kwasti@vdh.state.va.us
Wei	Lei	Texas Department of Health	1100 W 49th St		Austin	TX	78756-3160	512-458-7587 ext 2484	lei.wei@tdh.state.tx.us
Weist	Jeri	US EPA/NE	1 Congress St., Suite 1100		Boston	MA	02114	617-918-1568	weiss.jeri@epa.gov
Wente	Steve	US Geological Survey	2280 Woodale Drive		Mounds View	MN	55112	763-783-3272	spwente@usgs.gov
Wiles	Kirk	Texas Department of Health	1100 W. 49th St.		Austin	TX	78756	512-719-0215	kirk.wiles@tdh.state.tx.us
Wilkinson	Mike	Indiana State Department of Health	2 N.Meridian Street, Section 3-D		Indianapolis	IN	46204	317-233-7055	mwilkins@isdh.state.in.us
Williams	Luanne K.	North Carolina Division of Public Health	1912 Mail Service Center		Raleigh	NC	27699-1912	919-715-6429	luanne.williams@ncmail.net

Winters	Dwain	US EPA	1200 Pennsylvania Avenue, NW	Washington	DC	20460	202-566-1977	winters.dwain@epa.gov
Wolff	Steve	Wyoming Game & Fish Department	5400 Bishop Blvd.	Cheyenne	WY	82006	307-777-4559	steve.wolff@wgf.state.wy.us
Wooton	Maureen	Battelle	505 King Avenue	Columbus	OH	43201	614-424-4890	wootonm@battelle.org
Wright	Jay	Oklahoma Dept. of Environmental Quality	P.O. Box 1677	Oklahoma City	OK	73101-1677	405-702-1039	jay.wright@deq.state.ok.us
Yeaton	Violet	Port Graham Village Council	P.O. Box 5510	Port Graham	AK	99603	907-284-2227	vyeaton@yahoo.com

Appendix 5: Slides Presented by Speakers during the Forum

Part One: Slides Presented During Workshops

C. Contaminants in Stocked Fisheries: Potential for contamination, human exposure, and human health risks. Bob Brodberg, State of California, moderator.

1. *PCBs and Hatchery Trout in Pennsylvania—The Good, the Bad and the Ugly!* John Arway, State of Pennsylvania
2. *Regulating Contaminants in Feed for Fish*. Frances Pell, US FDA, Center for Veterinary Medicine

D. The Use of Composite Samples in the Development of Fish Advisories. Razelle Hoffman-Contois, State of Vermont, moderator.

1. *Use of Composited Fish Samples for Assessing Health Risks to High Intake Consumers.*. John Persell, Minnesota Chippewa Tribe, Research Lab
2. *Composite Sampling Analysis of Fish*. Henry D. Kahn, US EPA

E. Addressing Multiple Pollutants in Fish, Eric Frohmberg, State of Maine, Moderator

1. *Addressing Multiple Contaminants in Fish.*. Roseanne Lorenzana, US EPA Region 10
2. *Framework for Cumulative Risk Assessment*. Edward Bender, US EPA

Part Two: Slides Presented During Plenary Sessions

I. Update on Activities Related to the 2001 Forum

A. *New Version of the Risk Communication Guidance.* Barbara Knuth, Cornell University
B. *Update: Relationship of TMDLs to Fish Advisories*. Jim Pendergast, US EPA

II. Reports from the Weekend Sessions

A. *Methylmercury Contamination in Fish: Human Exposures and Case Reports*. Henry A. Anderson, State of Wisconsin
B. *Mercury Advisories*. Amy D. Kyle, University of California Berkeley

III. Advisories for Commercial Fish: Federal, State, and Tribal Approaches. Elaine Krueger, State of Massachusetts, Moderator

A. *Report on the Advisory Panel to the Food and Drug Administration on Mercury Advisories.* H. Vasken Aposhian, University of Arizona.
B. *FDA Consumer Advisory for Methylmercury*. Philip Spiller, US FDA
C. *Sport and Commercial Seafood Wisconsin Integrated Public Health Message: Maximize Health Benefit, Minimize Risk, Coordinate Health Message*. Henry A. Anderson, State of Wisconsin
D. *Context for Connecticut's Seafood Advisory.* Gary Ginsburg, State of Connecticut
E. *Consumer Advisory for Commercial Fish*. Andy Smith, State of Maine.

IV. Hot Topics—Chemicals of Concern. Luanne Williams, State of South Carolina, Moderator

A. Mercury

- *Methylmercury: Ongoing Research on Toxicology*. Kathryn R. Mahaffey, US EPA
- *Setting a Methylmercury Reference Dose (RfD) for Adults*. Alan H. Stern, State of New Jersey

B. Brominated Flame Retardants (Polybrominated Diphenyl Ethers or BDEs)

- *Occurrence of PBDE Flame Retardants in Fish*. Robert C. Hale, Virginia Institute of Marine Science
- *PBDEs: Toxicology and Human Exposure.* Linda S. Birnbaum, US EPA
- *Polybrominated Diphenyl Ethers (BDEs)*. Khizar Wasti, State of Virginia

C. Dioxins and Coplanar PCBs

- *Emerging Science of the Dioxin Reassessment*. Dwain Winters, US EPA

D. Lead

- *Application of the Lead IEUBK Model to Assess Spokane River Fish Consumption Health Risks.* Lon Kissinger, US EPA Region 10.
- *Occurrence of Lead in Fish*. Robert Brodberg, State of California

E. Polycyclic Aromatic Hydrocarbons

- *Polycyclic Aromatic Hydrocarbons (PAHs) in Fish and Invertebrates*. Usha Varanasi, Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration

V. Approaches to State and Tribal Advisories. Jeff Bigler, US EPA, Moderator

A. *Setting Statewide Advisories Based on Upper Percentile Lake Averages.* Eric Frohmberg, State of Maine
B. *Use of Maine's Statewide Advisory in a Tribal Setting*. Susan M. Peterson, Aroostook Band of Micmacs Environmental Laboratory
C. *North Dakota's Fish Consumption Advisory: A Statewide Advisory Based on Average Concentrations.* Mike Ell, State of North Dakota
D. *Advisories in Pennsylvania*. Bob Frey, State of Pennsylvania
E. *Minnesota Statewide Fish Consumption Advice*. Pat McCann, State of Minnesota
F. *Regional Fish Advisory for the Mississippi Delta*. Henry Folmar, State of Mississippi
G. *Consumption Advisories Based on 8 Meals per Month.* Joseph Beaman, State of Maryland

VI. Approaches to Considering Benefits in Advisory Programs. Dan Kusnierz, Penobscot Nation, Moderator

A. *Impacts of Fish Contamination in the Columbia River Basin*. Paul Lumley, Yakima Tribe
B. *Dietary Benefits and Risks in Alaskan Villages*. Sue Unger, Aleutian-Pribilof Islands Association

VII. Current Science on the Benefits of Fish Consumption. Andy Smith, State of Maine, Moderator.

A. *Overview of Benefits of Fish Consumption*. Judy Sheeshka, University of Guelph
B. *Use of Quality-adjusted Life Years to Assess Risks and Benefits of Fish Consumption*. Rafael Ponce, University of Washington

Please note that some speakers did not present slides.

Part One: Slides Presented During Workshops

A. Contaminants in Stocked Fisheries: Potential for contamination, human exposure, and human health risks. Bob Brodberg, State of California, moderator.

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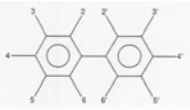
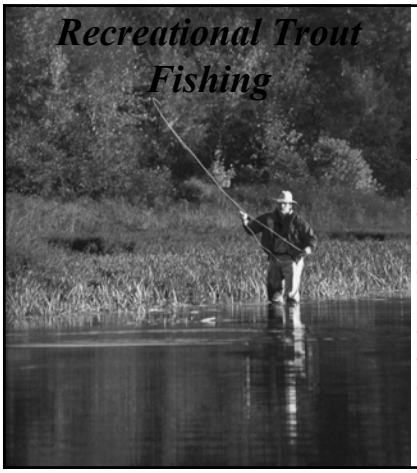
2. *Framework for Cumulative Risk Assessment*. Edward Bender, US EPA

PCBs and Hatchery Trout in Pennsylvania



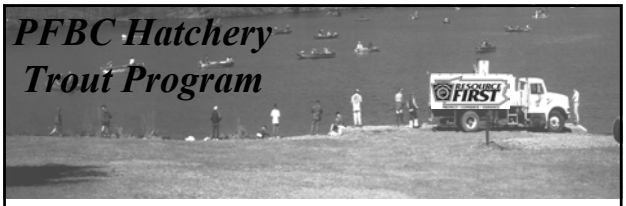
The Good, The Bad and the Ugly!!!

Recreational Trout Fishing



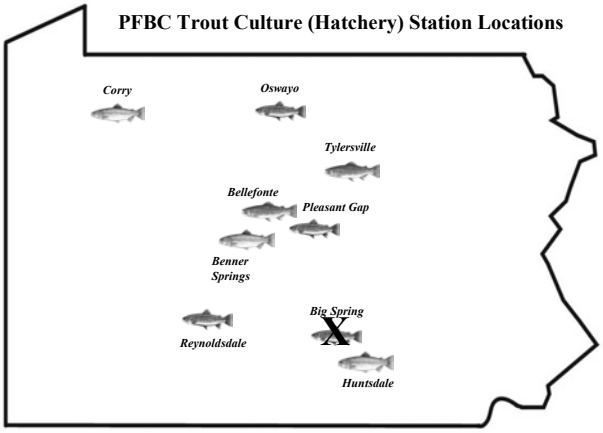
According to a 1996 U.S. Fish and Wildlife Service Report, Trout Fishing in the U.S., anglers spend more days (8,861,000 days valued at over $568M)) fishing for trout in PA , more any other state except California.

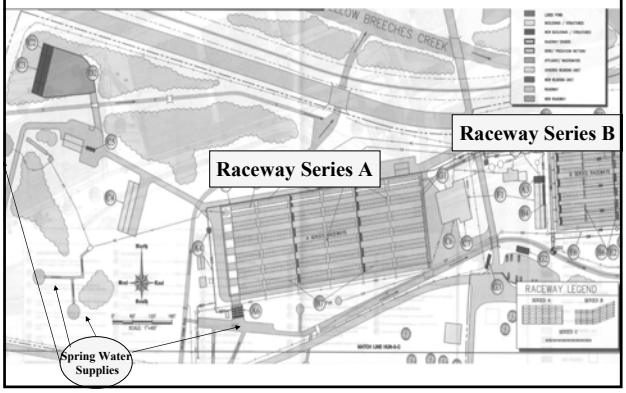
PFBC Hatchery Trout Program

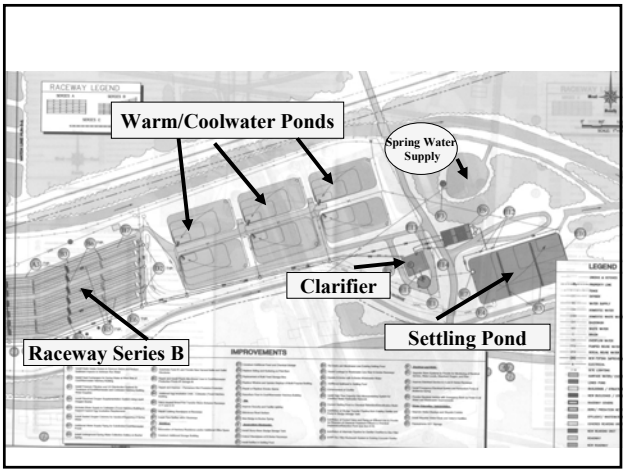


Eight trout hatcheries statewide that produce between 3.8 to 5.2 million catchable trout annually to stock more than 4500 miles of streams.

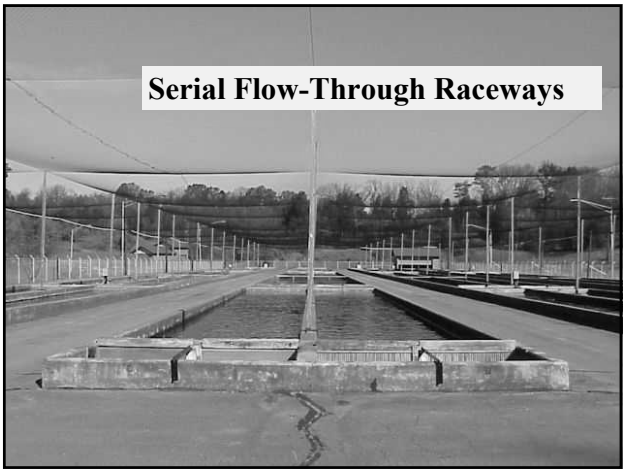
PFBC Trout Culture (Hatchery) Station Locations

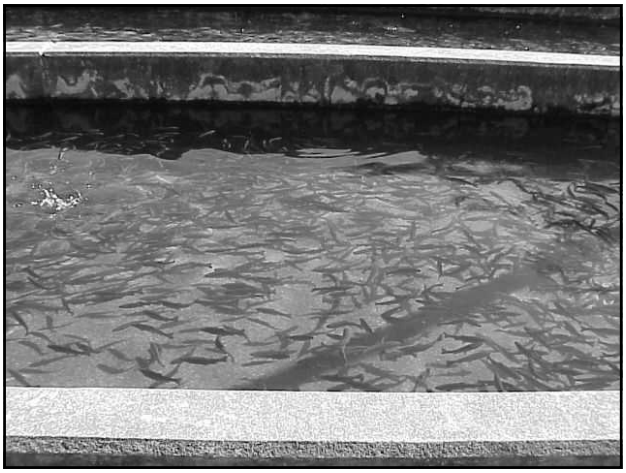


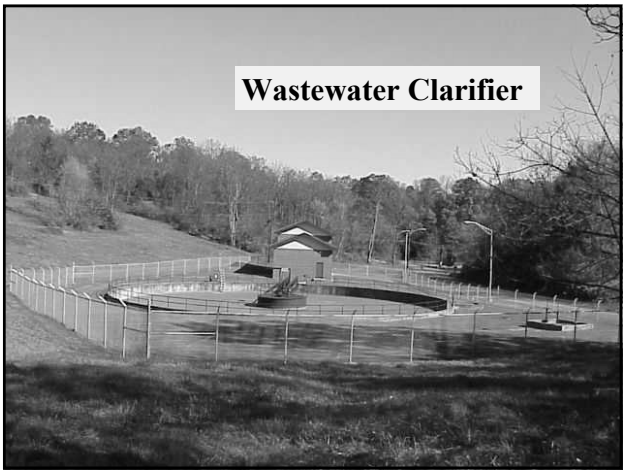


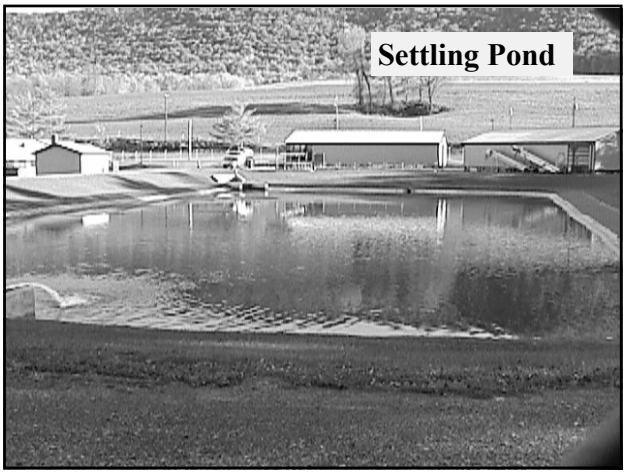

Warm/Coolwater Ponds
Spring Water Supply
Clarifier
Settling Pond
Raceway Series B

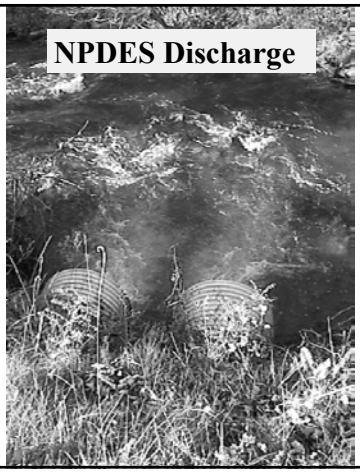
Spring Water Source


Serial Flow-Through Raceways

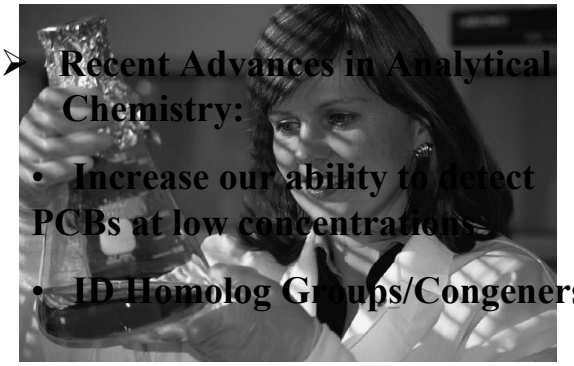



Wastewater Clarifier


Settling Pond



THE GOOD



- Recent Advances in Analytical Chemistry:
  - Increase our ability to detect PCBs at low concentrations
  - ID Homolog Groups/Congeners

THE GOOD

- *PA Tissue/Feed Extraction Protocols for PCBs*
  - Fish Feeds
    - Freeze dry then Accelerated Solvent Extraction (ASE)
    - US EPA Method 3545

THE GOOD

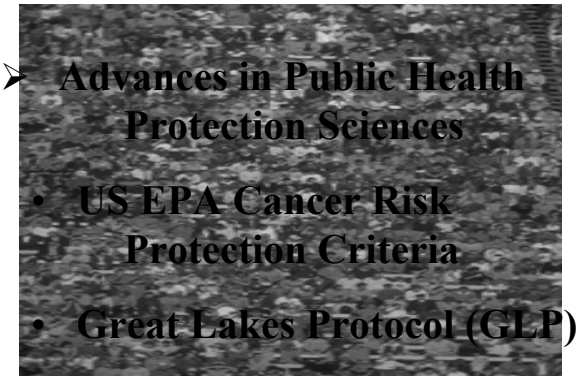
- Fish Tissue
  - Freeze dry then Super Critical Fluid Extraction (SFE) with CO_2
  - Modified US EPA Method 3561

THE GOOD

The PA PCB Analytical Protocol for Fish Tissue and Feeds

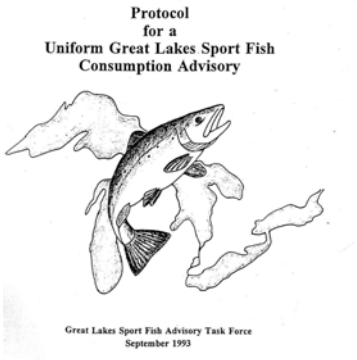
- Gas Chromatography/Electron Capture Detector (GC/ECD) Analysis (US EPA Method 8082)
  - Quantify Aroclors 1221, 1232, 1242, 1248, 1254 and 1260

THE GOOD



- Advances in Public Health Protection Sciences
  - US EPA Cancer Risk Protection Criteria
  - Great Lakes Protocol (GLP)

THE GOOD


Protocol
for a
Uniform Great Lakes Sport Fish
Consumption Advisory

Great Lakes Sport Fish Advisory Task Force
September 1993

The Good

- **Uses a weight-of-evidence approach.**
- **PA began applying this protocol to hatchery-reared trout in 1998.**

THE GOOD

- **Focused on PCBs which is the chemical contaminant most frequently encountered in Great lakes fish.**

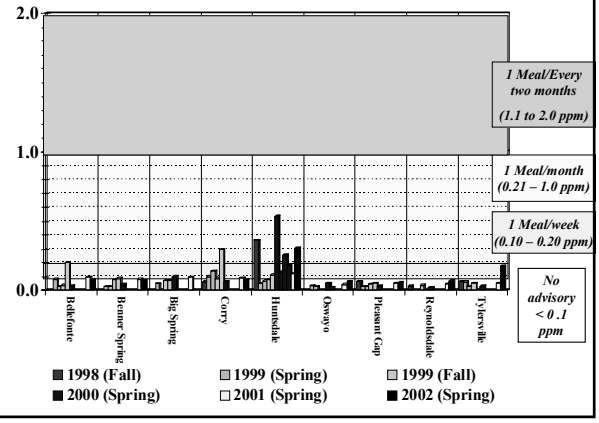
THE GOOD

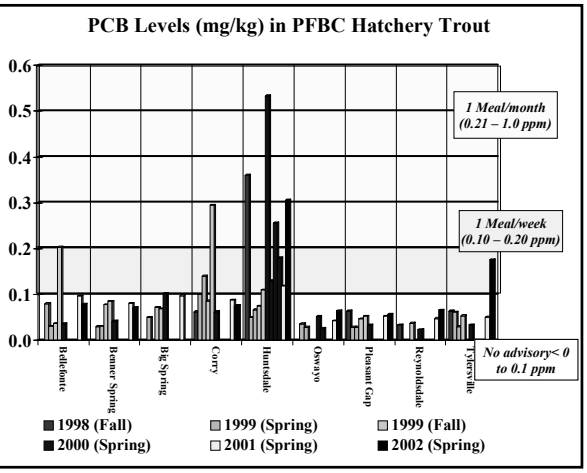
- **Non-cancer (neurological) endpoint to protect pregnant women and children and women of child-bearing ages.**

Great Lakes Protocol Advisory Groupings (1993)

- **Group 1 (No Advisory): 0 - 0.06 ppm**
- **Group 2 (1 meal/week - 52 meals/year): 0.06 - 0.2 ppm**
- **Group 3 (1 meal/month - 12 meals/year): 0.21 - 1.0 ppm**
- **Group 4 (6 meals/year): 1.1 - 1.9 ppm**
- **Group 5 (No consumption): >1.9 ppm**

PCB Levels (mg/kg) in PFBC Hatchery Trout

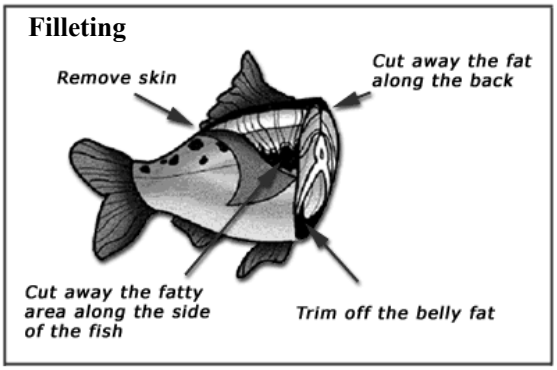




Hatchery Trout Sampling

- (1) 5 Fish Composite
- (5) 8 Fish Composites
  - ✓ UCL (95%) of a one tail test

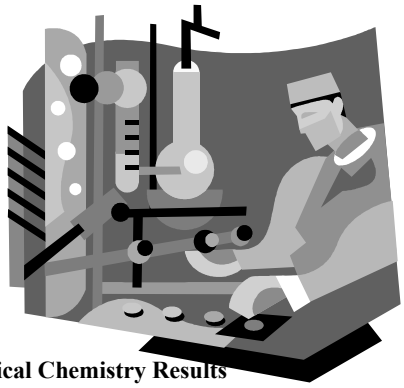
Variables



Variables

Partitioning in Body Tissues

Variables



Analytical Chemistry Results

Fish Feed Component Testing

- Fish Feed Components
  - Fish Oils
    - ✓ Crude
    - ✓ Deodorized
    - ✓ Winterized
  - Fish Meals
    - ✓Feather
    - ✓Soy
    - ✓Cereal
    - ✓Blood
    - ✓Bulk Flour
    - ✓Ground Wheat
    - ✓Soybean
    - ✓Poultry

Fish Feed Testing

- Fish Feed
  - Perdue Specialty Feeds
  - Zeigler Brothers

Fish Feed Component Results

- Fish Oils
  - ✓<0.05 to 0.938
  - ✓mean= 0.265
  - ✓n=6, 10 tests
- Fish Meals
  - ✓<0.05 to 0.102
  - ✓mean= 0.03
  - ✓n=6, 12 tests
- Other Ingredients
  - ✓<0.05

Results in mg/kg

Fish Feed Results

- Fish Feed
  - <0.05 to 0.2
  - mean= 0.061
  - n=24
  - 44 tests

Results in mg/kg

PSU Academic Study Objectives

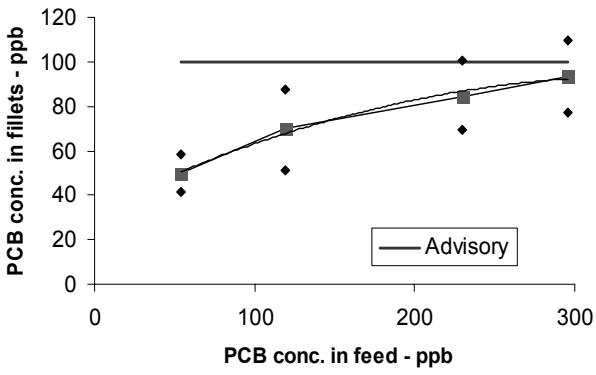
- ID Possible Sources of PCBs in PFBC Hatchery Trout
- Determine Bioaccumulation and Assimilation Rates

PSU Academic Study Objectives

- Determine the Relationship between PCB Concentrations in the Feed and in the Hatchery Trout
- Determine Seasonal Variations

Feed Formulations (*PCBs added)

Diet	Fish Meal	Menhaden Oil	PCB (ppb)
1	Herring	Distilled	69
2	Menhaden	Filtered	126
3*	Menhaden	Filtered	220
4*	Menhaden	Filtered	280



PSU Study Results

When feed concentrations are less than 0.126 ppm PCBs, concentrations in trout fillets after 6 months of feeding did not exceed 0.10 ppm (1 meal/week).

THE UGLY

RISK

COMMUNICATION!!!!!

Have I not walked without
an upward look
Of caution under stars that
very well
Might not have missed me when
they shot and fell?
It was a risk I had to take—
and took.

Robert Frost
***Bravado*, 1962**

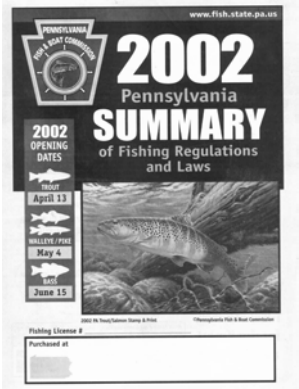
What is Risk?

- **Basically, it is a measure of the severity and probability of harm.**
- **Frost's poem suggests that it is an unavoidable part of our daily lives.**

Public Notice of Fish Advisories

General Statewide News Releases

Public Notice of Fish Advisories



Public Notice of Fish Advisories

On 11 April 2001 PA issued a general statewide advisory that states no person should eat more than one-meal-a-week of sportfish caught in any Commonwealth water.

Public Notice of Hatchery Trout Advisories

- **Subject to the statewide one-meal-a-week advisory plus…**
- **Additional advice on <u>www.fish.state.pa.us</u>**

Public Notice of Hatchery Trout Advisories

Pa. must alert public to dangers from fish, fowl, official says

By BILL McKINNEY
Morning News staff reporter

Erie County's chief aquatic biologist warned a state environmental advisory group that Pennsylvania is not protecting the public from chemicals in lake fish and waterfowl.

Robert Wellington, of the Erie County Health Department, acknowledged there is a price to pay for adequate testing and for publicly attaching health risks to the consumption of fish, but he said the alternative is unthinkable.

"...Not using them (human health risk standards), when we have as much information as we do about potential problems of eating unlimited amounts of certain fish is an un-

one who eats more than five pounds of fish a year.

Second, the FDA went on record years ago that its tolerance level for PCBs was probably not adequate.

Third, an advisory being proposed for use by all eight Great Lake states uses criteria for PCB risks that are 100 times more strict than Pennsylvania is now using.

Wellington said Arthur Davis, former secretary of the then Department of Environmental Resources, agreed in early 1993 that Pennsylvania would implement the proposed cautions along with the other Great Lakes states.

Since then, Wellington said, the states have not all agreed on specific

promised his help.

In other testimony before the council, elected officials from Jefferson County and Jefferson County municipalities complained that DEP has been ignoring the very Solid Waste Plan it ordered their county to prepare.

Worse, they said, DEP officials were publicly siding with applicants for new landfills, to the point the state officials defended the applicants at meetings and made it unnecessary for them to personally testify.

Jefferson County Commissioner Donald R. Hillard said his county's

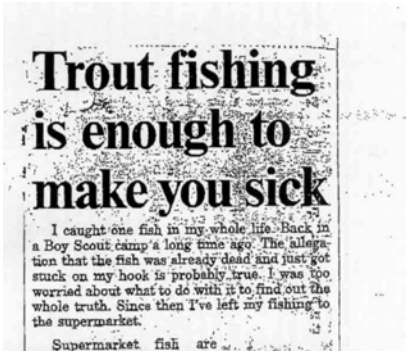
Hillard said it is myth to think permits will not be issued as long as they are consistent with county plans, that permits will not be issued if they interfere with county plans and that the DEP will act in a fair and independent manner when evaluating permit applications. He said the opposite is true.

"The county is left out of the decision making process. The county has no say as to the consistency of proposed facilities with other long-term plans, goals and objectives," he said.

David Steele, vice-chairman of the Jefferson County Solid Waste Authority, said it appears that the

ERIE, PA., MORNING NEWS, Wednesday, Septem

Public Notice of Hatchery Trout Advisories

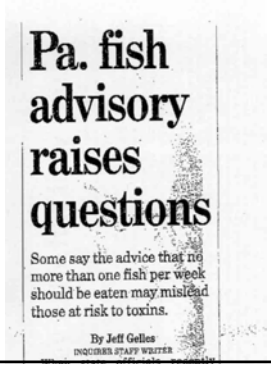


Trout fishing is enough to make you sick

I caught one fish in my whole life. Back in a Boy Scout camp a long time ago. The allegation that the fish was already dead and just got stuck on my hook is probably true. I was too worried about what to do with it to find out the whole truth. Since then I've left my fishing to the supermarket.

Supermarket fish are

Public Notice of Hatchery Trout Advisories



Pa. fish advisory raises questions

Some say the advice that no more than one fish per week should be eaten may mislead those at risk to toxins.

By Jeff Gelles
INQUIRER STAFF WRITER

Public Notice of Hatchery Trout Advisories

NEWS

Fish flap warrants investigation, say Democrats

By GEORGE STRAWLEY
The Associated Press

HARRISBURG — House Democratic leaders demanded that Gov. Tom Ridge's administration investigate problems surrounding the issuance of a health advisory warning Pennsylvania anglers about chemical contamination in the state's sport fish.

Environmental Protection advised people not to eat more than one meal of fish from Pennsylvania waters in a week as a precaution against mercury contamination.

When the mercury warning was issued, DEP officials from the Republican administration acknowledged "problems and difficulties" with the PCB tests performed by a private

up a better system to protect the lives of Pennsylvania and the resources in this state."

Vero, who suggested that withholding information on test results could be "downright criminal," called for an internal investigation by acting DEP Secretary Dave Hess as well as an outside review by the office of Democratic Auditor General Robert P. Casey Jr. A

get the public the health information they need."

A spokesman for the Fish and Boat Commission stood by his earlier characterization of the dispute as a case of two organizations reading different conclusions with the same results.

"There seems to be fundamental confusion as to what the consumption advisory really means," said the

handling of fish kitchens in the past.

Earlier in the day, biologist Eugene P. Moser Jr. provided to The Associated Press a copy of a March 7 report in which a DEP biologist recommended an advisory for the species based on test results. Attempts to obtain a copy directly from DEP were not immediately successful Friday.

A DEP spokesperson said test data

Public Notice of Hatchery Trout Advisories

Legislators rebuke fish commission

Public advisories on safe consumption amounts are confusing, they say.

BY ELLEN LYON
OF THE PATRIOT-NEWS

While state Fish and Boat

in the United States since 1977 because they are suspected of causing cancer, they persist in the environment.

In April, three days before trout fishing season opened, DEP advised people, especially pregnant and nursing mothers, women of child-bearing age and

Public Notice of Hatchery Trout Advisories

PRINTER'S NO. 3536

THE GENERAL ASSEMBLY OF PENNSYLVANIA

HOUSE RESOLUTION

No. 500 Session of 2000

INTRODUCED BY B. SMITH, CAWLEY, FORCIER, BENNINGHOFF, STABACK AND SURRA, MAY 11, 2000

REFERRED TO COMMITTEE ON RULES, MAY 11, 2000

A RESOLUTION

1 Urging the Pennsylvania Fish and Boat Commission to have studies
2 conducted concerning chemicals in its hatchery trout.

COMMONWEALTH OF PENNSYLVANIA
PENNSYLVANIA FISH AND BOAT COMMISSION
NOVEMBER 1999

FISH CONSUMPTION ADVISORY

DO NOT EAT TROUT TAKEN FROM THESE WATERS

THE PENNSYLVANIA FISH AND BOAT COMMISSI
AS ISSUED AN INTERIM CONSUMPTION STATEM

The End

Regulating Contaminants in Feed for Fish

Fran Pell
Consumer Safety Officer
Division of Compliance
Center for Veterinary Medicine
Food and Drug Administration

The Food and Drug Administration (FDA) has the responsibility to enforce the Federal Food, Drug, and Cosmetic Act (the Act) by ensuring that foods for man and animal are safe and free of residues of illegal contaminants.

'Food' means

(1) articles used for food or drink for man or other animals

(2) chewing gum, and

(3) articles used for components of any such article

The FDA's, Center for Veterinary Medicine (CVM) is responsible:

- for protecting the animal feed supply
- assuring that it is safe and wholesome,
- that incidence of harmful residues in human food derived from animals is minimized.

The Center uses Compliance Programs to give guidance to the Field on how we want our programs implemented by the Field.

The Feed Contaminants Compliance Program is designed to address the Center's responsibility for feed contaminants.

Animal feeds adulterated with pesticides, industrial chemicals, mycotoxins, and other microbiological agents may present a hazard:

- to livestock health and production,
- the nation's food supply,
- and to the public health by the residues which may occur in animal derived foods

The more frequently identified contaminants in animal feeds are toxic, carcinogenic, mutagenic, teratogenic, or otherwise deleterious to animal and human health.

The Feed Contaminants Compliance Program provides guidance for:

- Investigation of the cause(s) of violative sample findings and Contamination Response System (CRS) reports.

The CRS is an early warning system developed by the United States Department of Agriculture (USDA), Food Safety and Inspection Service (FSIS) for the reporting of tissue contaminants.

The Feed Contaminants Compliance Program provides guidance for:

- Collection and analysis of animal feed samples for pesticides, industrial chemicals, heavy metals, mycotoxins and microbiological agents.
- Surveillance of the industry to identify potential problem areas to be addressed under this program.

The Feed Contaminant program is:

- A cooperative program ☮
  - Our Field (investigators, compliance officers and analysts)
  - State counterparts could also collect samples for FDA
  - Center will issue directed assignments

- District's program monitor ☑
  - Drafts regional pesticide plan
  - Includes sampling for contaminants in human foods
  - Encouraged to work with the states

SCOPE OF THE COMPLIANCE PROGRAM

- Pesticide and industrial chemical samples assigned under this program are to be incorporated into the each FDA Regional Pesticide Sampling Plans.
- Guidance on developing FDA/State cooperative sampling plans.

SCOPE OF THE COMPLIANCE PROGRAM CONT'D

- More definitive guidance on priority feeds and feed ingredients which the Center has identified as high-risk commodities.
- Regional evaluations and headquarters review to determine the need for making adjustments to sampling plans.

- The Center will issue directed assignments as necessary.
- These directed assignments with the District's surveillance are expected to provide contaminants-related data.

- This will supplement the data from such sources as United States Department of Agriculture (USDA), Environment Protection Agency (EPA) and industry.

Example of directed assignment:

- Since fiscal year 2000, CVM issued sampling assignments to test for Dioxin.
- There were 50 samples collected for each assignment.
- Sampling a tiered approach

- Criteria for sampling
  - Past history of dioxin contamination
  - Likelihood ingredient will be used in a ration
  - Amount typically used in a ration
  - Amount of fat

- First tier ->
  - Feed suspect containing highest dioxin
    - Fish meal, oilseed, deodorizer distillates, animal fat and meat and bone meal
    - Ingredients where air deposition (corn)
    - Uptake from soil (beet molasses)
    - Fire during harvest (cane molasses)

- Fish meals sampled as part of the assignment
  - Catfish and anchovy (used for pet food)
  - Pacific species (pollock)
  - Menhaden (90% of fishmeal in U.S.)

- Second tier
  - Feed ingredients 2nd likelihood of elevated dioxin level
    - Oilseed meals
    - Fat-soluable vitamins
    - Complete Feeds
    - Milk Products
    - Minerals
    - Wood Products

- Third tier
  - Feed ingredients 3rd likelihood of elevated dioxin level
    - Sampling similar to previous assignment

Web site:

www.fda.gov/cvm

The End

Questions????

Email: fpell@cvm.fda.gov

USE of COMPOSITED FISH SAMPLES for ESTIMATING HEALTH RISKS to HIGH INTAKE CONSUMERS

John Persell
Minnesota Chippewa Tribe
Research Lab

Consider Two Factors

- Composited Fish
- Bolus Dosing

Types of Fish Composites

- Batch: Homogenize fish together (greater variance about the mean)
- Individual: Homogenize individual fish separately, take equal portions of individual homogenates and homogenize for composite

Composite Variance

- …"even under ideal conditions, the variance of the mean estimated from a set of composite samples underestimates the variance among fish." (Fabrizio, 1995)

Variance Larger in Contaminated Areas

- Fish move in and out of contaminated areas
- Fish have different metabolic rates
- Time of year sampled

Data from Fabrizio Study

- 195 Striped Bass
- Total PCBs in Muscle
- Range = 0.1 to 40.7 ppm
- Average = 3.57 ppm
- Variance = 24.105

The Perfect Homogenate

- Even with composited water samples, there may be difficulty in detecting the presence and severity of extreme concentrations (Fabrizio, 1995)
- Greater difficulty yet with fish homogenates
- Tendency to dilute out hot fish
- Wide range in whole fish homogenates

Bolus Dose

- A potentially large, intermittent dose
- May not be problematic for low intake consumers, however it is a concern for the most susceptible in high intake consumers
- The bolus dose has not been evaluated in most toxicity studies (EPA, 2000)

Those Most Susceptible

- Children: including fetuses and breast fed children; for fetuses, the timing of fetal exposure is at least as important as the dose
- Elderly: diminished detoxification capacities
- Persons taking pharmaceuticals

High Intake Fish Consumers

- Individuals, such as Tribal members utilizing traditional lifeways, are more exposed in general to fish contaminants. Intake ranges up to one pound per day (454 grams/day) in the Pacific Northwest; higher intakes have been reported for Alaska Tribes
- These high intake consumers are more exposed to bolus doses from highly contaminated fish

Recommendation

- When using composited fish homogenates to determine safe fish consumption quantities for high intake consumers, employ an additional safety factor of 3 to 10
- Use specific chemical toxicity as a safety factor metric
- This will offer a reasonable accounting of the inherent contaminant underestimates

Literature Cited

- Fabrzio, M.C., Frank, A.M., and Savino, J.F. Procedures for Formation of Composite Samples from Segmented Populations. Environ. Sci. Technol. 1995. 29: 1377-44.
- USEPA. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Vol. 2, 3rd Ed., EPA 823-B-00-008

Composite Sampling Analysis of Fish

Henry D. Kahn
Statistics & Analytical Support Branch
Engineering & Analysis Division
Office of Science and Technology
Office of Water
US Environmental Protection Agency

Composite Sampling Analysis of Fish

- Introduction
- Basics of Composite Sampling
- Examples: Analysis of Blood and Fish Tissue
- Assessment of the Effectiveness of Composite Sampling Analysis: Flounder Data
- Number of Fish in the Composite: Maine lakes Study
- Conclusions

Introduction

- Composite sampling is used widely in environmental and other applications.
  - Soil, water, solid waste, hazardous material
  - Biomedical, e.g., blood, pharmaceuticals
  - Manufacturing quality control,e.g., liquids, bulk materials

Introduction

- Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Vol. 1, Fish Sampling and Analysis, 3rd Edition, EPA 823-B-00-007, Nov 2000.
  - "Composite samples of fish fillets or of the edible portions of shell fish are recommended for analysis of target analytes in screening studies."
  - "Composite samples are homogeneous mixtures of samples from two or more individual organisms of the same species collected at a particular site and analyzed as a single sample."

Introduction

- Composite Sampling Analysis of Fish
  - A cost effective method for estimating mean contaminant levels in fish tissue
  - Provides sufficient amount (usually) of fish tissue for analyses
  - Does not provide information on individual fish

Basics of Composite Sampling

- Composite sample: collect a number of sample units and combine them (mix, blend, homogenize) into a new sample, i.e. the 'composite'. One or more measurements are made on the composite.
- Composite sampling supports inference regarding key population parameters (e.g., the mean) in a cost effective manner.
- Composite sampling does not provide information on individual sample units.

Basics of Composite Sampling

- Fundamental Concept: A composite sample is a mixture of individual sample units. Mixing results in physical averaging of individual units.
- Composite sampling is useful when:
  - Cost of analyzing individual samples is high
  - Cost of obtaining individual samples is relatively low
  - Samples can be thoroughly mixed
  - Study budgets are limited

Basics of Composite Sampling

Composite sampling objectives:

- **Objective is to estimate mean concentrations or presence/absence**
- **Information on individual sample units is not a priority**

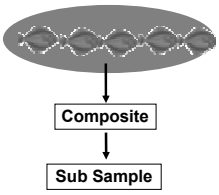
Example: Analysis of Blood Samples - Presence / Absence

- Composite Sample analysis in World War II
  - Large numbers of blood samples were analyzed for syphilis
  - Composite samples were formed from batches of individual samples
  - If composite tested positive, all individuals in the composite were retested separately
  - If a composite tested negative, all individuals in the composite were cleared

Example: Analysis of Blood Samples - Presence / Absence

- Methodology documented in a famous paper by Dorfman (1943) "The Detection of Defective Members of Large Populations"
  - batch size was optimized based on likelihood of syphilis and cost of analysis
  - inference regarding individuals using composites is possible but individual sample material is required

Example: Composite Analysis of Fish - Physical Averaging to Obtain Mean Estimate



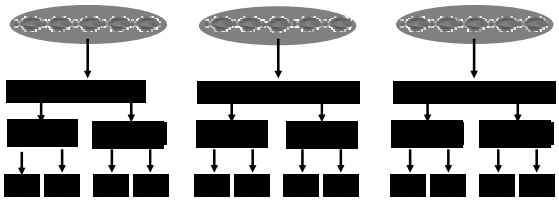
Measured concentration of Sub Sample = estimated mean of individual units

Assessment of the effectiveness of composite sampling

- It is typical in practice to make only one measurement on the sub sample
- The one measurement is adequate for estimating the mean of the individual units
- Additional sampling and analysis is required to obtain information on sub sampling and repeat measurement variability that will support the assessment of composite sampling

Assessment of the Effectiveness of Composite Sampling: Flounder Data

Conduct 15 Individual Analysis



Total number of samples for analysis = 27 (15 individuals + 12 dupes)

Statistical Analysis of Flounder Samples

	Individual Fish				
	Minimum Concentration	Maximum Concentration	Mean Concentration	95% CI for Mean Concentration[a]	Composite Concentration
PCB 118 (ng/kg)					
Composite a	254	349	305	[259 - 376]	298
Composite b	271	426	308	[251 - 410]	295
Composite c	331	437	385	[332 - 465]	369
Overall	254	437	333	[302 - 372]	321
Methyl Hg (ug/kg)					
Composite a	9.0	47	22	[12 - 110]	22
Composite b	8.4	37	23	[13 - 182]	23
Composite c	16	32	24	[17 - 46]	20
Overall	8.4	47	23	[17 - 35]	22

[a] Based on mean of log-normal distribution (CI method by Land [1972])
CI = Confidence Interval

Statistical Analysis of Flounder Samples

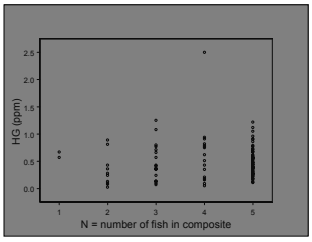
- Statistical comparisons do not show evidence of difference between composite and individual concentrations ($\alpha = 0.05$)
- The composite measurements provide good approximations to the *average* individual concentrations (i.e., the overall mean)
- Composite samples should be adequate for risk assessment
  - Costs are substantially less than for analysis of individual fish

Methyl Hg: Sub Sample / Duplicate Analysis

Number of Fish in the Composite

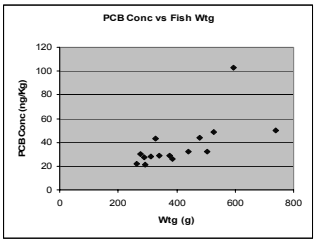
- Protocols for composite analysis specify a number of fish to be included in the composite
- In field studies it often is not possible to obtain the specified number of fish for each composite
  - This is usually not a significant problem
- Typically, the size of the fish in the composite is more important
  - Composites should be comprised of similar size fish since tissue concentration for many contaminants is correlated with size

Composite HG Concentration vs Number of Fish in the Composite



Data: *Fish Tissue Contamination in Maine Lakes*, State of Maine DEP (1997) from "Are the Fish Safe to Eat? Assessing Mercury Levels in Fish in Maine Lakes" by J. Hoeting & A. Olsen in Statistical Case Studies by Peck, Haugh, Goodman (1998)

PCB Concentration vs Fish Weight



Conclusions

- Composite sampling analysis of fish is effective
  - Theory, experimental results support this
  - Objectives for the analysis must be clear
- Protocols for sampling and analysis should be adhered to strictly
  - Number of fish in composite may vary without severely affecting results
  - Size of fish in composite is more likely to a critical factor

Conclusions

- Sub sampling and replicate analyses should be performed on, at least, a subset of samples
  - Important as a check on the effectiveness of composite analysis and chemical analysis
- Refer to Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Vol. 1, Fish Sampling and Analysis, 3rd Edition, EPA 823-B-00-007, Nov 2000.

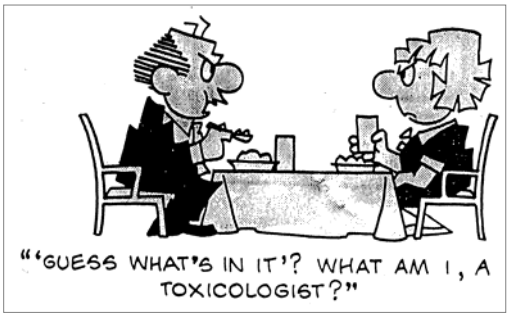
Addressing Multiple Contaminants in Fish

AFS/EPA National Forum on Contaminants in Fish

October 20, 2002

Dr. Roseanne Lorenzana

Multiple contaminants . . . .



U.S. EPA Guidance

- Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Vol. 2, Risk Assessment and Fish Consumption Limits (3rd edition, EPA 823-B-00-008, Nov 2000).

Available on EPA website ...

http://www.epa.gov/waterscience/fish/guidance.html

U.S. EPA Guidance

- Supplementary Guidance for Conducting Health Risk Assessment for Chemical Mixtures (EPA 630/R-00/002, August 2000).

Available on EPA website ...

http://www.epa.gov/ncea/raf/chem_mix.htm

Guidance for Fish Advisories, Vol 2, Risk Assessment and . . .

- Section 3.5
- Equation 3-13
  - Cancer

$$CR_{lim} = \frac{ARL \bullet BW}{\sum_{m=1}^{x}\left(\sum_{j=1}^{a} C_{mj} \bullet P_j\right) \bullet CSF} \qquad (3\text{-}13)$$

- Equation 3-16
  - Non-Cancer

$$CR_{lim} = \sum_{m=1}^{x}\left(\frac{RfD_m \bullet P_m}{C_m}\right) \bullet BW \qquad (3\text{-}16)$$

Fish Intake Rate Decreases . . .

$$CR_{lim} = \sum_{m=1}^{x}\left(\frac{RfD_m \bullet P_m}{C_m}\right) \bullet BW$$

Another example of this approach ...

"Fish Consumption Advisories: Toward a Unified, Scientifically Credible Approach", Dourson and Clark, Regulatory Toxicology and Pharmacology 12:161-178.

Paradigm for Mixtures

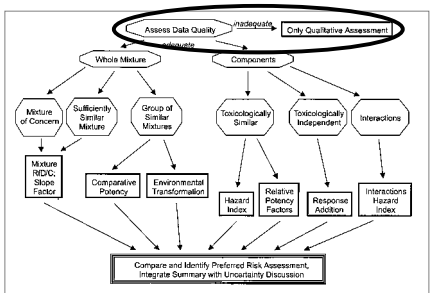
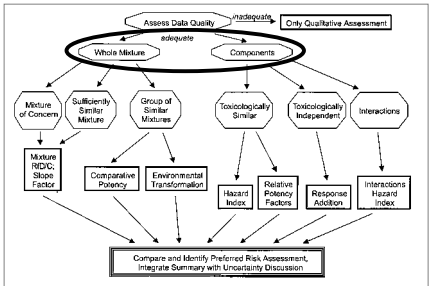


Figure 2-1. The different types of mixtures assessments based on the availability and quality of the data. All possible assessment paths should be performed.

Paradigm for Mixtures



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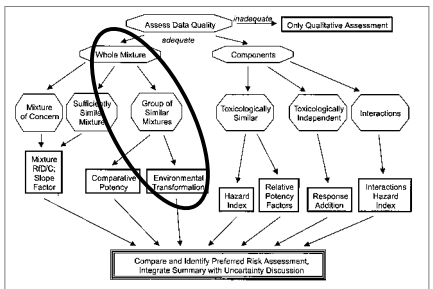

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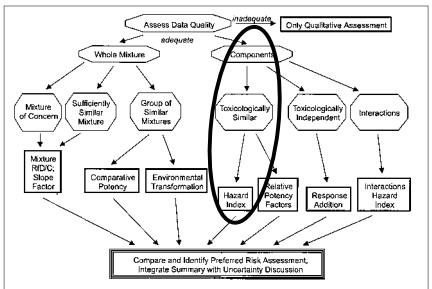


Figure 2-1. The different types of mixtures assessments based on the availability and quality of the data. All possible assessment paths should be performed.

Toxicologically Similar: Dose-Addition

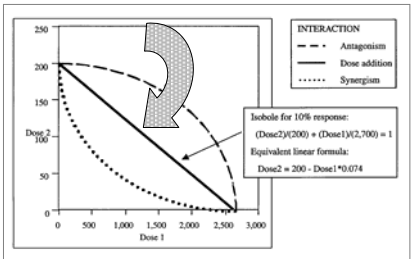


Figure 4-1. Isoboles for 10% response level of combination doses (d1, d2) of two chemicals showing the possible types of interaction.

Dose-Addition (cont'd)

- Hazard Index
- Relative Potency Factor
- Toxicity Equivalence Factor

Dose-Addition (cont'd)

- Hazard Index
  - More generally applicable, but more uncertainty
  - Assumes same "mode of action" and similarly shaped dose-response
  - Limitation: Exposures should be relatively low
  - Scaling factors should be related to each component's toxicity

Dose-Addition (cont'd)

- Relative Potency Factor (RFP)
  - Addition of scaled concentrations.
  - Expert judgment required.
  - Example: B2 PAHs are scaled to B(a)P
- Toxicity Equivalence Factor (TEF)
  - Specific type of RPF.
  - TEFs for dioxin congeners

Paradigm for Mixtures (cont'd)

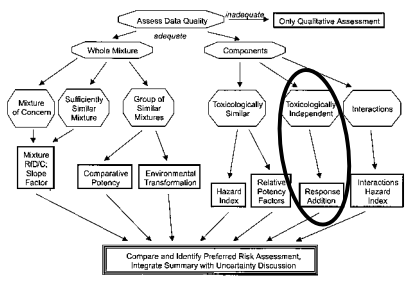
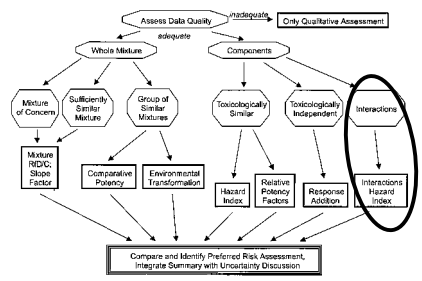


Figure 2-1. The different types of mixtures assessments based on the availability and quality of the data. All possible assessment paths should be performed.

Paradigm for Mixtures (cont'd)



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Paradigm for Mixtures (cont'd)

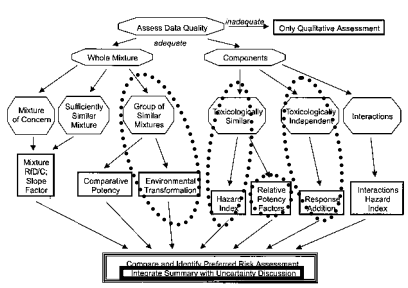


Figure 2-1. The different types of mixtures assessments based on the availability and quality of the data. All possible assessment paths should be performed.

Dose-Addition for other effects

Table 4-1. Example application of the target-organ toxicity dose

Chemical	Hepatic TTD	Renal TTD	Reproductive TTD	Oral exposure (mg/kg per day)	RfD (mg/kg per day)	HQ	Critical effect
Acetone	1.00E-01 RfD	1.00E-01 RfD	NA	4.E-02	1.E-01	0.40	Renal, hepatic
Chloroform	1.E-02 RfD	1.E-01 TTD	NA	5.E-03	1.E-02	0.50	Hepatic
Dibutyl phthalate	NA	NA	2.E-01 TTD	8.E-02	1.E-01	0.80	Incr. mortality
Diethyl phthalate	NA	NA	5.E+00 TTD	1.E+00	8.E-01	1.25	Growth
Di(2-ethyl-hexyl) phthalate	2.E-02 RfD	2.E-02 RS	5.E-02 TTD	1.E-02	2.E-02	0.60	Hepatic
Phenol	NA	2.E+00 TTD	NA	3.E-01	6.E-01	0.50	Developmental
HI-RfD	1.5	2.0	2.3				
HI-TTD	1.5	1.2	0.8				

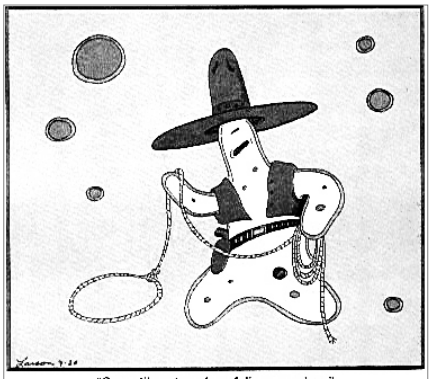
In the TTD columns, the source of the value is coded as:
TTD: new TTD developed for this effect.
RfD: this is the critical effect, so the TTD=RfD.
RS: insufficient data for a TTD, so RfD used as a surrogate.
TTDs and RfDs are from Mumtaz et al. (1997). Exposure levels (dose) are set for illustration only.

Uncertainties

- Data Quality.
- Quality of Health Effects Data.
- Information on Interactions.

For more information . . .

Consult "User Fact Sheets" in the Supplemental Guidance for Conduction Health Risk Assessment of Chemical Mixtures for summary of uncertainties associated with each approach.



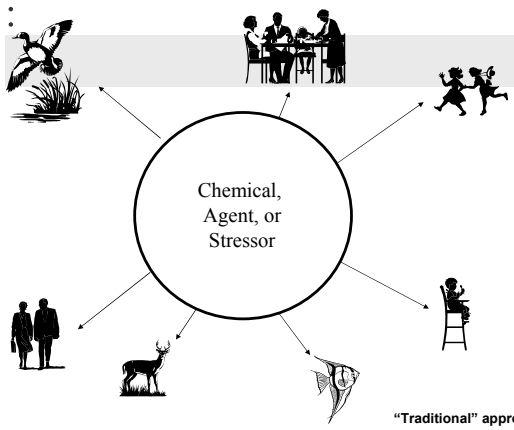
"So, until next week — Adios, amoebas."

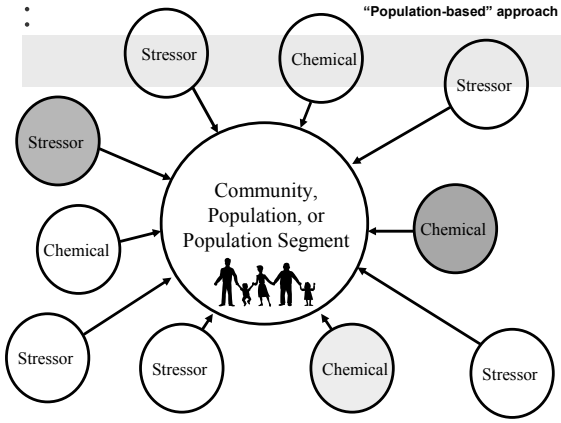
Framework for Cumulative Risk Assessment

Edward Bender ORD
EPA Risk Assessment Forum Technical Panel on Cumulative Risk Assessment

Cumulative Risk Assessment

- "Traditional" Risk Assessment:
  - Where we've been
- Cumulative Risk Assessment (CRA):
  - Why change?
- Framework: What is CRA?
- Guidelines: How do we do CRA?
- How the Framework relates to Fish Advisories ?





Framework vs. Guidelines

- Framework: General description of the topic. An **information document** laying out scope of the subject and how various parts fit together.
- Guidelines: Description of how it's done, including **boundaries** (e.g., limits of "good science") not to be exceeded.

Types of Issues

- Process issues: Extent of public participation, Role of risk managers, etc.
- Technical/scientific issues: Feasibility of certain components, Assumptions and defaults, etc.
- Policy issues: Requirements, etc. (will not be discussed)

Working Definition

- **Cumulative risk assessment:** The examination of the *accumulation* over time (across sources, across routes, etc.) of stressors or exposures that can cause adverse effects, and then the *integration* of the effects these stressors or exposures cause into an estimate and characterization of the risk caused to the individual or population by the stressors *acting together.*

Organization of Framework

1. Introduction
2. Planning, Scoping, and Problem Formulation Phase
3. Analysis Phase
4. Interpretation Phase
5. Glossary
6. References

Where are we going?

- Finish Framework document this year
- Examine case studies and issues for tools and methods through 2004
- Then begin Guidelines work
- http://www.epa.gov/ncea/raf/pdfs/frmwrk_for_cra/Draft_Framework_April23_2002.pdf

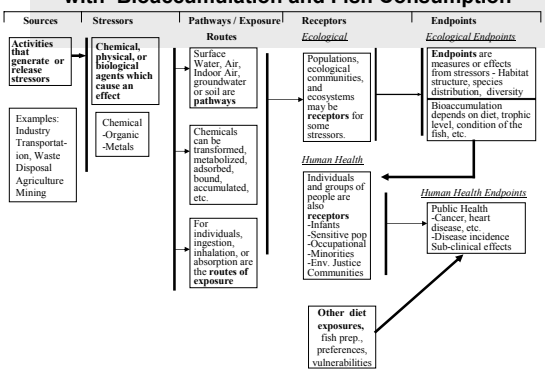
Applying the Framework to Fish Advisories

- Planning and scoping.
  - Problem-Fish are or may be contaminated with one or more chemicals. How do we protect the public?
  - What do we know about stakeholders, sources, exposures and adverse effects?

Conceptual Model

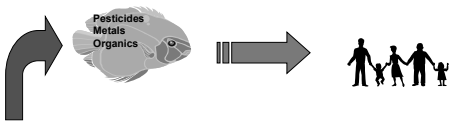
- Defines the goals and assessment context
- Tool for learning, communicating, and consensus building
- Describes linkages among sources, stress, and entities at risk.

A Generalized Conceptual Model with Bioaccumulation and Fish Consumption



Are they contaminated?

How and What?



Who is exposed?

Sources
-Agriculture
-Mining
-Discharge

Analysis Plan for the Assessment

- Describes agreements on data sources, models, quality, and methods
- Carries forward assumptions, rationale for scope, stakeholder values and risk management objectives.
- Helps the analysis inform risk management option selection

Fish Hazard Screen

	Pesticides (4)	Metals (2)	Organics (3)
Sources	Agriculture	Mining	Industrial
Pathways	Direct-fish	Trans-Fish	Direct-Fish
Human Route	Fish Ingestion	Fish Ingestion	Fish Ingestion
	Water	Water	Water
	Food	Food	
Possible Effects	Neurotoxic	Kidney function	Cancers

Exposure and Stakeholders

How often do they eat fish?
What part of the fish do they Eat?
Do they drink water from The sites of concern? Etc.

Health status of stakeholders
-Pre-existing disease?
-Other exposures?
-Dietary habits?
-Lifestyle?
-Health care? …

Concerns of stakeholders
-other unidentified contaminants?
-safety of fish supply?
-costs of risk management?
-scientific uncertainty?

Technical issues

Vulnerability

- Susceptibility/Sensitivity
- Differential exposure
- Differential preparedness
- Differential ability to recover

- Question: How do these factors change risk?

Analysis Phase

- Collect and evaluate data to address the problem
- Fish Advisories may be for :
  - Public notice
  - Part of Remediation, or perhaps
  - To monitor effectiveness of Risk Management actions

Stressors Acting Together

- Combination toxicology- common mech.
- Combining risks-occupational ex.
- Risk factor approach-Heart Disease, RSC
- Biomarkers or biomonitoring
- QALYs, DALYs, LLEs and other

Combining different risks

- Can different types of risk be combined?
- Common metric approach
- Index approach

Uncertainty

- Few good examples of uncertainty analysis for Cumulative Risk Assessments
- New GIS-based technology poses new challenges in uncertainty analysis
- What type of analysis would be useful to a decision-maker?

Risk Characterization

- Draws on scoping and problem formulation
- Do data validate model assumptions (stressors, sources, etc.)
- How are susceptibilities/exposures of fish consumers considered in the CRA
- How does the Fish Advisory help consumers manage risks?

CRA May Apply to Fish Advisories

- To Clarify the Problem and ID Stakeholders
- To Plan Analysis and Monitoring
- To Place Fish Contamination risks in a larger context
- To Help the Public Understand and Manage Risks

Part Two: Slides Presented During Plenary Sessions

I. Update on Activities Related to the 2001 Forum

A. *New Version of the Risk Communication Guidance.* Barbara Knuth, Cornell University
B. *Update: Relationship of TMDLs to Fish Advisories*. Jim Pendergast, US EPA

II. Reports from the Weekend Sessions

A. *Methylmercury Contamination in Fish: Human Exposures and Case Reports*. Henry A. Anderson, State of Wisconsin
B. *Report on Mercury Advisory Worksheets*. Amy D. Kyle, University of California Berkeley

III. Advisories for Commercial Fish: Federal, State, and Tribal Approaches

A. *FDA Consumer Advisory for Methylmercury*. Philip Spiller, US FDA
B. *Sport and Commercial Seafood Wisconsin Integrated Public Health Message: Maximize Health Benefit, Minimize Risk, Coordinate Health Message*. Henry A. Anderson, State of Wisconsin
C. *Context for Connecticut's Seafood Advisory.* Gary Ginsburg, State of Connecticut
D. *Consumer Advisory for Commercial Fish*. Andy Smith, State of Maine.

IV. Hot Topics—Chemicals of Concern

A. Mercury

- *Methylmercury: Ongoing Research on Toxicology*. Kathryn R. Mahaffey, US EPA
- *Setting a Methylmercury Reference Dose (RfD) for Adults*. Alan H. Stern, State of New Jersey

B. Brominated Flame Retardants (Polybrominated Diphenyl Ethers or BDEs)

- *Occurrence of PBDE Flame Retardants in Fish*. Robert C. Hale, Virginia Institute of Marine Science
- *PBDEs: Toxicology and Human Exposure.* Linda S. Birnbaum, US EPA
- *Polybrominated Diphenyl Ethers (BDEs).* Khizar Wasti, State of Virginia

C. Dioxins and Coplanar PCBs

- *Emerging Science of the Dioxin Reassessment*. Dwain Winters, US EPA

D. Lead

- *Application of the Lead IEUBK Model to Assess Spokane River Fish Consumption Health Risks.* Lon Kissinger, US EPA Region 10.
- *Occurrence of Lead in Fish*. Robert Brodberg, State of California

E. Polycyclic Aromatic Hydrocarbons

- *Polycyclic Aromatic Hydrocarbons (PAHs) in Fish and Invertebrates*. Usha Varanasi, Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration

V. Approaches to State and Tribal Advisories

A. *Setting Statewide Advisories Based on Upper Percentile Lake Averages.* Eric Frohmberg, State of Maine
B. *Use of Maine's Statewide Advisory in a Tribal Setting*. Susan M. Peterson, Aroostook Band of Micmacs Environmental Laboratory
C. *North Dakota's Fish Consumption Advisory: A Statewide Advisory Based on Average Concentrations.* Mike Ell, State of North Dakota

D. *Advisories in Pennsylvania*. Bob Frey, State of Pennsylvania
E. *Minnesota Statewide Fish Consumption Advice*. Pat McCann, State of Minnesota
F. *Regional Fish Advisory for the Mississippi Delta*. Henry Folmar, State of Mississippi
G. *Consumption Advisories Based on 8 Meals per Month.* Joseph Beaman, State of Maryland

VI. Approaches to Considering Benefits in Advisory Programs

A. *Impacts of Fish Contamination in the Columbia River Basin*. Paul Lumley, Yakima Tribe
B. *Dietary Benefits and Risks in Alaskan Villages*. Sue Unger, Aleutian-Pribilof Islands Association

VII. Current Science on the Benefits of Fish Consumption

A. *Overview of Benefits of Fish Consumption*. Judy Sheeshka, University of Guelph
B. *Use of Quality-adjusted Life Years to Assess Risks and Benefits of Fish Consumption*. Rafael Ponce, University of Washington

New Version of the Risk Communication Guidance

Barbara Knuth
Cornell University

What is changing?

Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume IV – *Risk Communication*

EPA 823-R-95-001
March 1995

Why Change the Guidance?

- Risk communication must be culturally appropriate.
- Involve the partners.
- Continually assess the partnership and message.
- Help the partners to take action.

The Development Team

- Technical contractor: Tetra Tech, Inc.
- Consultants:
  - John Hesse
  - Barbara Knuth
  - Amy Kyle
  - Judy Sheeshka
  - Patrick West
- Stakeholders:
  - Workgroup
  - General

Approach for Revised Guidance

- Risk communication modules that can be targeted for specific needs.
- Modules developed by state and culturally- diverse stakeholders, and nationally- recognized consultants.

Approach for Revised Guidance

- Acknowledge contamination is not "acceptable."
- Encourage community involvement.
- Link to other phases of the risk analysis process.

Approach for Revised Guidance

- Continue to enhance the user-friendly set of risk communication outreach materials under development by the National Fish and Wildlife Contamination Program.
- Web-based to encourage "tailored" use of guidance appropriate to community needs.

Developing a Web-based Guidance

The stakeholders advised:

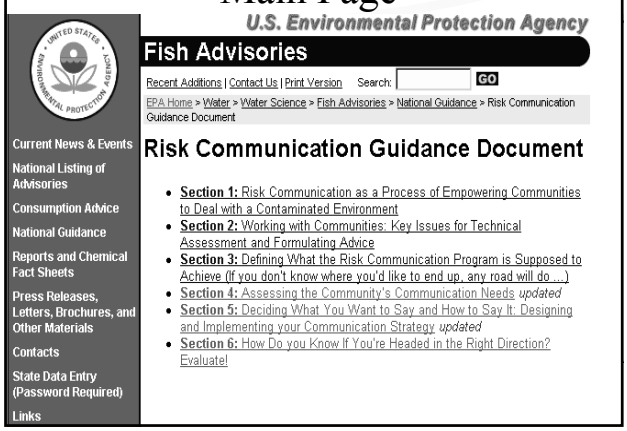
- Keep the concise risk communication framework.
- Add case studies to illustrate important points.
- Provide techniques for applying the framework to different situations.

Developing a Web-based Guidance

The stakeholders advised:

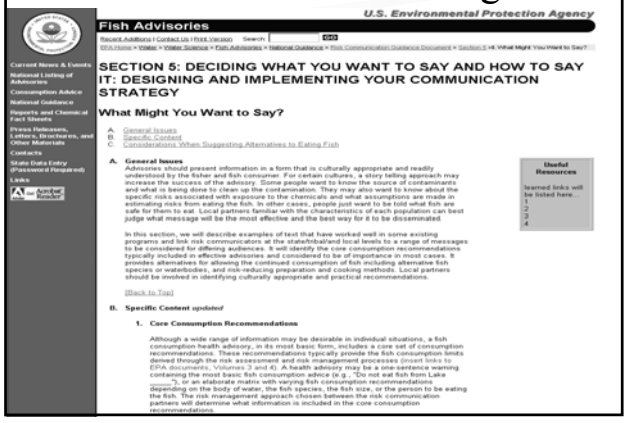
- Be realistic (funding, time, people).
- Link to tools and examples.
- Include fish consumption benefits.

Main Page



Section Home Page

Section Information Page



Link to Information Box

Information Box

General Advisory for Eating Sportfish

The general health advisory for sportfish is that you eat no more than one meal (one-half pound) per week of fish taken from the state's freshwaters and some marine waters at the mouth of the Hudson River. These include the New York waters of the Hudson River, Upper Bay of New York Harbor (north of Verrazano Narrows Bridge), Arthur Kill, Kill Van Kull, Harlem River and the East River to the Throgs Neck Bridge (see map on page 14). This general advisory is to protect against eating large amounts of fish that have not been tested or may contain unidentified contaminants. The general advisory does not apply to most marine waters.

Close Window

Advantages to Web Approach

- Guidance is more accessible to a wide range of fish consumption advisory programs and groups issuing or learning about consumption advisories.
- Guidance is less daunting – web pages to negotiate rather than a large book to read.

Advantages to Web Approach

- Materials may be developed for a specific type of partner audience; more "tailored" than a general process that leaves many decisions and few directly-related examples or tools.
- A living document modified and updated easily.

Advantages to Web Approach

- Customized population-specific modules.
- More choices of examples, tools, methods, and current information related to fish consumption advisories and specific partners.
- Supports early inclusion of partner audiences and communicators in the risk communication process.

Advantages to Web Approach

- Responsive to stakeholders who indicated a web-based approach has the potential to be more useful.
- Allows the format to become issue-oriented, based on the path a user takes, rather than process-oriented.

Possible Disadvantages of Web-based Approach

- The web-based guidance is accessible only to those with web access.
- The living document will need to be updated continually.

Next Steps

- Development team drafting all sections, links, information boxes, etc.
- Ongoing stakeholder work group review.
- General stakeholder comment, use, revisions.

Thanks to the Stakeholder Workgroup!

Janice Adair
Rosetta Alcantra
Robert Brodberg
Mike Callam
Josee Cung
Henry Folmer
Kenny Foscue
Eric Frohmberg
Jim Labelle
Randall Manning
Maria Maybee
Dave McBride
Pat McCann
Ora Rawls
Roland Shanks
Brian Toal
Luanne Williams

Update: TMDLs and Fish Consumption Advisories

Jim Pendergast
USEPA Office of Water
Washington, DC

Topics Covered Today

- Methyl Mercury TMDLs
- Methyl Mercury Criterion and TMDLs
- Advisories and TMDLs
- New TMDL Rule

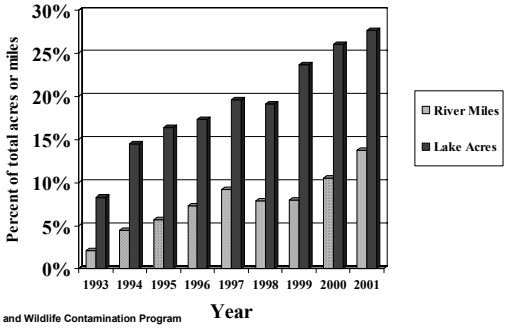
Methyl Mercury TMDLs

- What is the TMDL picture for mercury?
- What will it take to reduce mercury loadings?
- What is the news about alternatives to TMDLs?

Mercury in Watersheds

- In 1998, of 21,800 impaired waterbodies
  - ~4,000 listed for metals (including mercury)
  - ~1,100 listed specifically for mercury
    - ~8 states listed atmospheric deposition as source
    - ~650 segments impaired by atmospheric deposition
- As of 2001, 44 states have issued mercury fish consumption advisories

Percent of U.S. River Miles and Lake Acres Under Advisory: 1993-2001

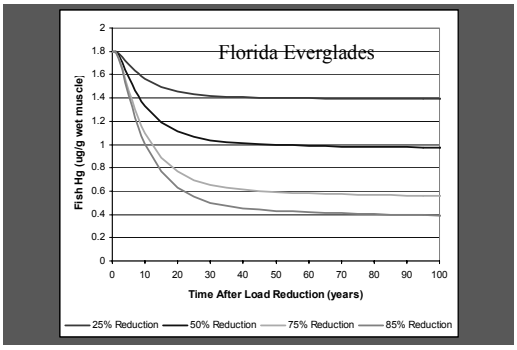


National Fish and Wildlife Contamination Program

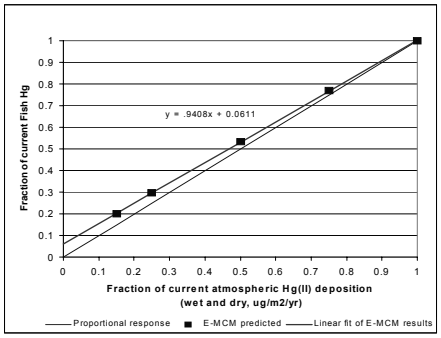
Mercury TMDL Issues

- Long timeframe to achieve water quality standards
- Regional/global scope of mercury deposition, as well as local scale deposition
- Dependence on non-water programs (e.g., air sources and contaminated sediments)
- Small loadings from water point sources compared to air sources

How Long to Recover?

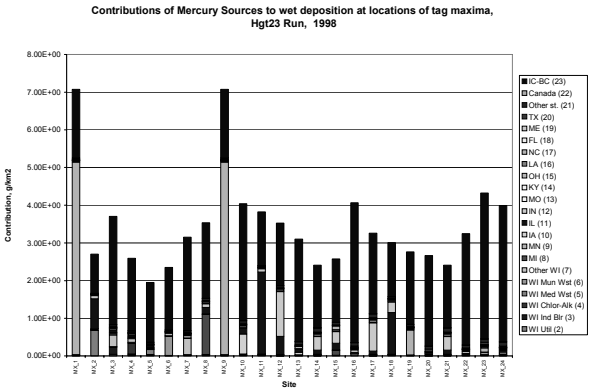


Florida Mercury TMDL Pilot: Mercury Loads vs. Levels in Fish



Needed vs Expected Reductions in Mercury Loads for GA TMDLs

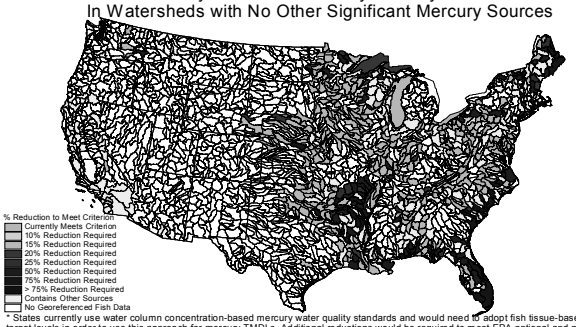
Basin	Water Quality Target (ng/l)	% Reduction in Hg Loadings to Meet Target	% Reductions from Existing Clean Air Act Regulations
Alapaha	4.9	64	17-25
Ochlockonee	1.6	76	31-41
St. Mary's	1.9	56	1-6
Satilla	3.2	61	31-39
Suwanee	2.8	58	9-15
Withlacoochee	6.8	40	33-43
Ohoopee	3.5	24	42-54



New Approaches to Hg TMDLs

- Abridged Approach: Mercury Maps
  - Geographic information system containing fish-tissue and other data on a watershed-by-watershed basis
  - Screens watersheds on national scale by comparing fish Hg concentrations against new MeHg criterion
  - Links air deposition and fish tissue mercury through simple model (linear relationship)
- Regional Approach: New England Pilot
  - Will combine Mercury Maps and regional model
  - Goal is to evaluate regional approach, e.g., identify waters where existing controls are likely to achieve the criterion

Estimated Percent Reductions in Air Deposition Load Necessary to Meet New Methylmercury Criterion* In Watersheds with No Other Significant Mercury Sources



* States currently use water column concentration-based mercury water quality standards and would need to adopt fish tissue-based target levels in order to use this approach for mercury TMDLs. Additional reductions would be required to meet EPA national and most state fish advisory levels, which are often set below the methyl-mercury criterion.

Note: Watersheds highlighted yellow have "significant" mercury sources other than deposition, defined as where the total estimated load from Publicly Owned Treatment Works (POTWs) and pulp and paper mills is greater than 5% of estimated waterbody delivered mercury at a typical air deposition load (10 g/km2/yr), and/or where mercury cell chlor-alkali facilities, mercury mines, or significant past producer gold mines are present. See text of report for data sources for point source dischargers and mines.

Source: National Listing of Fish and Wildlife Advisories (NLFWA) Mercury Fish Tissue Database (June, 2001).

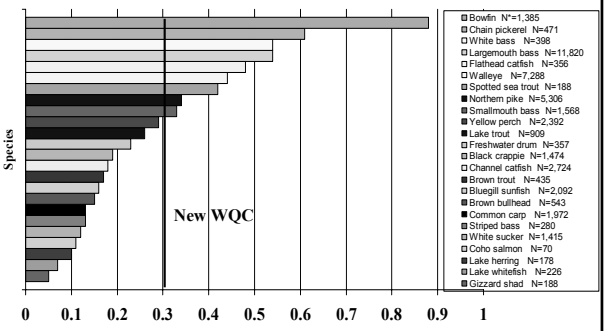
Quicksilver-TMDL Workgroup

- State participants include WI (co-chair), ME, CT, CA, CO, FL, GA, IL, MN, OR
- Workgroup will focus on air deposition-dominated mercury TMDLs (mining issues later)
- Initial ideas include the following:
  - Develop separate category on 303(d) lists for waters impaired by pollutants from air deposition
  - Allow alternatives such as regional or screening TMDLs
  - Develop interim goals and indicators of progress

MeHg Criterion and TMDLs

- How will the new criterion affect TMDLs?
- What is the status of the implementation guidance?
- What will the implementation guidance include?

Mean Mercury Concentration in Tissues of Selected Fish Species (all sample types)



Source: NLFWA February 2002, data from 1987-2001

State WQS Adoption Expectation

- EPA not pushing states to adopt new criterion until implementation guidance published
  - technical issues
  - resource issues
- Some States interested in adopting new criterion now

MeHg Implementation Guidance: Key Elements and Issues

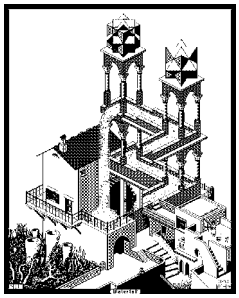
- Water Quality Standards, e.g.,
  - translating methyl Hg to total Hg
  - site specific criteria flexibility
  - expression of criterion (tissue or water)
  - variances and UAAs
- Defining impairment
  - trophic level averaging
  - size averaging
  - appropriate analytical methods
- Approaches to TMDLs
- Permitting, especially for small sources

How Long to Finish?

Oct: Revise draft
Nov: Outreach discussions
Management review
Dec: Draft for release

60 to 90 day comment period

Advisories and TMDLs



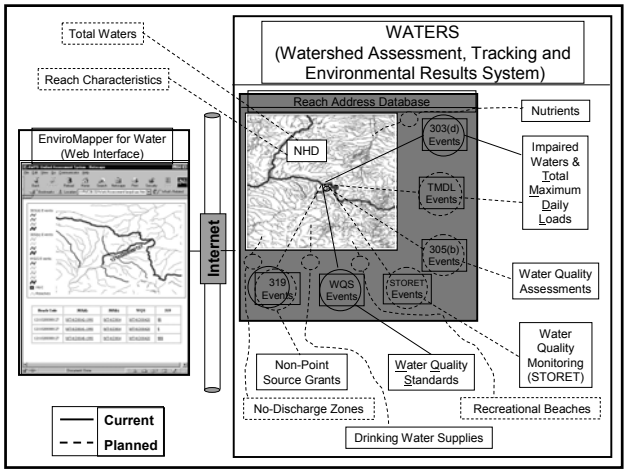
- What does the October 2000 guidance really say?
- What is EPA's vision on the relationship between water quality standards and advisories?

2000 Guidance

- Must list waters when risk-based fish advisories based on waterbody-specific data and same risk basis of WQS
  - same type of data collection
  - same threshold value
- Not required to list for fish advisories without waterbody-specific data
  - thus statewide advisories do not trigger listings
- Shows cross-walk between listings and National Shellfish Sanitation Program (NSSP) Growing Area Classifications

Advisories Are Not Always Impairments

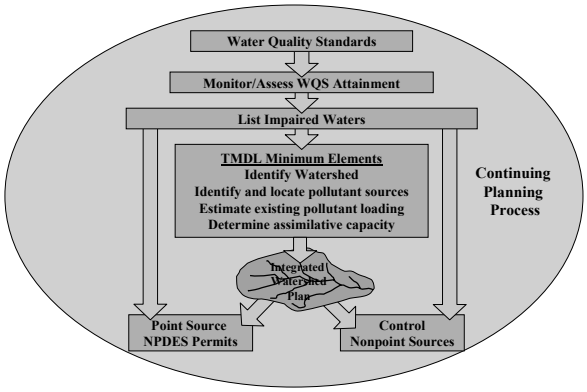
- Impairments
  - Population are exposed at greater than acceptable risk
  - Considers mixture and range of species and ages
- Advisories
  - Individuals are exposed at greater than acceptable risk
  - Some waterbody specific; some regional or statewide
  - Some are size specific and some are species specific



New TMDL Rule

- What is it likely to include?
- When will it happen?

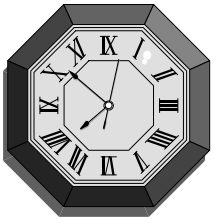
Clean Water Act Framework



TMDL Rule Objectives

- Achieve steady reasonable progress towards achieving water quality standards (WQS)
- Encourage planning and management on a watershed basis
- Support adaptive implementation, trading, and pre-TMDL voluntary efforts
- Enable States to do planning and implementation
- Improve accountability for results
- Improve monitoring and listing
- Leverage funding from non-EPA programs

TMDL Rule Timing



- Proposed rule in November 2002
- Final rule in Spring 2004 at the earliest
- Reality check -- This may change!!

Information Sources

- TMDL homepage - http://www.epa.gov/owow/tmdl
  - EPA guidance and documents
  - Maps and information on impaired waters
  - Links to other TMDL websites
  - Regulations and supporting information
- Fish Advisory homepage - http://www.epa.gov/waterscience/fish
  - National guidance
  - Listings of advisories

Methylmercury Contamination in Fish: Human Exposures and Case Reports

Clarion and Radisson Hotels
Burlington, Vermont
October 19-20, 2002

Sponsorship

- U.S. Environmental Protection Agency
- American Fisheries Society
- American Academy of Pediatrics
- American College of Obstetricians and Gynecologists
- Association of Occupational and Environmental Clinics
- Centers for Disease Control and Prevention (National Center on Birth Defects and Developmental Disabilities)

Steering Committee

- Kathryn Mahaffey, Ph.D. – Chair
- Henry Anderson, MD
- Sophie Balk, MD
- David Bellinger, Ph.D.
- Jeff Bigler
- Tom Burke, Ph.D.
- Ronald Dobbin, CIH, MSC-OH
- Betsy Fritz
- Catherine Joseph
- Donald Mattison, MD
- Michael Shannon, MD, MPH

Goals

- To inform participants on the distribution of blood methylmercury concentrations in the general population of the U.S.
- To evaluate cases of elevated methylmercury exposures
- To present expert advice on neuropsychological and/or neurological evaluation strategies to assess impact of elevated methylmercury exposures
- To develop a product providing information from this workshop

Selected Program Topics

- Developmental Health: Risks and Benefits
- Methylmercury Toxicity and Exposure – Toxicokinetics and Biomarkers
- Chelation: Metal Complexing and Metal Mobilization
- Medical Associations – Overviews and Approach
- Methylmercury Exposure Assessments – New Jersey / St. Lawrence River

Selected Program Topics (cont)

- Methylmercury Clinical Assessments – California / Boston / Wisconsin / New Jersey
- Biomonitoring and Population Data – German Methods and NHANES
- Neuropsychological and/or Neurological Evaluation Strategies
- Population Assessment Methods – questionnaires
- Risk Communication and Outreach – WI, ME

Goal #1 Key Points

To inform participants on the distribution of blood methylmercury concentrations in the general US pop

- National data available are NHANES
- 1999-2000 NHANES only covers women (16-49) and children (1-5) for mercury (e.g., blood, hair, urine)
- Blood mercury data indicate 7.8% women above 5.8 µg/L
- Fish consumption correlated well with blood mercury (<1 ml/wk = 2% and 1+ ml/wk = 15% above 5.8 µg/L)

Recommendations:

- Mercury should become core biomarker for all pops
- Correlate health status and NHANES biomarkers

Goal #2 Key Points

To evaluate cases of elevated methylmercury exposures

- Growing interest in biomonitoring for mercury
- Reports of fish consumption resulting in blood mercury > 50 µg/L
- New "at risk" pop recognized in high income consumers of fresh fish; subsistence individuals also reported

Recommendations:

- Clinical testing guidelines and treatment guidance needed (professional associations must endorse and promote)
- Targeted outreach needed for "at risk" pops

Goal #3 Key Points

To present expert advice on neuropsychological and/or neurological evaluation strategies to assess impact of elevated methylmercury exposures

- Adult low level mercury health effects are likely to impact the neurological system
- Pre-natal toxicity is predominately neurological
- No signature neurological effect pattern

Recommendations:

- Clinical neurological testing protocol must be developed for low level mercury exposures (professional associations must endorse and promote)

Next Steps

- Effective partnerships and consortium building (both governmental and non-governmental)
- More research and better understanding of cardiovascular effects in adult men (and women)
- Greater public and professional communication of mercury exposure hazards and prevention methods
- To integrate fish consumption advice = speak with a single voice (e.g., framework for national fish advisories)
- $$$

Any Questions?

State and Tribal Mercury Advisories:

Results from worksheets

Amy D. Kyle, MPH PhD

Purpose of worksheet

- Look at starting point for state and tribal advisories
- Focus is on lowest mercury concentration used as basis for advisories in various categories
- Provides informative, if imperfect, point of comparison between states and tribes
- "Get some idea"

What we did

- Simple worksheet distributed by AFS through email in advance of meeting
- Worksheets also available at regional meetings
  - Some regional meetings discussed them and some didn't
- Results compiled from those returned
- 39 states and 4 tribes provided information

How to compare?

- Purpose was to gain an idea of what mercury concentrations in fish were leading to advisories
- This is imperfect because states and tribes don't always use the same mercury concentration in different advisories
- To try to gain comparability, asked for the **lowest** concentration of mercury for each of several types of advisories

Categories of advisories

- Used four basic categories of advisories:
  - **General Population – apply to everybody not otherwise mentioned**
    - advisories for NO consumption of fish
    - advisories for restricted consumption of fish
  - **Sensitive Populations – identified groups**
    - advisories for NO consumption of fish
    - advisories for restricted consumption of fish

Who responded?

- 39 states and 4 tribes
- States that responded have 81.3 of population of women of child-bearing age
- 34 states and four tribes reported issuing advisories recommending no consumption or restricted consumption for fish with mercury
  - at least one other is currently developing an advisory
  - one tribe uses state or federal advisories

General Population – no consumption of fish

- 15 states and three tribes report issuing at least one advisory of this type for mercury
- Mercury concentrations for these advisories range from 0.5 to 2.88 ppm
- The concentrations of mercury that trigger these advisories should be comparable
  - Because there is no advice regarding number of allowable meals or meal size

General population: restricted consumption

- 28 states and two tribes report issuing at least one advisory of this type
  - Applies to everyone not covered by a more specific advisory
- Mercury concentrations from 0.059 to 1 ppm
- Triggering concentrations of mercury will depend on advice offered (size and number of meals)
  - Allowable meals per year from 12 to 96
  - Meal size from 3 to 16 ounces

Mercury allowed in advisories for the general population

- Compare allowable total mercury per year
- Range is from 0.48 to 7.71 milligrams of mercury per year
  - Calculated by: number of meals x meal size = total fish consumed per year- converted to kilograms
  - ppm equals milligrams per kilogram
  - Multiply kilograms of fish consumed by allowable concentration = total milligrams

Sensitive Population: No Consumption

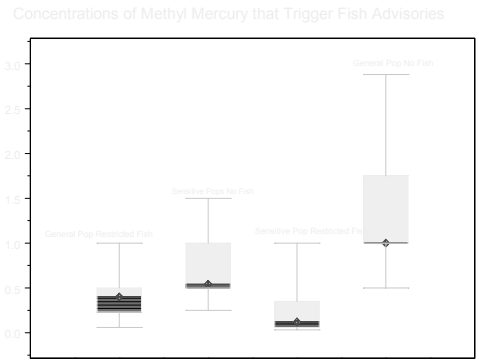
- **23 states** report issuing at least one advisory of this type
- Mercury concentrations from 0.25 to 1.5 ppm
- The concentrations of mercury that trigger these advisories should be comparable
  - Because there are is no advice regarding number of allowable meals or meal size

Sensitive Populations: restricted consumption

- 23 states and one tribe report issuing at least one advisory of this type
- Mercury concentrations from 0.032 to 0.5 ppm
- Triggering concentrations of mercury will depend on advice offered
  - Significant differences in advice regarding number and size of allowable meals
  - Allowable meals per year from 12 to 104

Mercury allowed in advisories for sensitive populations

- Compare allowable total mercury per year
- Range is from 1.37 to 47.4 milligrams of mercury per year
  - Calculated by: number of meals x meal size = total fish consumed per year- converted to kilograms
  - ppm equals milligrams per kilogram
  - Multiply kilograms of fish consumed by allowable concentration = total milligrams



Limitations

- Asked only about "lowest" concentration: may or may not be a good representation of overall approach
- May be only a small percentage of advisories
- Advisories are often issued for more than one meal size; these results report for the largest one
- Can be multiple pollutants: mercury may be part of an advisory but not the primary driver

FDA Consumer Advisory for Methylmercury

Philip Spiller
Director, Office of Seafood
Center for Food Safety and Applied Nutrition

- One FDA seafood advisory: MeHg
- Still a work in progress
- What our experience so far tells us about advisories generally
- Developing an advisory: first ID the major decisions that will have to be made, and that will be reflected in the advisory

- Federal advisory: national/uniform in scope
- FDA's mission: food in interstate commerce, not recreational/subsistence

Three Major Decisions

- Who is the advisory for? Everyone? "Target" population(s)?
- What outcome are we seeking in the target population?
- How to structure the advisory to achieve the desired outcome?

Targeting the Advisory: Background

- MeHg is a neurotoxin with effects at high doses.
- Primary exposure in U.S. is through fish
- Public Health questions involve determining exposure over time necessary to cause an effect

Targeting the Advisory: Adults?

- Threshold effects: 50 ppm
- Seychelles/Faroe Islands: 5-7 ppm
- United States: 0.2 ppm
- Few above the ADI

Targeting the Advisory: developing fetus

- Seychelles finds no effects
- Faroe Islands finds effects
- ATSDR relies on Seychelles
- EPA relies on Faroe Islands
- FDA issues advisory to protect fetus, as a matter of public health prudence.

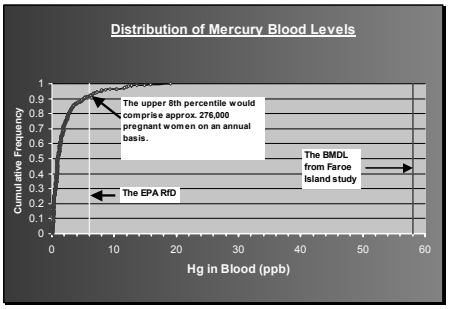
Outcome

- OPTION: keep exposure below highest no effect level from Seychelles and Faroe Islands
- That level of exposure is hard to reach, even without an advisory
- Over time, 98th percentile consumer must eat fish containing 5x the average amount of MeHg

Outcome

- OPTION: keep exposure below "worst case ADI-type level
- FDA's ADI: adult/general pop.
- ATSDR's MRL: fetus, less conservative
- EPA's RfD: fetus, more conservative

U.S. Exposure vs. Risk Management Levels



Structure

- To achieve objective
- To minimize impact on majority in target population whose consumption is not an issue
- To retain benefits
- To keep it as simple as possible in order to encourage people to follow it

Structure

- Avoid "highest" species, which are named
- OK to eat up to 12 oz. per week of a variety of fish
- Check local advisories for recreational
- Subsistence fishermen check with local authorities

Conclusion

- MeHg is a neurotoxin that can be found in nearly all fish
- Public health issue is consumption over time
- Risk reduction can occur while still consuming fish
- Primary focus has been susceptible subpopulation

Conclusion

- Taking all that into account:
- Primary target: pregnant women and women of childbearing age who may become pregnant
- Outcome: keep exposure below all "tolerable daily intake" levels established for MeHg

Sport Fish & Commercial Seafood

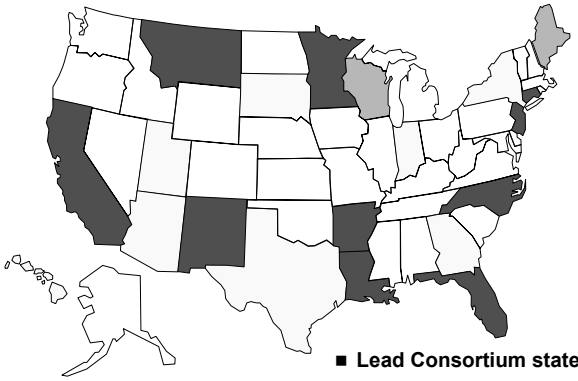
Wisconsin Integrated Public Health Message:

Maximize Health Benefit, Minimize Risk,
Coordinate Health Message

Henry A. Anderson, MD.
Chief Medical Officer
WI Division of Public Health
Madison, WI

With assistance from Candy Schrank, WDNR
and the WDPH fish advisory team, Wisconsin Maine Mercury consortium

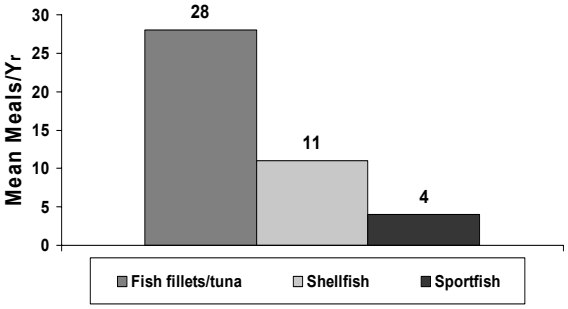
12 State Mercury Survey (2001)



12 State Mercury Survey

Average Number of Meals during Previous Year

(All women N =3,015)

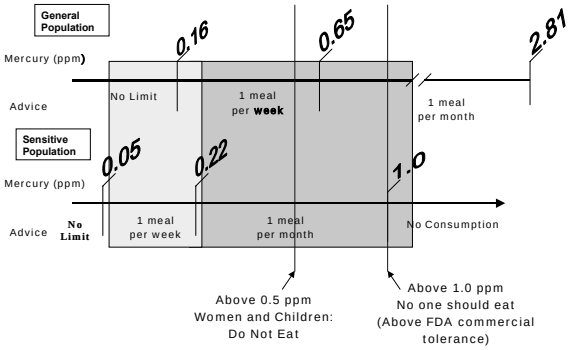


Consumption by Hair Mercury Intervals

Interval* Mean	10th	25th	50th	75th	90th	100th
Total fish	10 meals/ year	19 meals/ year	33 meals/ year	43 meals/ year	52 meals/ year	73 meals/ year
Total Sport Fish	2 meals/ year	4 meals/ year	3 meals/ year	7 meals/ year	7 meals/ year	9 meals/ year
Hair mercury N= 410	0.05 ppm	0.12 ppm	0.2 ppm	0.43 ppm	.78 ppm	1.89 ppm

*Intervals = 0-10%, 11-25%, 26-50%, 51-75%, 76-90%, 91-100%

Mercury Advisory Groupings Using EPA Reference Dose



2002 Wisconsin Mercury Fish Advisory

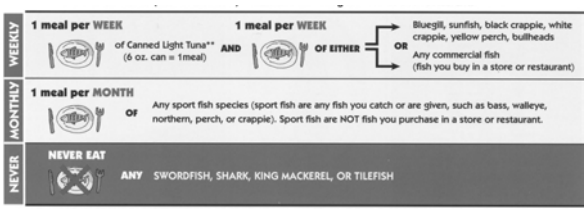
General Statewide Guidelines
most inland waters

and

Site Specific Consumption Advice (92)
where data indicates
more stringent advice is necessary

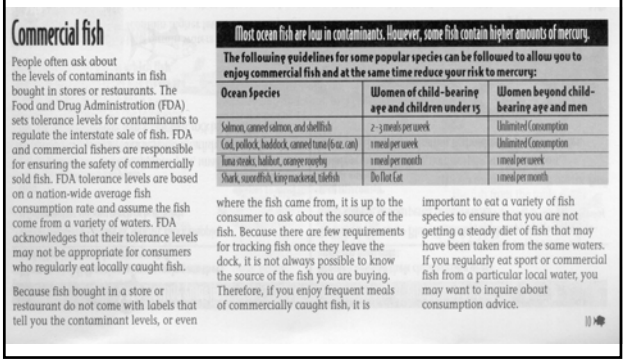
A Woman and Child's Guide to Eating Fish from Wisconsin (2002)

(includes sport and commercial fish)



Currently use FDA "never eat" list
Future years, review monitoring data, coordinate advice on commercial fish with other states

Wisconsin 2002 Mercury Advisory includes Commercial Fish Advice



Commercial fish

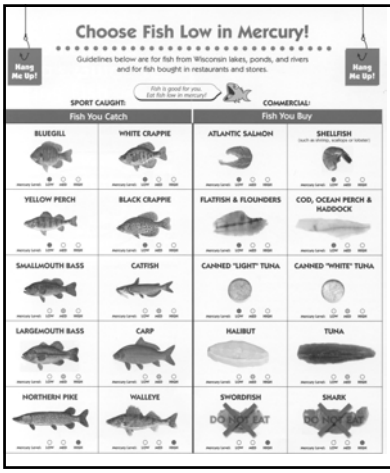
People often ask about the levels of contaminants in fish bought in stores or restaurants. The Food and Drug Administration (FDA) sets tolerance levels for contaminants to regulate the interstate sale of fish. FDA and commercial fishers are responsible for ensuring the safety of commercially sold fish. FDA tolerance levels are based on a nation-wide average fish consumption rate and assume the fish come from a variety of waters. FDA acknowledges that their tolerance levels may not be appropriate for consumers who regularly eat locally caught fish.

Because fish bought in a store or restaurant do not come with labels that tell you the contaminant levels, or even where the fish came from, it is up to the consumer to ask about the source of the fish. Because there are few requirements for tracking fish once they leave the dock, it is not always possible to know the source of the fish you are buying. Therefore, if you enjoy frequent meals of commercially caught fish, it is important to eat a variety of fish species to ensure that you are not getting a steady diet of fish that may have been taken from the same waters. If you regularly eat sport or commercial fish from a particular local water, you may want to inquire about consumption advice.

Most ocean fish are low in contaminants. However, some fish contain higher amounts of mercury.

The following guidelines for some popular species can be followed to allow you to enjoy commercial fish and at the same time reduce your risk to mercury:

Ocean Species	Women of child-bearing age and children under 15	Women beyond child-bearing age and men
Salmon, canned salmon, and shellfish	2–3 meals per week	Unlimited Consumption
Cod, pollock, haddock, canned tuna (6 oz. can)	1 meal per week	Unlimited Consumption
Tuna steaks, halibut, orange roughy	1 meal per month	1 meal per week
Shark, swordfish, king mackerel, tilefish	Do Not Eat	1 meal per month



2002 Wisconsin Woman and Child's Guide

Wisconsin Sport Fish Consumption Advisory Support Program

Joint Environment and Health Agency Program

Environment - Comprehensive sport fish monitoring species, size, location

Health - Human biomonitoring, health outcomes, advisory evaluation* **

*Funded by the Agency for Toxic Substances and Disease Registry Grant # H75/ATH598322
**Funded by the United States Environmental Protection Agency Cooperative Agreement # CR 826283-01-0

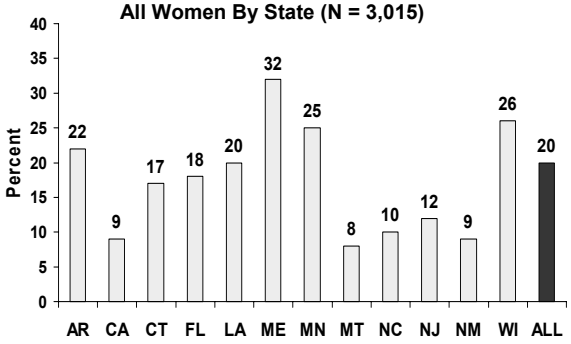
Wisconsin Sport Fish Monitoring Program

Year	Sites Sampled	Samples Collected
Prior to 1980	234	3,003
1980-1989	939	11,139
1990-1999	683	11,565
2000	96	806
Total	1,952	26,513

Mercury 12 State Survey

Advisory Awareness among Women

All Women By State (N = 3,015)



Recommendations

- Need increased commercial fish monitoring designed to assist in advisory placement
- Need increased human biomonitoring
- Need continued health effects research, especially potential cardiovascular effects

Come Fish In Wisconsin

*Catch and release

Sport Fish & Commercial Seafood

Wisconsin Integrated Public Health Message:

Maximize Health Benefit, Minimize Risk, Coordinate Health Message

Any Questions?

Context for CT's Seafood Advisory

- Recreational Advisories since 1980s
- Major sampling for Hg in lakes: 1996-1997
- Resulted in statewide freshwater advisory
- 4 waterbodies particularly high: avg. bass conc. ≥1 ppm
- Natural question: commercial fish

Hg Exposure Potential from Seafood

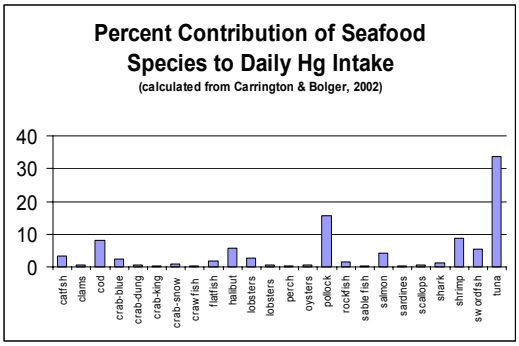
- Swordfish, shark ≥ 1 ppm
- Tuna steak ≈ 0.3 - 0.5 ppm
- Canned tuna (Yess, 1993):
  - 0.1 ppm - chunk or chunk light
  - 0.3 ppm - chunk white or solid white
- Infrequent consumption of swordfish/shark (e.g., once per month) equals meHg RfD
- Frequent consumption of canned tuna (e.g., 2 or more times / week) ≥ RfD

National Trends for Hair Hg Concentrations

•NHANES, 1999 - 702 women
- 50th % = 0.2 ppm
- 75th % = 0.5 ppm
- 90th % = 1.4 ppm

•Simulation of seafood consumption

(Carrington and Bolger, 2002)
- consumption rates and Hg concs for 24 commerical species
- matched NHANES distribution for women



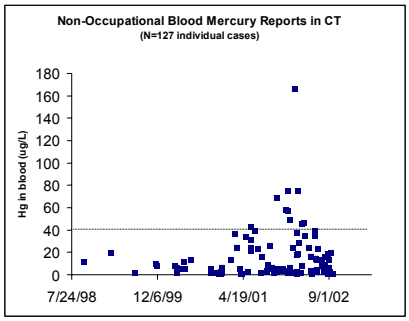
New Jersey Hg Biomonitoring in Pregnant Women (Stern et al., 2001)

- 189 women sampled
- average Hair Hg = 0.53 ppm
  - 9.5% between 1 and 2 ppm
  - 1.6% between 2 and 4 ppm
  - sporadic cases over 4 ppm
- calculated that 10-15% ingest > RfD
- canned tuna most popular fish meal
  - 30 of 83 fish meals/year
- fish consumption patterns only weakly correlated with hair or blood Hg

CT Mercury Biomonitoring Data

(EPA Mercury Advisory Awareness Study, 2000)

- 17 women, 18-45 yrs old sampled
- mean hair Hg +/-sd = 1.0+/- 0.8 ppm
- percentiles: 50th - 0.86 ppm
  95th - 2.36 ppm
  max detect - 2.54 ppm
- fish intake data sketchy but comm. fish much more common than sportfish
- anecdotal reports of elevated blood Hg in non-occupational settings



CTDPH Commerical Advisory

- Swordfish and shark:
  - Do not eat if in high risk group
  - Everyone else - 1 to 2 meals per month
- Canned tuna lumped with other commercial fish - 1-2 meals per week
- Choose species low in Hg and PCBs - e.g., haddock, cod, flounder, salmon

Commercial Advisory for PCBs?

- LIS striped bass & bluefish - elevated PCBs
  - 303 bass (1994): avg = 1.18 ppm
  - 57 bluefish (1998): avg for >25" = 1.26 ppm
- CTDPH has recreational but no commercial advisory for these species
  - uncommon in marketplace in CT
  - questions about sources if do occur in market
- Need data on bluefish and striped bass in marketplace

Consumer Advisory for Commercial Fish

Maine Department of Human Services

Bureau of Health

Why Issue Advice on Commercial Fish?

- **It's the fish most commonly consumed**
  - **Women in focus groups asked for information**
  - **80% Maine women of childbearing age eat fish, BUT only 21% report eating any sport-caught fish**
  - **Higher hair mercury levels (e.g. > 1 ppm) associated with eating commercial fish**

Consumer Advisory for Commercial Fish

Guiding Principles

- **Wanted to follow / support updated US FDA advice**
  - **BECAUSE – want to avoid confusion & strive for consistency**
  - **BECAUSE – want buy-in from health care providers**
- **Wanted to redirect fish consumption behavior toward fish lower in mercury**
  - **SO, single out "light" vs "white" canned tuna**
  - **SO, provide limits for general population**
- **Keep it simple**

Consumer Advisory for Commercial Fish

Consumer Advisory for Commercial Fish

Ocean Fish and Shellfish

❖ Striped bass and bluefish	Limit:	For everyone, 2 meals per month	
❖ Swordfish, shark, tilefish and king mackerel	Limit:	• For pregnant and nursing women, women who may get pregnant, and children under 8, NO meals	FDA Advice
		• For all others, 2 meals per month	No FDA Advice?
❖ Canned tuna (the 6 ounce size) "White" tuna has more mercury than "light" tuna.	Limit:	• For pregnant and nursing women, women who may get pregnant, and children under 8, 1 can of "white" or 2 cans of "light" tuna per week	"White" vs "Light"
		No limits for all others as part of a balanced diet	
❖ All other ocean fish and shellfish including canned fish and shellfish	Limit:	• For pregnant and nursing women, women who may get pregnant, and children under 8, 2 meals per week	FDA Advice
		No limits for all others as part of a balanced diet	

Risk Communication Strategy

- **Target pregnant women**
  - **WIC clinics**
  - **OB/GYN, FP/OB, NMW**
- **Target fishing households with kids**
  - **Matches of Birth Certificate and Fishing License Registries**
- **Target newlyweds ?**
  - **Timed mailings based on marriage licenses**

Next Steps

- **Improve risk communication materials**
  - **Redesign brochure for more general population**
  - **Mixing and Matching Limits**
- **Evaluate effectiveness**
  - **Surveys of random samples from birth certificate registry**
    - ✓ **awareness of "safe eating guidelines"**
    - ✓ **fish consumption behavior (changes?)**
    - ✓ **hair mercury levels**

Acknowledgements

Funding Support

- **U.S. Environmental Protection Agency Office of Water**

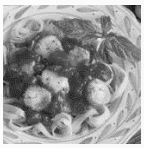
Collaborators

- **Henry Anderson & Laurie Draheim, Wisconsin Division of Family and Community Health**
- **Sue Stableford, UNE Adult Health Literacy Center**
- **Doug Campbell, Campbell Creative**

Methylmercury:
Ongoing Research on Toxicology

Kathryn R. Mahaffey, Ph.D.
U.S. Environmental Protection Agency, Washington, D.C.

Dietary Sources of Fish & Shellfish Vary Widely
Virtually All Contain Methylmercury



Current Toxicology Projects

- Brief note on NRC 2000 Methylmercury Assessment and US EPA's 2001 RfD
- ***Relation of biomonitoring measures.***
- Current reports on blood and hair mercury concentrations in the US
- ***Reports on adverse cardiac outcomes in adults***

Basis for US EPA's RfD for Methylmercury

"Methods and Rationale for Derivation of a Reference Dose for Methylmercury by the US EPA"

Deborah Rice, Rita Schoeny and Kathryn Mahaffey, *in press – Feb 2003*
Risk Analysis.

EPA's BMDL for Methylmercury Is Based On:

- Neuropsychological tests that indicate neuropsychological processes involved with a *child's ability to learn and process information.*
- ***Doubling*** the risk of scores in a range considered *clinically subnormal.*

Biomarkers of Mercury Exposure and the RfD

Relation of Cord/Fetal Blood Mercury Concentration and Maternal Blood Mercury Concentration

US EPA's Assessment of "Benchmark Dose Lower Bound" for Methylmercury

- BMDL based on a doubling of the prevalence of scores on tests of developmental function in a range recognized as clinically subnormal.
- Both US EPA and NRC utilized a BMDL of approximately 58 ug/L of ***cord*** blood.
- Dose conversion of ***cord*** blood [Hg] to ***maternal*** blood [Hg] assumed to be 1:1.

Comparison of Maternal Blood and Cord Blood Mercury Concentrations

Current risk assessments assume that cord blood and maternal blood [Hg] are equal.

More recent assessments indicate cord blood is, on average, 1.7 times higher in mercury than maternal blood concentrations.

58 ug/L cord blood [Hg] ~ 34 ug/L maternal blood [Hg]

Factors Contributing to Differences in Ratios

- Differences in kinetics of maternal distribution of methylmercury in her body.
- Differences in ratio of cord blood [CH3Hg] to maternal blood [CH3Hg]. Range of means from 2.17 to 1.08. Individual data far more variable. Vahter et al. (2000) reported 5th and 95th percentiles were 0.88 to 3.1.

Dose-Response on the Basis of Blood [Hg]

Cord [Hg] for BMDL: 58 ug/L

Maternal [Hg] at 1:1 cord:maternal ratio: 58 ug/L

Maternal [Hg] at 1.7:1 cord:maternal ratio: 34 ug/L

What range of maternal blood concentration are associated with a doubling of the prevalence of neuropsychological deficits?

Blood Mercury Concentrations in the United States Population

NHANES Data

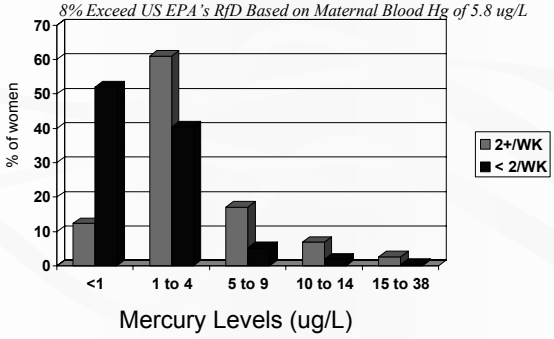
NHANES 1999/2000 - Blood Mercury

Women Ages 16 – 49 Years

Blood Hg Ug/L	*Number of Subjects*	*50th Percentile*	*90th Percentile*
Women	1709	0.94 (0.73 – 1.15)	4.84 (4.11 – 5.57)

Total Mercury Levels in Women, Aged 16-49 by Weekly Fish Consumption Levels

8% Exceed US EPA's RfD Based on Maternal Blood Hg of 5.8 ug/L



US EPA's Reference Dose for Methylmercury

Effects in Adults

Are there cardiovascular effects of low-dose exposure to methylmercury?

Adult Cardiovascular Effects
Association with Mercury Exposures

- Salonen et al. studied 1983 men living in Eastern Finland aged 42 to 60 years (Salonen et al., Circulation 91:645-655, 1955; Atherosclerosis 148:265-263, 2000).
- Report that mercury is a risk factor for coronary and fatal cardiovascular disease.
- Dietary intake of fish and mercury were associated with significantly increased risk of acute myocardial infarction and death from coronary heart disease, cardiovascular disease and any death.
- Men in the highest tertile (2 ppm and higher) hair mercury had a 2-fold (95% CI 1.2 to 3.1; P=0.005) age- and CHD-adjusted risk of AMI and a 2.9-fold (95% CI, 1.2 to 6.6; P 0.014) adjust risk of cardiovascular death.
- Carotid intima-media thickness increased with increases in hair mercury concentration. Suggest mercury accumulation in the human body associated with accelerated progress of carotid atherosclerosis (Salonen et al., 2000).

Methylmercury: Exposure and Effects

Setting a Methylmercury Reference Dose (RfD) for Adults

Alan H. Stern, Dr.P.H., DABT

Division of Science, Research & Technology
New Jersey Department of Environmental Protection

Trenton NJ

The Two-Tiered Advisory Structure

- The policy of the U.S. EPA is to derive a single RfD per chemical
  - based on goal of protecting most sensitive group
  - generally, members of the sensitive group are not known, or cannot control their exposure (e.g., air, drinking water)
    - therefore, protection of sensitives results in overprotection of general population

- However, for MeHg, the sensitive population is well characterized
  - women of childbearing age, pregnant women, young children
- Individuals have reasonable control over exposure
  - consumption of fish with lower Hg conc.

- In principle, this lends itself to a two-tiered advisory structure
  - sensitive population and general population
  - general population is not overly protected and has less potential limitations on obtaining nutritional value from fish
  - sensitive population is protected at more stringent level

- Two-tiered approach based on two RfDs
  - neuro-developmental effects for sensitive population
    - current RfD
  - neurological effects for general population
    - paraesthesia – predictive and protective for progression of neurological effects
    - old RfD
      - from Iraq and Minimata

- Currently, 12-13 states follow such a two-tiered approach
- Appropriateness of approach is predicated on assumption:

$$Rfd_{gen} > RfD_{sens}$$

- Current RfD = 0.1 ug/kg/day

  Old RfD = 0.3 ug/kg/day
  - difference is small, but significant for fish advisories

- Is assumption that $Rfd_{gen} > RfD_{sens}$ correct?
- NAS/NRC report highlights several areas of uncertainty for general ("adult") RfD
  - cardiovascular effects
  - immunotoxic effects

Summary of reported findings for cardiovascular endpoints for MeHg

- Salonen et al. (1995)
  - middle aged Finnish men
  - mean hair Hg = 1.92 ppm
    - approx. 2.3 times NJ general pop. mean
  - for hair Hg >2 ppm, adjusted RR for

    AMI, CHD, and CVD = 1.7-2.1
    - in NJ ~20% of general population >2 ppm

- Salonen et al. (2000)
  - middle aged men in Finland
  - 4 year follow-up assessing hair Hg, and atherosclerosis progression
    - ultrasound determination of carotid artery thickness
  - after adjustment for co-variates, men in upper quintile of hair Hg (2.8 ppm) had 40% increase in arterial wall thickness

Implications for Hg Fish Advisory Structure

- $RfD_{general} > RfD_{sensitive}$
  - retain two tiered advisory structure
    - currently only separated by 0.2 ug/kg/day
    - if $RfD_{general}$ decreases by 0.1 ug/kg/day will difference in advisories be significant?
- $RfD_{general} < RfD_{sensitive}$
  - one advisory?
    - does cardiovascular endpoint apply to women?

EPA Sponsored Effort

- Contract with State of NJ (in process)
  - PI - Dr. Alan H. Stern
  - Co-PI Dr. Andy E. Smith, ME
- State toxicologists, epidemiologists, risk assessors
  - 6-7 states represented
- independent consultants in statistics and cardio-epi
- 12-18 months duration

Occurrence of PBDE Flame Retardants in Fish

Robert C. Hale Virginia Institute of Marine Science

VIMS: M. La Guardia, E. Harvey, M. Mainor, E. Bush, M. Gaylor, S. Ciparis, M. Jacobs & D. Luellen

Virginia Dept. of Environmental Quality: J. Gregory, A. Barron, G. Darkwah & R. Browder

Brominated Flame Retardants (BFRs)

- Chemicals added (up to 30% by weight) to reduce fire hazard associated with our wide use of flammable polymers & textiles

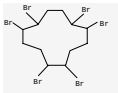
BFR use saves:

Lives

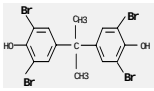
Property

Environmental damage

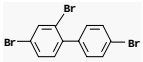
Brominated Flame Retardants (BFRs) Differ in Structure



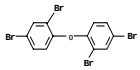
Hexabromocyclododecane (HBCD)



Tetrabromobisphenol-A (TBBP-A)

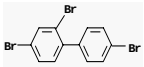


Polybrominated Biphenyls (PBBs)



Polybrominated diphenyl Ethers (PBDEs)

Once upon a time… we stopped using PBBs



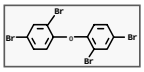
Learned that their structural similarity to PCBs and other *persistent, bioaccumulative & toxic* (PBT) chemicals was problematic

PBBs accidentally introduced into MI livestock feed in 1973

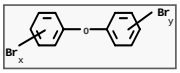
Destroyed large numbers of animals

MI residents still carry PBB burdens.

Shhhh….Apparently we shifted to PBDEs instead…

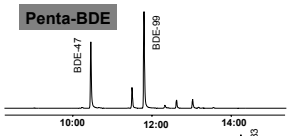


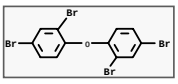
3 Commercial PBDE Mixes

	Uses Nondispersive?	1999 Demand American % of global use
Deca-BDE	Thermoplastics & textiles	24,300 MT 44.3 %
Octa-BDE	ABS plastics	1375 MT 35.9 %
Penta-BDE	Polyurethane foam	8290 MT 97.5 %!!!

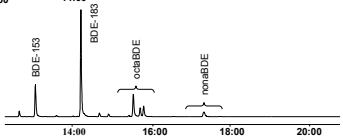
Commercial PBDE products

Penta-BDE

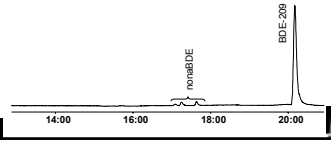




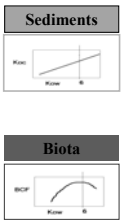
Octa-BDE

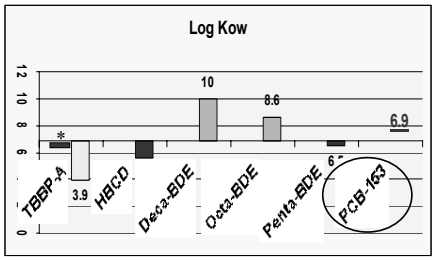


Deca-BDE



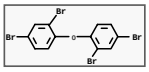
K_{ow} of BFRs versus PCB-153 Bioaccumulation & sediment partitioning





* Methylated TBBP-A log Kow 6.4

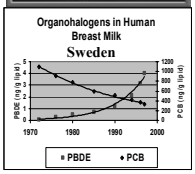
PBDEs: General Environmental Concerns



- Resistant to environmental degradation
- Long-range transport – POP?
  - Less brominated congeners – atm transport
- Accumulation in fish is a major pathway for human exposure – as per PCBs
- PBDEs accumulate in lipid-rich tissues
  - Penta-BDE mix > Octa-BDE > Deca- BDE
    - BDE-47 bioconcentration > PCBs

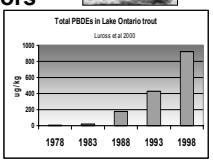
PBDE Research: Europeans More Active

- Reporting PBDEs in fish, mostly less brominated, since 1980's
- Detected even in remote areas
  - Arctic & deep ocean
- Rising in human breast milk
- E.U. Ban of Penta- mix in 2003
- Concern turning to Deca-BDE
  - Debromination?



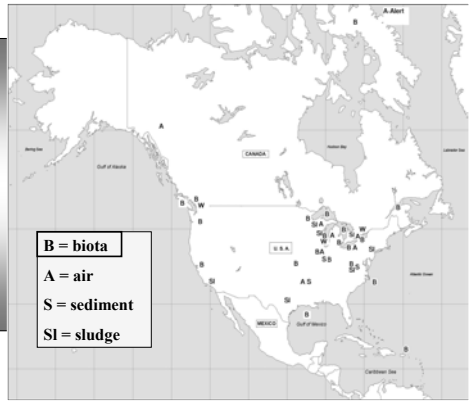
Overview: PBDEs in U.S.

- No specific U.S. regulations or widespread monitoring
- Detected in U.S. aquatic environment in 1987
  - EPA: Atlantic dolphin mortality event
    - Tetras – Hexa PBDEs ~ 200 ug/kg (lipid)
- Marine mammals high accumulators
  - Indigenous populations at future risk?
  - San Fran Harbor seal 8325 ug/kg
    - 65-fold increase from 1988-2000
- U.S. fish increasing over time
  - Penta-like congeners most common



Reports of PBDEs in North America limited- despite our high Penta- use

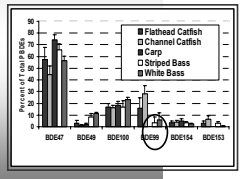
PBDE flame retardants in the North American Environment submitted to: *Environment International* 2002



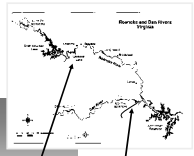
Case Study: PBDEs in Virginia Fish

In: Environ. Sci. Technol. 2001

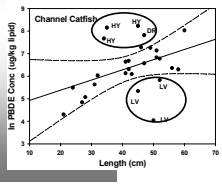
- VA DEQ/VIMS fish PCB study
- 1998-9 Roanoke Basin
- PBDEs ubiquitous in fish?
  - BDE-47 in 89% of Roanoke Basin fish fillets composited fillets (133 sites, n=332)
- 40-70% BDE-47; followed by –100 & -99
  - Carp anomalously low in BDE-99
  - Derived from Penta- mixture?
  - Deca- & Octa-BDEs absent



PBDEs in VA Fish

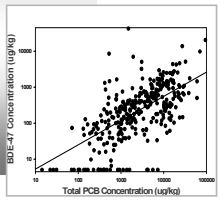


- In Roanoke/Dan River VA Basin
  - 16 "warm" spots (>1000 ug/kg lipid basis)
    - Highest in Hyco River
    - Lowest in Leesville Lake
      - surrounded by dams
  - Suggests local PBDE sources
    - *Debunks* "historical drilling muds" & "marine sponge" explanations



PBDEs in VA Fish

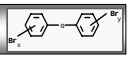
- Roanoke Basin fish among highest PBDEs in world
  - Home to numerous textile mills & furniture manufacturers
- Basin has historical PCB issues
  - PCBs/PBDEs in fish often correlated
    - …but not always
    - …different uses of PCBs & PBDEs
- BDE-47 conc. rivaled PCB-153 in half of fish samples



PBDEs in VA Fish

- One VA "hot" spot
  - "Innocuous" Hyco River skirts VA/NC border
    - Small tributary of the Dan River
  - Exceeded Viskan River fish (Sweden)
  - Carp fillet 47,900 ug/kg (lipid), PCBs low
    - Equivalent to 1000-2000 ug/kg wet
    - VDH set fish advisory limit of 5000 ug/kg
    - Source remains under investigation
      - Sewage treatment plant related?

PBDE Take-Home Concepts



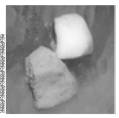
- BFRs serve a crucial role
- 3 PBDE mixes have different uses, properties & risks
- Penta-BDE product most bioaccumulative in fish
- U.S. uses 98% of global Penta-BDE production
- PBDEs are now ubiquitous & environmental levels increasing
- Point & nonpoint sources of PBDEs exist, magnitudes uncertain
- Congener pattern in fish differs from commercial mixtures
  - Impacts risk calculation
  - Complicates source & fate determination

PUF as a Source of BDEs to Sludge?

BDEs in foam?

10% of 1 kg=100g

Exposure to UV & weather



Foam yellows, surface fragments

Foam fragments carried to STP

Sorption & inclusion in solids

STP Sludge 100,000 kg @ 1000 µg/kg!

PBDEs: Toxicology and Human Exposure

Linda S. Birnbaum, Ph.D., D.A.B.T.
NHEERL/ORD/US EPA

Major Industrial Products
(~67 metric tons/year)

- DBDE – largest volume (75% in EU)
  - 97% DBDE; 3% NBDE
  - Polymers, electronic equipment>textiles
- OBDE
  - 6%HxBDE; 42%HpBDE; 36% OBDE; 13%NBDE; 2%DBDE – multiple congeners (unclear if any PeBDE)
  - Polymers, esp. office equipment
- PeBDE
  - Textiles – esp. polyurethane foams (up to 30%)
  - Recommended ban in EU(no production/only import)
  - Mainly PeBDE+TeBDE, some HxBDE

PBDEs in Biotic and Abiotic Samples

- Air: 47>99>100>153=154
- Sediment: 99>47 (pattern reflects commercial PeBDE); also some nona and deca
- Sewage Sludge: 1-3mg/kg in US; pattern ~PUFs
  - Point sources (~DBDE) --->0.1-5 mg/kg
- Biota: 47>99=100 except if near manufacturing site (pattern does NOT reflect commercial PBDEs)
- Invertebrates≤Fish<<marine mammals

PBDEs (con) Ecotoxicity

- PeBDE>>OBDE>DBDE
  - Highly toxic to invertebrates (Larval development, LOECs in low µg/l range)
- DBDE/OBDE
  - May be low risk to surface water organism and top predators
  - Concern for waste water, sediment, and soil organisms
  - CONCERNS:
    - Presence of lower brominated congeners in OBDE
    - Photolytic and/or anaerobic debromination
    - Formation of PBDDs/PBDFs

Mammalian Toxicity of PBDEs

- Hepatotoxic
- Enzyme Induction
- DBDE – hepatocarcinogen (high dose)

Neurotoxic Effects

- Developmental Neurotoxicants
  - Perinatal; neonatal – pnd10 in mice
  - 47,99,153,209
  - Spontaneous behavior (mice)/hyperactivity
  - Permanent changes in brain function
- Developmental exposure -→Increased susceptibility of adults exposed to low doses of PBDEs
- *In vitro* changes in signalling pathways

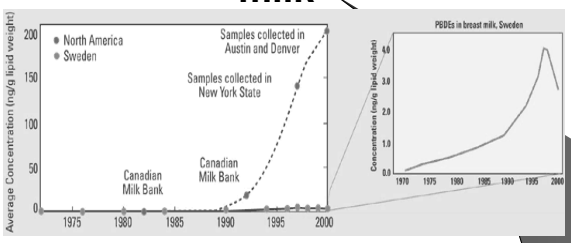
Endocrine Disrupting Effects

- AhR Effects
  - Relevance for commercial BFRs?
    - combustion can produce PBDDs/PBDFs
    - Recently found in human adipose tissue
- Thyroid
  - OH-PBDE metabolites bind to transthyretin
  - Parent PBDEs - Effects on T4 seen *in vivo*
    - induction of UDP-glucuronyl transferase
    - Rats and mice; body burdens as low as 0.8 mg/kg
- Estrogenic
  - OH-PBDEs
  - Sulfotransferase inhibition (mostly *in vitro)*

Pharmacokinetics of PBDEs

- Absorption – DBDE is poorly absorbed
- Distribution – lipid binding is important
  - Fat: 47>99>>>209
  - Liver: covalent binding from 99,209
- Metabolism – hydroxylation, debromination, O-methylation
- Excretion – feces is major route

Trends of BDEs in human milk



Betts : Env Sci Technol Dec, 2001

Total BDEs in contemporary human milks (ng/kg lipid) (Ryan and Patry, 2002)

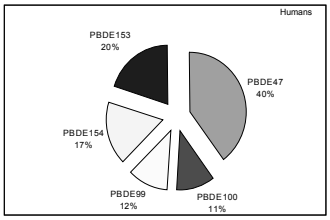
Country	No samples	Year	Median	Mean
Sweden	93	1996-1999	3.2	4.0
Japan	12	2000 ?	1.4	1.3
Canada	50	2001-02	25	64
USA (adipose)	23	1998	41	86

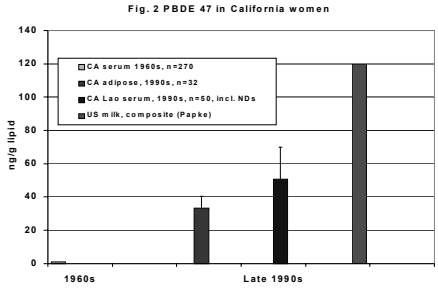
Total BDEs (n=7) in Canadian individual human milks (ng/kg lipid) (Ryan and Patry, 2002)

Location	No samples	Year	Median	Mean
Canada	72	1992	3.0	15
Canada	50	2002	25	64

PBDEs in Human Samples

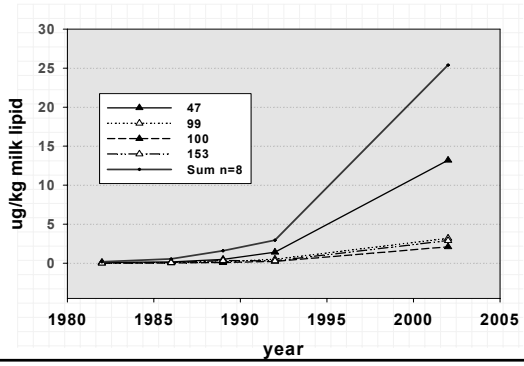
(Petreas et al., 2002)

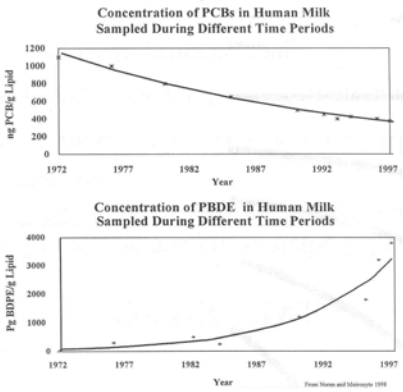




(Petreas et al. 2002)

Time Trends of BDEs in Canadian Breast Milk (Ryan and Patry, 2002)





Ryan and Patry, 2002

PBDEs in Human Samples

- Pattern of congeners is different from commercial mixtures (and food)
  - 47>99 in US and Europe(others: 100,153,183, 209?)
  - In Japanese, 99 and 153>47
- Large interindividual differences
- Increasing time trends – levels doubling every 2-5 years
- PBDEs and PCBs levels are not correlated
  - In most samples today, PCBs>PBDEs
- different sources and/or time sequence

Time Trends of Biotic Levels

- Rapid increases from 70s thru 90s
- Maybe slight decrease in Sweden
  - Ban on use of PeBDE?
- Levels still increasing in America
  - Continued use of PeBDE?
- ARE LEVELS HIGH ENOUGH TO SEE EFFECTS??? NEED MORE TOX DATA!

What next?

- More systematic human and environmental monitoring
- More information on fate and transport – are commercial products breaking down? And into what?
- More tox data - Focus on congeners present in people and wildlife, NOT commercial products since they are altered in the environment

Polybrominated Diphenyl Ethers (BDEs)

Khizar Wasti, Ph.D.

Virginia Department of Health

Phone: (804) 786-1763
FAX: (804) 786-9510
E-mail: kwasti@vdh.state.va.us

http://www.vdh.state.va.us/hhcontrol

Toxicity of Deca-BDE

- The acute toxicity in experimental animals is low; oral LD50 in rats is >5mg/kg.
- No adverse effects were noted in rats fed at doses of up to 800 mg/kg BW for 30 days
- No evidence of carcinogenic, reproductive, teratogenic, or mutagenic effects
- Epidemiological studies in occupationally exposed workers did not indicate any symptoms attributable to BDEs exposure
- Oral RfD 0.01 mg/kg/day

Toxicity of Octa-BDE

- Low acute oral toxicity; LD50 in rats >5-28 g/kg
- Low chronic toxicity
- Teratogenicity-at doses of 25 and 50 mg/kg BW, resorptions or delayed ossification of different bones and fetal malformations were noted in rats. These changes were not seen at 15 mg/kg or less. In rabbits there was no teratogenicity, but fetotoxicity was seen at maternally toxic dose of 15 mg/kg. A no-effect level was 2.5 mg/kg
- Mutagenicity- negative
- Carcinogenicity- no data available
- IRIS Data Base- Oral RfD 0.003 mg/kg/day

Toxicity of Penta-BDE

- Low acute oral toxicity; LD50 in rats 6-7 g/kg
- Rats given diet containing 100 mg/kg for 90 days showed no clinical effects
- Not found to be mutagenic
- No data on carcinogenicity
- IRIS Data Base- Oral RfD 0.002 mg/kg/day

Toxicity of Tetra-BDE

- Virtually no human or animal data are available
- Toxicity may be similar to commercial Penta-BDE since it contains significant amount of tetra-isomer

Derivation of Allowable BDE Levels in Fish

Based on oral RfD,

Penta-isomer	0.002 mg/kg/day
Octa- isomer	0.003 mg/kg/day
Deca-isomer	0.01 mg/kg/day

BDE Task Force

- Virginia Department of Health
- Virginia Department of Environmental Quality
- Virginia Department of Game and Inland Fisheries
- Virginia Institute of Marine Sciences
- North Carolina Department of Health and Human Services
- North Carolina Department of the Environment
- U.S. Environmental Protection Agency
- Centers for Disease Control and Prevention

Selection of RfD for Risk Assessment

- Use the RfD value for penta-isomer, 0.002 mg/kg/day
- EPA suggested an interim RfD for tetra-isomer, 0.001 mg/kg/day. This RfD was based on the assumption that the tetra-BDE was twice as toxic as the penta-isomer

Derivation of Acceptable Concentration in Fish

$$C = \frac{RfD \times BW \times T}{MS \times NM}$$

C = acceptable concentration
RfD= reference dose
BW = average adult weight (70 kg)
T = Time period, 30 days/month
MS = meal size, 8-ounce or 0.227 kg
NM = number of meals/month, 2

Allowable Concentration of BDEs in Fish for Two Meals per Month

$$\frac{0.001 \text{ mg/kg/day} \times 70 \text{ kg} \times 30 \text{ days/month}}{0.227 \text{ kg/meal} \times 2 \text{ meals/month}}$$

= 4.62 ~ 5.0 mg/kg or parts per million (ppm)

Number of Allowable Fish Meals per Month at Various BDE levels

Concentration	# of Meals per month
1 ppm	9.3
1.47 ppm	6.3
2 ppm	4.6
3 ppm	3.1
4 ppm	2.3
5 ppm	1.9
9 ppm	1
10 ppm	0.9

Guidance for Issuing Fish Consumption Advisories

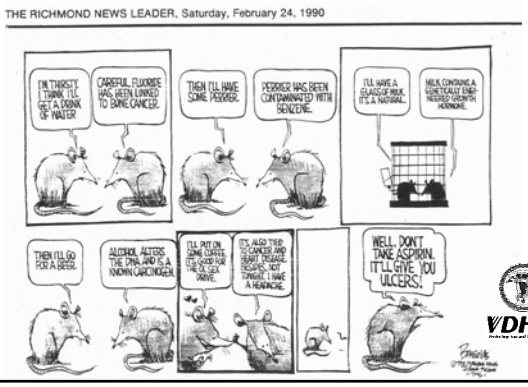
BDE concentrations

- Below 5 ppm — No Advisory
- 5 ppm - < 10 ppm — Two 8-oz meals/month
- >10 ppm — No consumption

Since reproductive or developmental effects of tetra-BDE have not yet been evaluated, it would be prudent for pregnant women, nursing mothers, and young children to avoid consumption of fish contaminated with BDEs above 5 ppm

The Dose Makes the Poison

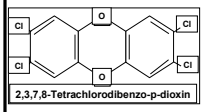
Not every contaminant (in low concentrations) is harmful



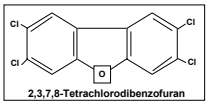
EMERGING SCIENCE OF THE DIOXIN REASSESSMENT

Dwain Winters
Director Dioxin Policy Project
Office of Pollution Prevention and Toxics
US EPA
202 566 1977
winters.dwain@epa.gov

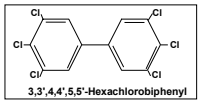
Dioxin-Like Compounds



2,3,7,8-Tetrachlorodibenzo-p-dioxin



2,3,7,8-Tetrachlorodibenzofuran



3,3',4,4',5,5'-Hexachlorobiphenyl

Dioxins
75 congeners
7 toxic

2,3,7,8-TCDD
1,2,3,7,8-PeCDD
1,2,3,4,7,8-HxCDD
1,2,3,6,7,8-HxCDD
1,2,3,7,8,9-HxCDD
1,2,3,4,6,7,8-HpCDD
1,2,3,4,6,7,8,9-OCDD

Furans
135 congeners
10 toxic

2,3,7,8-TCDF
1,2,3,7,8-PeCDF
2,3,4,7,8-PeCDF
1,2,3,4,7,8-HxCDF
1,2,3,6,7,8-HxCDF
1,2,3,7,8,9-HxCDF
2,3,4,6,7,8-HxCDF
1,2,3,4,6,7,8-HpCDF
1,2,3,4,7,8,9-HpCDF
1,2,3,4,6,7,8,9-OCDF

PCBs
209 congeners
12 toxic

3,3',4,4'-TeCB
3,3',4,4',5-PeCB
3,3',4,4',5,5'-HxCB
Plus 9 others

Toxic Equivalency (TEQ)

- *Fundamental to evaluation of this group of compounds*
- *Based on inspection of multiple endpoints and/or receptor binding (WHO criteria)*
- *Reassessment Chapter Summarizes Scientific Support*
- *WHO_{98} internationally accepted*

Five Compounds Make up About 80% of the Total TEQ in Human Tissue

- **Four of 17 Toxic CDD/CDF Congeners**
- **One of the 12 toxic PCBs**
  - ***2,3,7,8-TCDD***
  - ***1,2,3,7,8-PCDD***
  - ***1,2,3,6,7,8-HxCDD***
  - ***2,3,4,7,8-PCDF***
  - ***PCB 126***

Current Dioxin Exposure/Body Burdens

- **~ 1 PG TEQ/Kg/Day (PCDDs/PCDFs/PCBs)**
- **Possible Higher Intake Populations**
  - **Nursing infants**
  - **Fatty Diet**
  - **Some subsistence fishermen and farmers in proximity to contamination**

Body Burden Best Dose Metric

(Ng/Kg BW)

- *Accounts for differences in half-life*
- *Results in strong agreement between human and animal data*
- *Adopted by WHO, EC, HHS*

Dioxins and Human Carcinogenicity

2,3,7,8-TCDD	➔	**Carcinogenic to humans**
Other dioxin-like compounds	➔	**Likely to be carcinogenic**
Complex Environmental Mixtures	➔	**Likely to be carcinogenic**

Based on:
- **Unequivocal animal carcinogen**
- **Limited human information (epidemiological/other)**
- **Mechanistic plausibility**

Cancer potency increasingly focusing on human studies

Note: (IARC) classified TCDD as a Category 1, "Known" human carcinogen. DHHS 9th Report on Carcinogens (ROC) the same

Quantitative estimate of cancer risk

- **Cancer slope factor is based primarily on recently published analyses of human studies and is revised upward by a factor of ~6 over the 1985 EPA value based on 1978 study in rats**
- **Cancer risks to the general population may exceed 10^{-3} (1 in 1,000) from background (dietary) exposure but are likely to be less and may even be zero for some individuals**

Non-cancer Toxicants in Animals and Humans

- ➔ Developmental Toxicity
  Targets:
  - Developing Immune System
  - Developing Nervous System
  - Developing Reproductive System
- ➔ Immunotoxicity
- ➔ Endocrine Effects
- ➔ Chloracne
- ➔ Others

Body Burdens Associated With Non-Cancer Effects

➔ **Adverse Effects**	**Ng/Kg**	**MOE***
➢ *Developmental neurotoxicity:*	22	*4*
➢ *Developmental/reproductive toxicity:*	0.7 - 42	*0.1 - 8*
➢ *Developmental immunotoxicity:*	50	*10*
➢ *Adult immunotoxicity:*	1.6 - 12	*0.3 - 2*
➢ *Endometriosis:*	22	*4*
➔ **Biochemical Effects**		
➢ *CYP1A1 Induction:*	0.6 - 33	*0.1 - 7*
➢ *CYP1A2 Induction:*	2.1 - 83	*0.4 - 17*

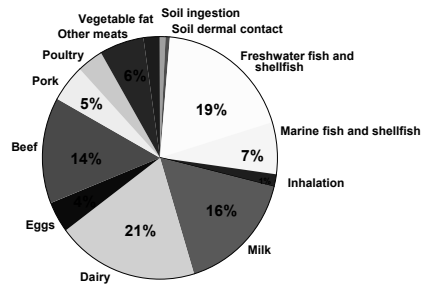
***MOE = effect level / current average U.S. background body burdens of 5 Ng/Kg**

Characterization of Non-Cancer Effects

- **Identification of non-cancer effects in animals and human are sufficient to generate a similar level of concern to cancer**
- **Adverse non-cancer effects have been observed in animal and humans within 10 times background exposure.**
- **It is likely that part of the general population is at, or near, exposure levels where adverse effects can be anticipated**
- **EPA will rely on MOE rather than RfD as the risk descriptor for dioxin non-cancer risk**

U.S. Adult Average Daily Intake of CDDs/CDFs/ Dioxin - Like PCBs

65 pg TEQ_{DFP}-WHO_{98}/day



U.S. Levels in Food CDD/CDF/PCB

TEQ_{WHO98} (whole weight basis)

Media	CDD/CDF[a]	References	PCB[a]	References	Total
Beef ppt	n=63 **0.18** ± 0.11 Range = 0.11 - 0.95	Winters et al. (1996a)	n = 63 **0.084**	Winters et al. (1996b)	**0.26**
Pork, ppt	n=78 **0.28** ± 0.28 Range = 0.15 - 1.8	Lorber et al. (1997b)	n = 78 **0.012**	Lorber et al. (1997b)	**0.29**
Poultry, ppt	n=78 **0.068** ± 0.070 Range = 0.03 - 0.43	Ferrario et al. (1997)	n = 78 **0.026**	Ferrario et al. (1997)	**0.094**
Milk, ppt	n=8 composites **0.018**	Lorber et al. (1998b)	n = 8 composites **0.0088**	Lorber et al. (1998b)	**0.027**
Dairy, ppt	n = 8 composites 0.12	Based on data from Lorber et al. (1998b)	n = 8 composites **0.058**	Based on data from Lorber et al. (1998b)	**0.18**
Eggs, ppt	n=15 composites **0.081**[c]	Hayward and Bolger (2000)	n = 18 plus 6 composites **0.10**[d,e]	Schecter et al. (1997) Mes and Weber (1989), Mes et al.	**0.13**
Vegetable Fats, ppt	n=30 **0.056** ± 0.24[g]	Versar (1996b)	n = 5 composites **0.037**[c]	Mes et al. (1991)	**0.09**
Freshwater Fish and Shellfish, ppt	n=222 **1.0**[d]	Fiedler et al. (1997), Jensen and Bolger (2000), Jensen et al. (2000), U.S. EPA (1992)	n = 1 composite of 10 samples plus 6 composites **1.2**[de]	Schecter et al. (1997) Mes and Weber (1989), Mes et al. (1991)	**2.2**
Marine Fish and Shellfish,	n=158 **0.26**[d]	Fiedler et al. (1997a), Jensen et al. (2000)	n = 1 composite of 13 **0.25**[d,e]	Schecter et al. (1997), Mes et al. (1991)	**0.57**

Background CDD/CDF TEQs in Fish and Shellfish, Consumption Rates, and Intakes

Fish Class	Species	Consumption Rate (g/day)	N	CDD/CDF TEQ Conc. (Pg/g fresh wt.)	CDD/CDF TEQ Intake (pg/day)
Estuarine Finf	Flounder (e)(f)	0.58	3	1.8	1.0
	Rockfish/Striped Bass (d)	0.043	26	1.2	0.052
	Salmon (d)	0.042	39	0.57	0.024
	Mullet (a)	0.034	2	0.068	0.0023
	Other				
	Flatfish	0.39	0		
	Perch	0.19	0		
	Croaker	0.13	0		
	Herring	0.12	0		
	Anchovy	0.042	0		
	Smelts	0.0074	0		
	Eel	0.0038	0		
	Sturgeon	0.00017	0		
	Total Other*	0.88	0	1.3	1.1
Freshwater Finfish	Catfish-farmed (b,d,h)	0.90	30	2.0	1.8
	Trout-farmed (e,h)	0.41	6	1.9	0.78
	Perch (e) (walleye)	0.17	3	1.2	0.20
	Carp (e)	0.14	4	1.2	0.17
	Pike (e) (pickerel)	0.035	3	0.49	0.017
	Salmon (d)	0.00083	39	0.57	0.00047
	Other				
	Whitefish	0.012			
	Cisco	0.0012	0		
	Smelts	0.00050	0		
	Rainbow	0.00017	0		
	Sturgeon	0.014	0		
	Total Other*		0	1.3	0.018
Total Freshwater/Est. Finfish		**3.3**	**116**	**1.6**	**5.3**
Freshwater/Estuarine Shellfish	Shrimp (b,c)	2.0	19	0.080	0.16
	Crab Average (i)	0.30	33	0.37	0.11
	Oyster Average (i)	0.15	18	0.47	0.070
	Scallop (d)	0.0011	11	0.16	0.00018
	Crayfish (i)	0.0090	25	0.30	0.0027
	Other				
	Clam	0.014	0		
	Snails	0.0017	0		
	Total Other**	0.0157	0	0.43	0.0068
Total Freshwater/Est. Shellfish		**2.5**	**106**	**0.14**	**0.35**
Unknown Freshwater/Est. Species	Fish***	0.14	0	1.3	0.18
Total Fresh./Est. Fish		**5.9**	**222**	**1.0**	**5.8**

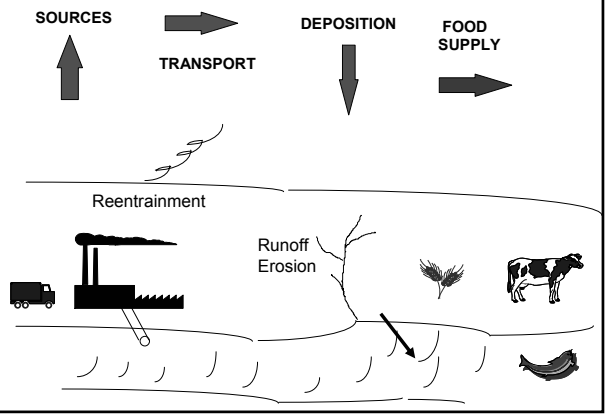
Background CDD/CDF TEQs in Fish and Shellfish, Consumption Rates, and Intakes

Fish Class	Species	Consumption Rate (g/day)	N	CDD/CDF TEQ Conc. (Pg/g fresh wt.)	CDD/CDF TEQ Intake (pg/day)
Marine Finfish	Tuna (c)	3.1	16	0.060	0.19
	Cod (c)	1.4	18	0.15	0.21
	Salmon (d)	1.3	39	0.57	0.74
	Pollack (d)	0.25	19	0.22	0.055
	Mackerel (a)	0.11	1	0.95	0.10
	Other				
	Porgy	0.36	0		
	Haddock	0.31	0		
	Whiting	0.26	0		
	Squid	0.17	0		
	Perch	0.13	0		
	Sardine	0.12	0		
	Sea Bass	0.10	0		
	Swordfish	0.098	0		
	Pompano	0.084	0		
	Octopus	0.073	0		
	Flatfish	0.045	0		
	Halibut	0.035	0		
	Snapper	0.032	0		
	Whitefish	0.012	0		
	Smelt	0.0066	0		
	Shark	0.0046	0		
	Roe	0.0011	0		
	Total Other****	1.8	0	0.39	0.72
Total Marine Finfish		**8.0**	**93**	**0.25**	**2.0**
Marine Shellfish	Scallop (d)	0.19	11	0.16	0.030
	Lobster (d)	0.19	16	0.26	0.049
	Crab (d)	0.16	38	0.36	0.058
	Other				
	Clams	0.70	0		
	Mussels	0.070	0		
	Conch	0.0021	0		
	Snails	0.0017	0		
	Total Other****	0.77	0	0.26	0.20
Total Marine Shellfish		**1.3**	**65**	**0.26**	**0.34**
Unknown Marine Species	Seafood (g)***	0.080	0	0.39	0.031
	Fish***	0.220	0	0.39	0.09
Total Marine Fish		**9.6**	**158**	**0.26**	**2.5**
TOTAL FISH		**15.5**	**292**(j)	**0.53**	**8.3**

Pathways and Sources of Human Exposures

- **Pathways:**
  - ➔ **Ingestion of soil, meats, dairy products, fish**
  - ➔ **Inhalation of vapors and particulates**
  - ➔ **Dermal contact with soil**
- **Sources:**
  - ➔ **Combustion**
  - ➔ **Metal Smelting, Refining, Processing**
  - ➔ **Chemical manufacturing**
  - ➔ **Biological and Photochemical Processes**
  - ➔ **Reservoir sources**

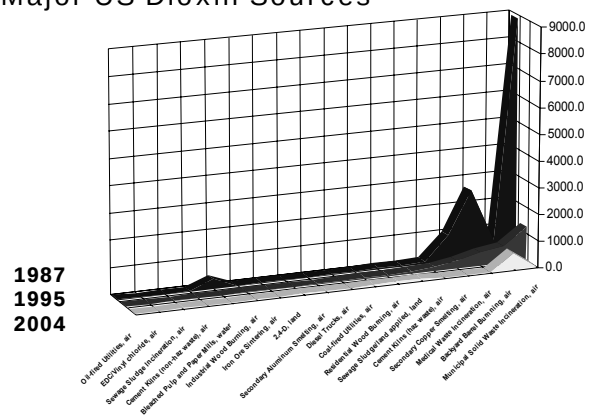
Sources and Pathways to Human Exposures



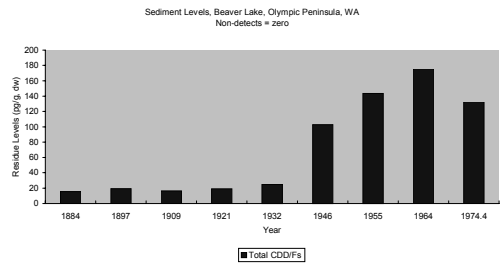
Inventory of Sources of Dioxin in the U.S.	1987 Estimate (g TEQ/yr)	1995 Estimate (g TEQ/yr)	% change
Municipal Solid Waste Incineration, air	8877.0	1250.0	38%
Backyard Barrel Burning, air	604.0	628.0	19%
Medical Waste Incineration, air	2590.0	488.0	15%
Secondary Copper Smelting, air	983.0	271.0	8%
Cement Kilns (haz waste), air	117.8	156.1	5%
Sewage Sludge/land applied, land	76.6	76.6	2%
Residential Wood Burning, air	89.6	62.8	2%
Coal-fired Utilities, air	50.8	60.1	2%
Diesel Trucks, air	27.8	35.5	1%
Secondary Aluminum Smelting, air	16.3	29.1	1%
2,4-D, land	33.4	28.9	1%
Iron Ore Sintering, air	32.7	28.0	1%
Industrial Wood Burning, air	26.4	27.6	1%
Bleached Pulp and Paper Mills, water	356.0	19.5	1%
Cement Kilns (non-haz waste), air	13.7	17.8	1%
Sewage Sludge Incineration, air	6.1	14.8	0%
EDC/Vinyl chloride, air	NA	11.2	0%
Oil-fired Utilities, air	17.8	10.7	0%
Crematoria, air	5.5	9.1	0%
Unleaded Gasoline, air	3.6	5.9	0%
Hazardous Waste Incineration, air	5.0	5.8	0%
Lightweight ag kilns, haz waste,air	2.4	3.3	0%
Kraft Black Liquor Boilers, air	2.0	2.3	0%
Petrol Refine Catalyst Reg., air	2.2	2.2	0%
Leaded Gasoline, air	37.5	2.0	0%
Secondary Lead Smelting, air	1.2	1.7	0%
Paper Mill Sludge, land	14.1	1.4	0%
Cigarette Smoke, air	1.0	0.8	0%
EDC/Vinyl chloride, land	NA	0.7	0%
Primary Copper, air	0.5	0.5	0%
EDC/Vinyl chloride, water	NA	0.4	0%
Boilers/industrial furnaces	0.8	0.4	0%
Tire Combustion, air	0.1	0.1	0%
Drum Reclamation, air	0.1	0.1	0%
TOTALS	13,995	3,252	
Percent Reduction from 1987		77%	

updated 3/08/01

Major US Dioxin Sources



20th Century Trend



Poorly Characterized Sources

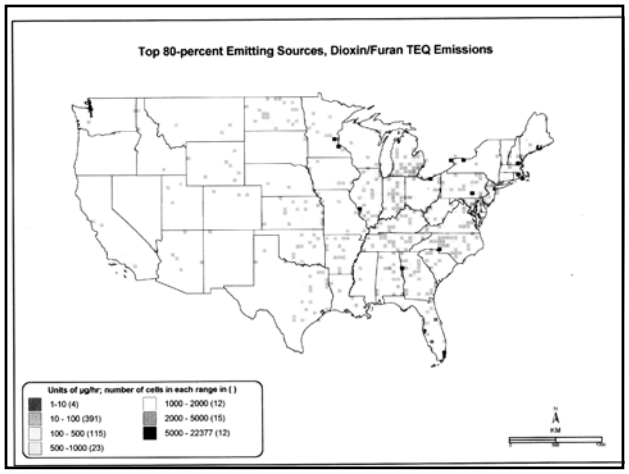
- Secondary steel electric arc furnaces
- Coke production
- Ceramic manufacturing
- Clay processing
- Ferrous and non-ferrous foundries
- Asphalt mixing plants
- Primary magnesium
- TiO_2
- Wood stoves
- Forest fires
- Brush fires
- Range fires
- Ag burning
- Landfill fires
- Structural fires
- Landfill flares
- Rural soil erosion to water
- Urban runoff to surface water
- Utility poles and storage yards
- Landfill fugitive emissions
- Transformer storage yards

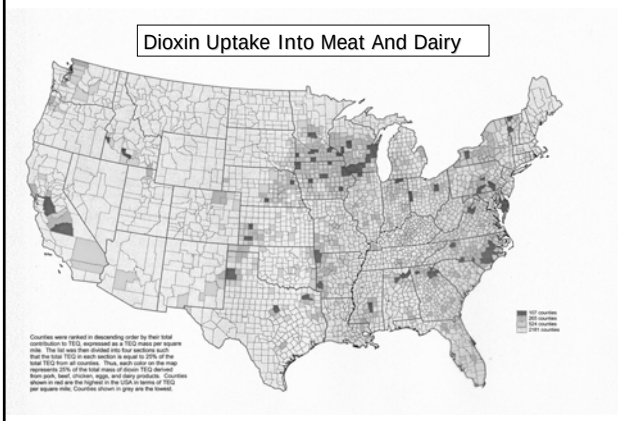
Reservoir Sources

Old releases of dioxins that are temporarily stored in environmental compartments to later be reintroduced into the circulating environment:

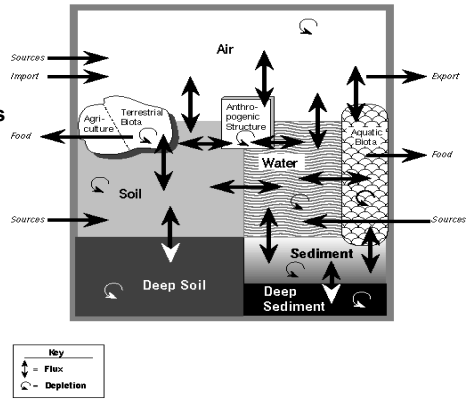
- **Soil**
- **Sediment**
- **Biota**
- **Materials**

Reservoirs contribute as much as 50% to general population exposure.



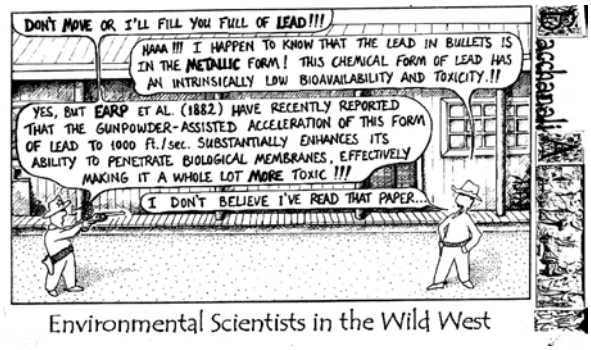


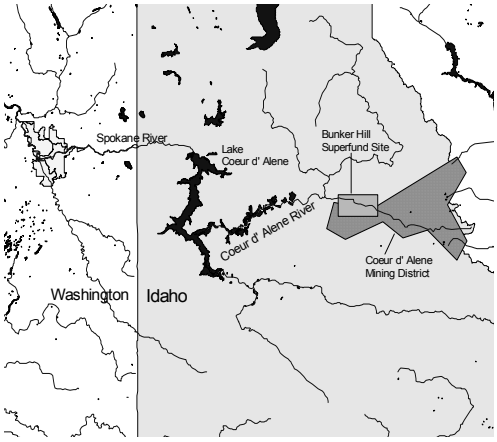
Fluxes Among Dioxin Reservoirs



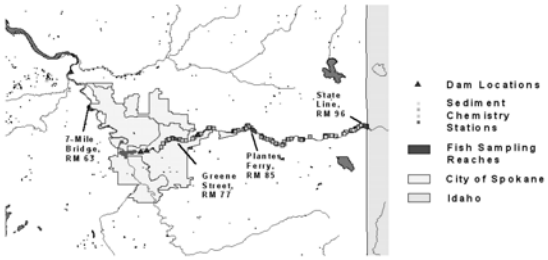
Application of the Lead IEUBK Model to Assess Spokane River Fish Consumption Health Risks

Lon Kissinger, U.S. EPA Region 10

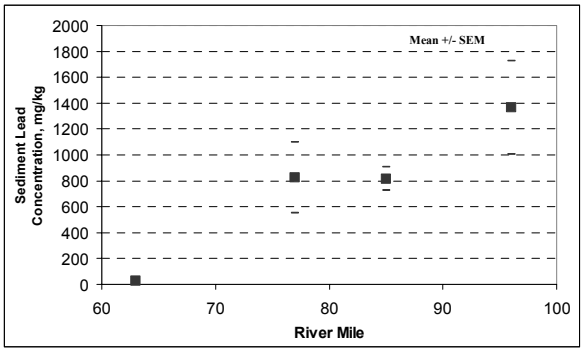




Fish Tissue & Sediment Sampling Locations



Spokane River Sediment Lead Concentrations Near Fish Sampling Locations



Lead Risk Assessment

- Based on internal measure of exposure, **blood lead level (PbB)**
- Risks assessed by comparing predicted population PbB values to PbB values associated with health effects.
- This approach integrates lead risks for all exposure routes.

Dose-Response → ?Threshold

Observed Effect	Children Blood Lead µg/dl	Adults Blood Lead µg/dl
Death	≥125	?
Neurological		
Encephalopathy	70	100
Sub-clinical → Peripheral Neuropathy	40	40
Central Nervous System		
↓ Hearing		10
↓ Cognitive IQ	10	-
↓ Psychomotor Function	10	-
↓ Birth weight/ Term length	10	-
Anemia	20	80
↓ Heme synthesis	10	10
Renal nephropathy	40	40
Hypertension		25
↓ Vitamin D	< 30	
↓ Sperm count & function		40

Adapted from Casserett & Doull's TOXICOLOGY and ATSDR

Models Used to Assess Lead Health Risks

- Models used:
  - Risks to children: ages 0 to 84 months assessed using the Integrated Exposure Uptake Biokinetic Model (IEUBK)
  - Risks to developing fetus: determined using the adult lead model.
- Information at: **EPA's Lead Technical Review Workgroup: http://www.epa.gov/superfund/programs/lead/**

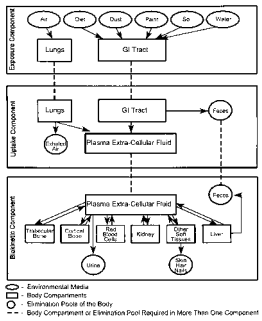
EPA IEUBK Model for Lead

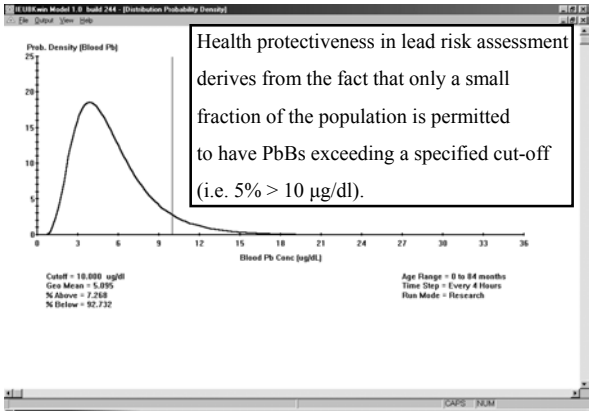
Integrated Exposure Uptake BioKinetic

Exposure

Uptake

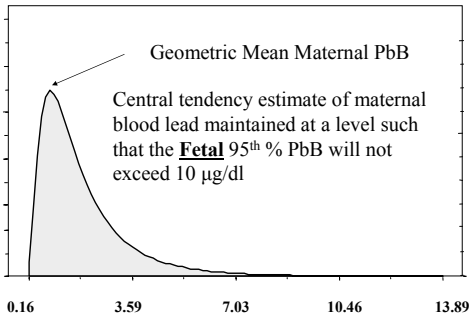
BioKinetics



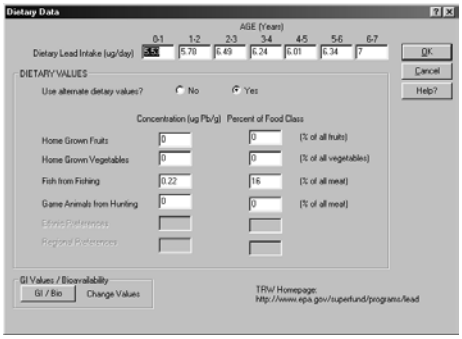


Health protectiveness in lead risk assessment derives from the fact that only a small fraction of the population is permitted to have PbBs exceeding a specified cut-off (i.e. 5% > 10 µg/dl).

The Adult Lead Model



Dietary Lead Input Screen for the IEUBK Model



Key IEUBK Model Parameters

- Fraction of meat consumption that consists of locally caught fish.
- Concentration of lead in fish tissue.
- Lead concentration and intake rates for other media (e.g. water, soil, house dust)

Fraction of Meat Consisting of Spokane River Fish: Fish Consumption Rate

- What childen's fish consumption rate to use?
- Identified populations included:
  - Recreational anglers
  - Laotians
  - Russian immigrants that consumed fish cakes prepared by grinding fish after removal of head & spine.
- **Problem**: No quantitative information

Fraction of Meat Consisting of Locally Caught Fish: Fish Consumption Rate (continued)

- Opted to use tribal fish consumption rates for children age 0 to 72 months.
- Rates taken from the Columbia River Intertribal Fish Commission Fish Consumption Study (EPA, 2002).
- 65th percentile consumption rate of 16.2 g/day was used as a health protective central tendency estimate.

Fraction of Meat Consisting of Locally Caught Fish: Meat Consumption

IEUBK model variable: meat_all(t)

Meat Consumed per Day by Age Group

Age (months)	g/day
12-24	87
25-36	96
37-48	102
49-60	107
61-72	112
72-84	121

Avg. for children 0-72 months = 101 g/day, therefore, a fish consumption rate of 16.2 g/day is 16% of total meat consumption

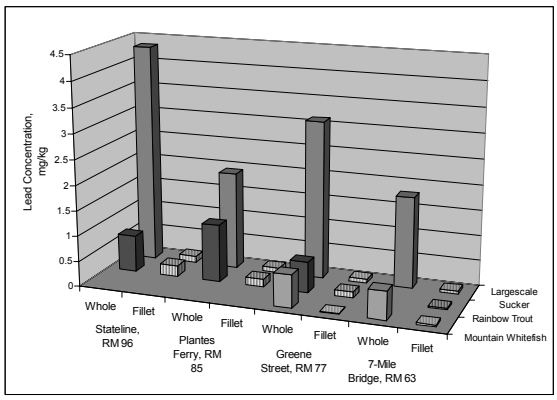
Fish Species Assayed for Lead

Mountain Whitefish

Largescale Sucker

Rainbow Trout

Spokane River Fish Fillet & Whole Body Lead Concentrations

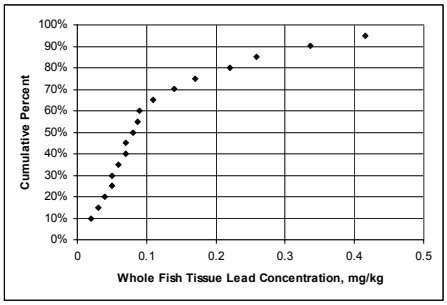


Comparison of Spokane River Average Whole Fish Lead Levels with National Values (mg/kg)

	Schmitt			Spokane River	
Statistic	Overall	Rainbow Trout	Largescale Sucker	Rainbow Trout	Largescale Sucker
Mean	0.168	0.15	0.115	0.823	2.79
SD	0.393		0.09		
N	315	2	17		

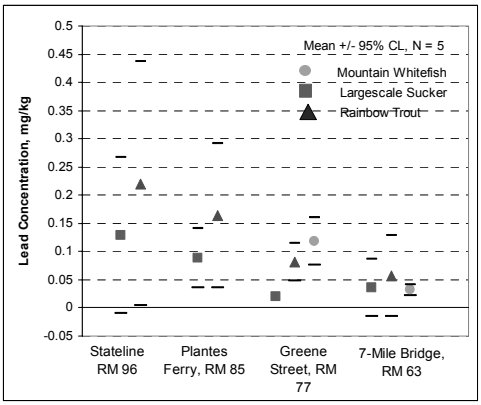
C.J. Schmitt and W.G. Brumbaugh, 1990. National Contaminant Biomonitoring Program: Concentrations of Arsenic, Cadmium, Copper, Lead, Mercury, Selenium, and Zinc in U.S. Freshwater Fish, 1976-1984. Archives of Environmental Contamination and Toxicology. 19:731-747.

Distribution of Lead Concentrations in Whole Fish



C.J. Schmitt and W.G. Brumbaugh, 1990

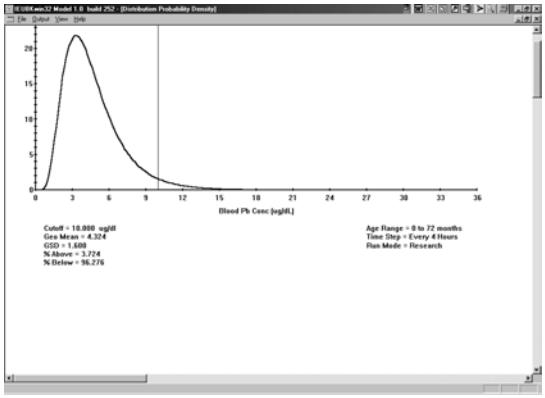
Spokane River Fish Fillet Lead Concentrations



Selected IEUBK Model Parameters

- Stateline trout fillet lead concentration of 0.22 mg/kg.
- Soil concentration of 230 mg/kg.
- All other parameters set at model defaults.

IEUBK Model Results, Rainbow Trout Fillet Consumption



PbBs Resulting from Consumption of Whole Fish

Species	Max Observed Concentration (mg/kg)	% > 10 Micrograms per dl
Largescale Sucker	**4.34**	**62%**
Rainbow Trout	**1.14**	**15%**
Mountain Whitefish	**0.56**	**6%**

Computing Pb Fish Fillet Consumption Limits

In order to run the IEUBK model, fish meals are converted to fish intake as % of meat intake:

$$\frac{(\text{N meals per month X 8 oz.}) / 30 \text{ days X } 28.349 \text{ g / oz.}}{\text{IEUBK daily meat intake in g / day}}$$

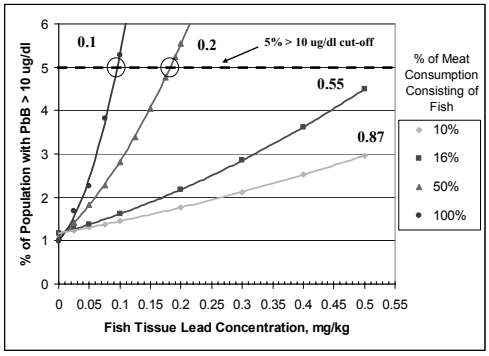
Comparison of Children's and Adult Fillet Meal Limits

	8 oz. Meals per Month	
	IEUBK	ALM
Species	Children	Adults
Rainbow Trout	4	8
Largescale Sucker	7	14
Mountain Whitefish	13	52

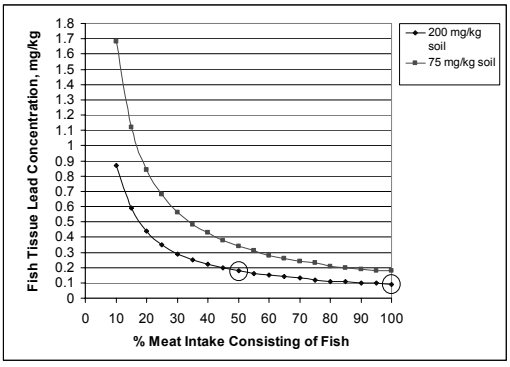
PCB Based Spokane River Fish Consumption Limits

	PCB Conc., ppb		Allowable 8 oz. Meals per Year	
Species	Avg.	High End	Avg.	High End
Rainbow Trout	880	1312	2.6	1.7
Largescale Sucker	148	182	15.2	12.4

PbB by Fish/Meat Diet Fraction & Fish Lead Concentration



Combinations of % Fish/Meat Intakes & Fish Tissue Lead Concentrations That Cause 5% of the Population to have PbBs of 10 ug/dl (Children Age 0 through 84 Months)



Issues/Model Improvements to consider:

- Consider altering the model to accept more population specific dietary information.
- Evaluate how the model does with subsistence consumption.
- Are there differences in bioavailability of lead found in bone/cartilage vs. muscle tissue?
- Change consumption rate data entry from fish as % of meat consumption to g/day.

Acknowledgements

- **Nancy Beck**, U.S. OMB
- **Steven Box**, USGS
- **Robert Duff**, WA Dept. of Health/ATSDR
- **Art Johnson**, WA Dept. of Ecology
- **Mike LaScuola**, Spokane Regional Health District
- **Terry Maret**, USGS
- **John Roland**, WA Dept. of Ecology
- **Marc Stifelman**, U.S. EPA

Equations for the Adult Lead Model

Intake of Lead from Soil and Fish

$$PbB_{adult,\ central} = PbB_{adult,0} +$$

$$BKSF \times (PbS \times IR_s \times AF_s \times EF_s + PbF \times IR_F \times AF_F \times EF_F) / AT$$

Equations for the Adult Lead Model (continued)

What maternal blood lead level will be protective of the fetus?

$$PbB_{fetal,\ 0.95\ goal} = PbB_{adult,\ central\ goal} \times GSD^{1.645} \times R_{fetal/maternal}$$

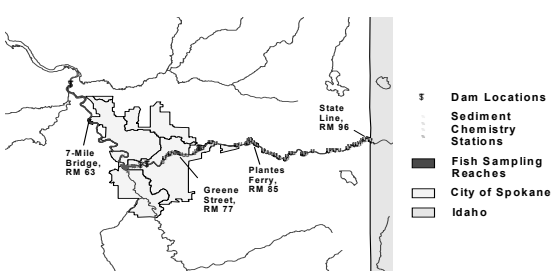
$$PbB_{adult,\ central\ goal} = (PbB_{fetal,\ 0.95\ goal}) / (GSD^{1.645} \times R_{fetal/maternal})$$

Finally, is $PbB_{adult,\ central} < PbB_{adult,\ central\ goal}$?

Supplement

- The following slides were not presented at the forum but were provided by the author for inclusion in the proceedings.

Spokane River Sediment and Fish Sampling Locations

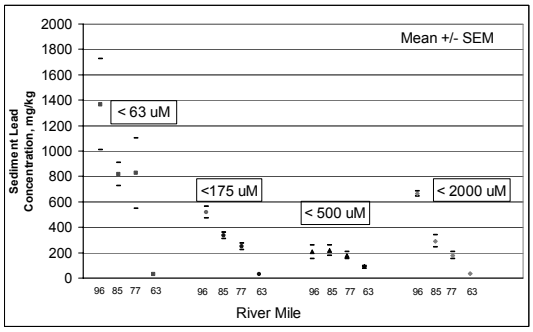


Relationship Between Particle Size and Sediment/Tissue Lead Concentration

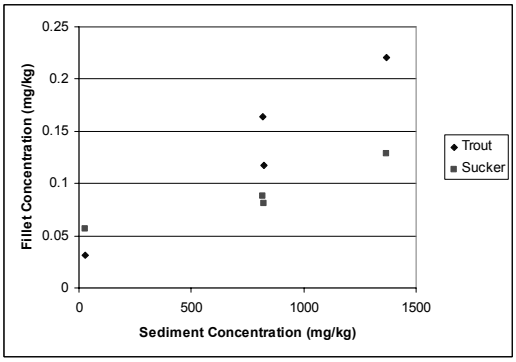
- Lead analyses done for particle size ranges of <63 µM, <175 µM, <500 µM & <2000 µM
- Avg. lead concentrations for each size range determined for sediment stations in the vicinity of fish sampling areas.
- Fillet/Whole fish vs. sediment lead concentrations plotted for different size ranges.

Sediment data compiled by Box and Wallis, USGS, 2000

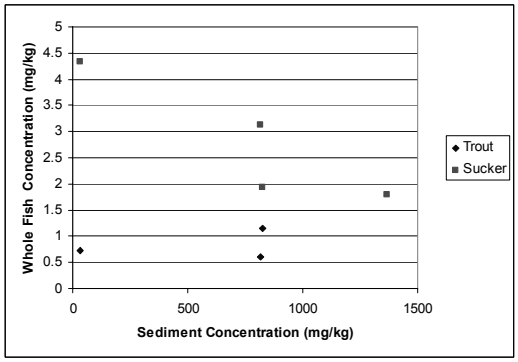
Sediment Lead Concentrations by Reach and Particle Size



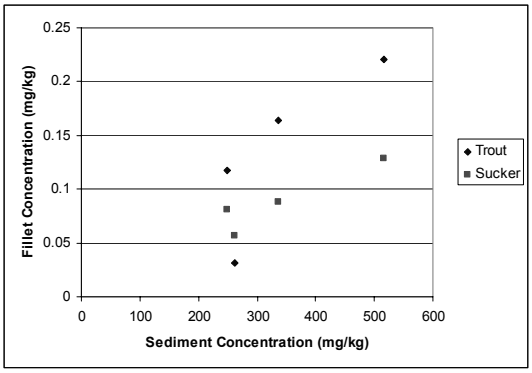
Sediment - Fillet Lead Concentration Relationship, Particle Size <63 µM



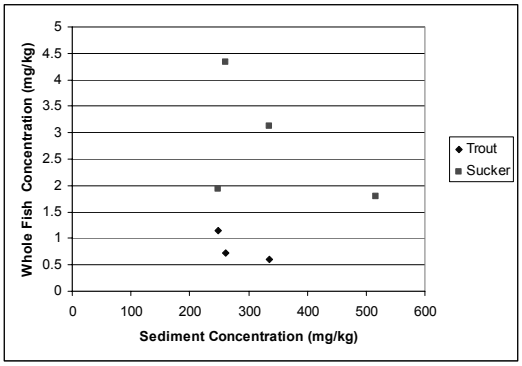
Sediment – Whole Fish Lead Concentration Relationship, Particle Size <63 µM



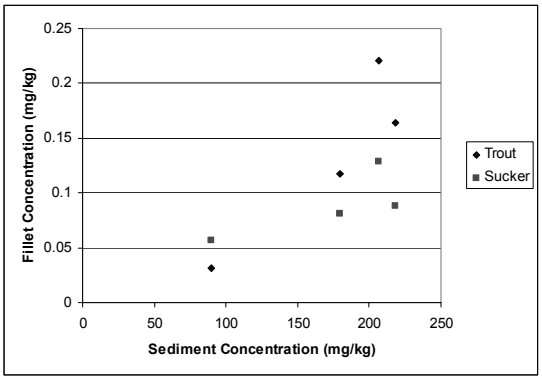
Sediment - Fillet Lead Concentration Relationship, Particle Size <175 µM



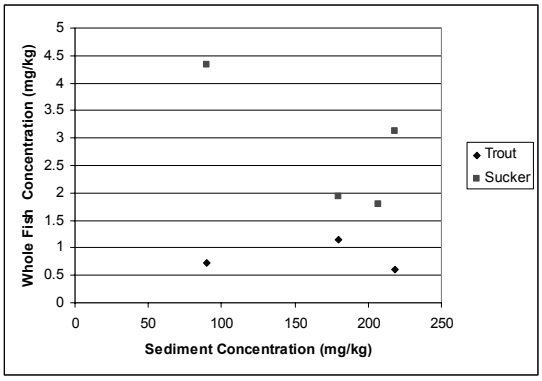
Sediment – Whole Fish Lead Concentration Relationship, Particle Size <175 µM



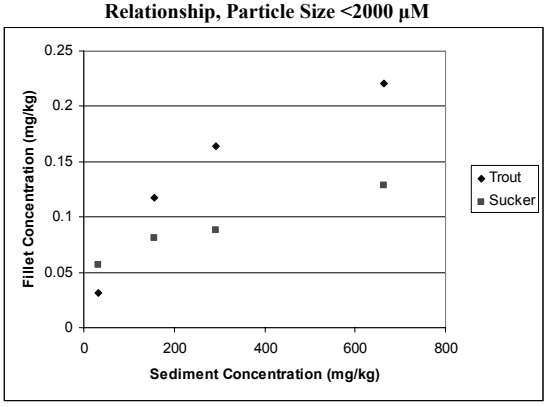
Sediment - Fillet Lead Concentration Relationship, Particle Size <500 µM



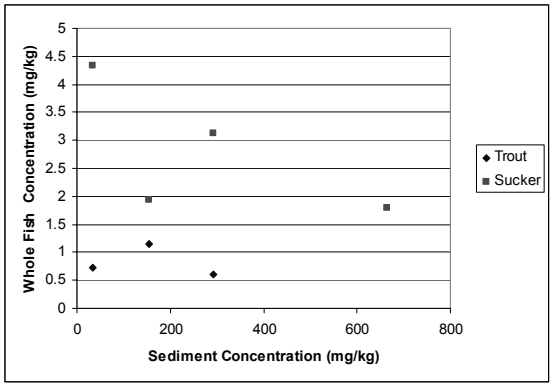
Sediment – Whole Fish Lead Concentration Relationship, Particle Size <500 µM



Sediment - Fillet Lead Concentration Relationship, Particle Size <2000 µM



Sediment – Whole Fish Lead Concentration Relationship, Particle Size < 2000 µM



Ratio of Fillet Tissue to Sediment Lead Concentration

Particle Size	Rainbow Trout	Large Scale Sucker
<63	3.9E-04	5.5E-04
<175	3.8E-04	2.6E-04
<500	7.1E-04	5.3E-04
<2000	6.5E-04	6.8E-04
All Sizes	5.3E-04	5.1E-04

Comments on Use of Lead Tissue/Sediment Ratios

- Lead tissue/sediment ratios may be a useful method for screening as to whether or not fish consumption lead hazards exist.
- More work needs to be done to characterize these ratios.

Occurrence of Lead in Fish

Examples from Georgia,
Maine, and California

A Note on Contamination
during Sample Preparation

Georgia
Summary of Detected Lead
Concentrations in Fish Fillet
Composites

Georgia
Means of Detected Lead Values Only
by Basin

	All Species		Largemouth Bass		Channel Catfish	
Basin	Composites (N)	Mean Lead (ppm)	Composites (N)	Mean Lead (ppm)	Composites (N)	Mean Lead (ppm)
Altamaha	1	1.10	1	1.10		
Chattahoochee	25	1.52	4	1.98		
Coosa	4	2.05				
Flint	7	1.34	3	1.33	3	1.30
Ocmulgee	6	14.62	3	8.57	2	15.50
Oconee	7	2.16	2	2.55		
Ogeechee	6	2.50	1	2.50	1	2.50
Savannah	9	2.06	3	2.28		
Suwannee	1	4.30				
Tallapoosa	2	1.40				

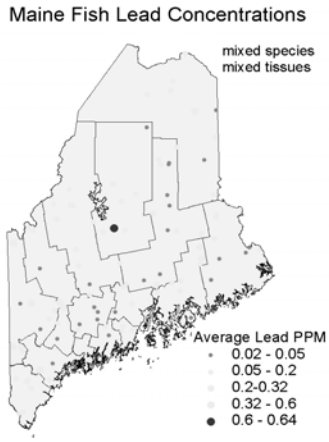
Other detects in hogsuckers, trout and sunfish

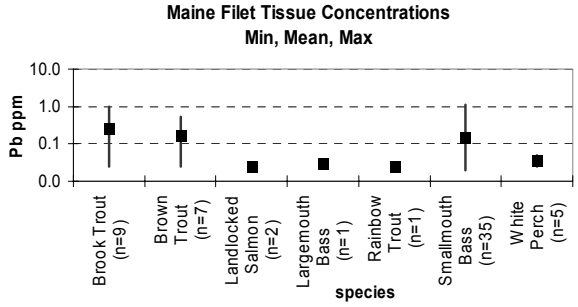
Georgia
All Species (Pb)

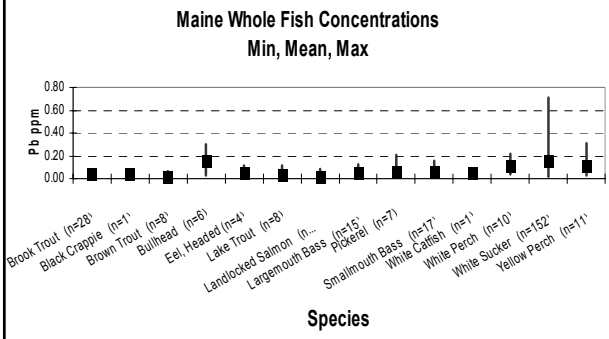
By Hydrologic Unit

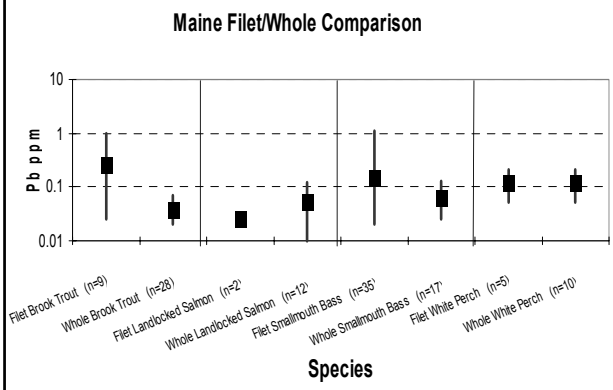
Georgia
Largemouth Bass (Pb)

Georgia
Channel Catfish (Pb)





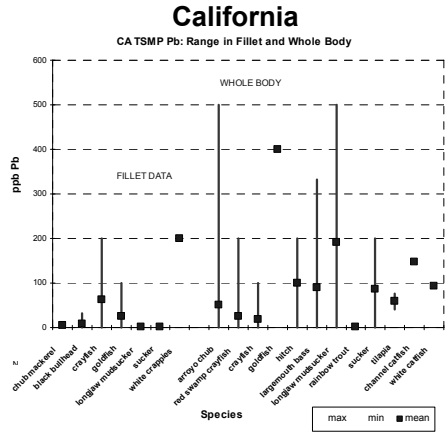




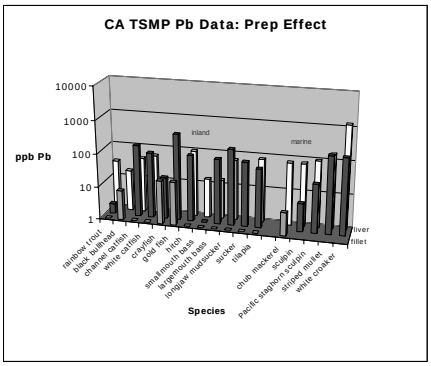
California

Fillet Non-detects in TSMP

Species	N	Species	N
Arroyo chub	1	Lahonton cutthroat trout	1
Bluegill	4	Largemouth bass	7
Brook trout	1	Mozambique tilapia	1
Brown trout	4	Orangemouth corvine	1
Carp	4	Rainbow trout	1
Channel catfish	4	Red swamp crayfish	5
Green sunfish	1	Brown smoothhound shark	1
Hitch	1	Leopard shark	1



California



The Effects of Sample Preparation on Measured Concentrations of Eight Elements in Edible Tissues of Fish from Streams Contaminated by Lead Mining

Christopher Schmitt and Susan E. Finger

Arch. Environ. Contam. Toxicol. 16, 185-207 (1987)

Effect of Preparation Method

Grand (seven sites) geometric mean concentration lead

In ppm

Taxa	Normal Prep	Clean Prep	Difference
Bass N=13	0.097	0.024	4X
Catfish N=13	0.314	0.031	10X
Redhorse N=14	0.228	0.220	equal

Redhorse sucker has intermuscular bones

Conclusions

- **Preparation methods can effect reported Pb concentration**
- **Cross contamination from skin, bone, mucus and scales can effect reported Pb concentration**
- **Cross contamination and non-muscle fragments can effect sample heterogeniety**

Acknowledgements

Eric Frohmberg, Maine

Randy Manning, Georgia

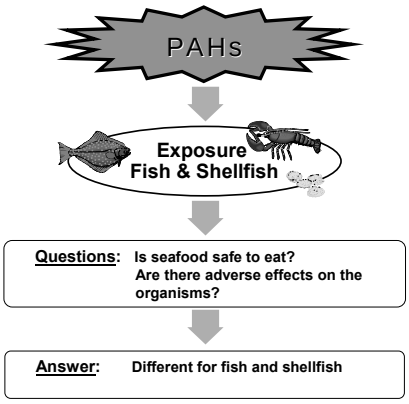
Polycyclic aromatic hydrocarbons (PAHs) in fish and invertebrates

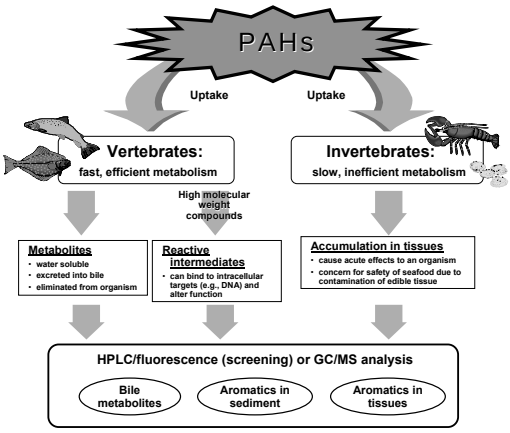
Usha Varanasi

Northwest Fisheries Science Center
NOAA Fisheries
Seattle, Washington

Polycyclic aromatic hydrocarbons (PAHs)

- **Petrogenic (LMW) and pyrogenic (HMW) sources**
- **Natural sources (seeps, fires)**
- **Anthropogenic sources (spills, internal combustion engines, coal burning, wood preservatives)**





Responding to PAH contamination

Questions that need to be answered:

- **Chemical composition of the source**
- **Fate and toxicity of the source**
- **Resources at risk**
- **Type of investigation to be conducted**
- **Sampling design**
- **Analytical approaches**

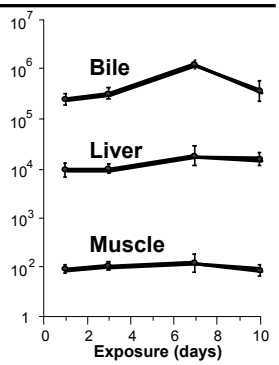
Tiered approach: Screening -vs- Detailed analyses

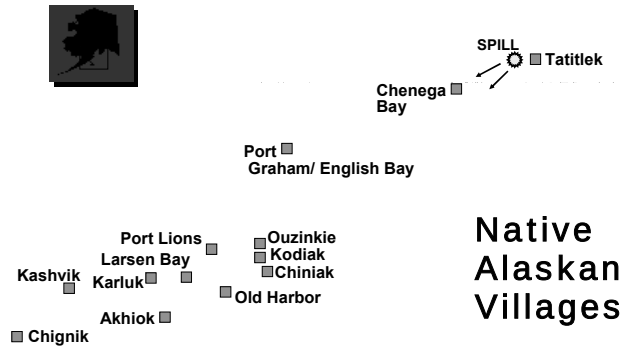
- **Screening methods are rapid and cost-effective**
- **Screening methods provide a semi-quantitative estimate of contamination in samples**
- **Screening allows priority selection of a subset of samples for detailed analysis (e.g., GC/MS)**
- **Detailed analyses provide confirmation of screening results**
- **Detailed analyses provide quantitative information about individual contaminants**

Screening Methods: Analyzing AC metabolites in bile

Laboratory exposure of fish to contaminated sediments demonstrated that:

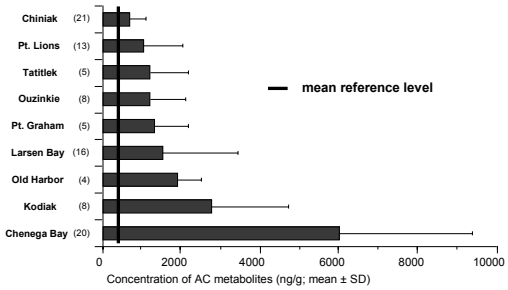
- **ACs readily taken up**
- **ACs extensively metabolized**
- **Metabolites concentrated in bile for elimination**
- **Marked differences in tissue concentrations**





Native Alaskan Villages

Concentrations of AC metabolites in pink salmon bile following the *Exxon Valdez* oil spill

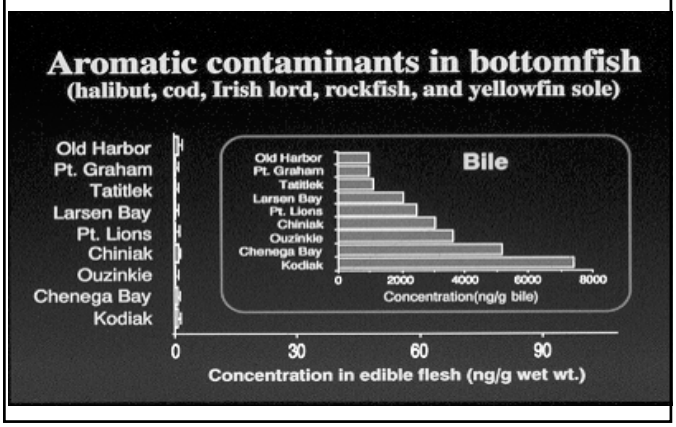


Total PAHs measured in fish muscle and invertebrates after EVOS 1990

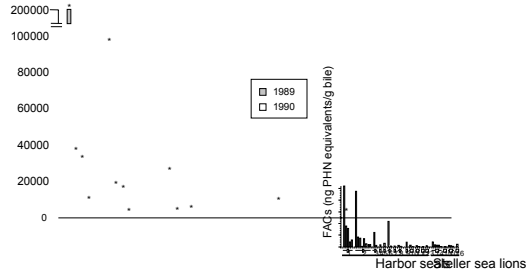
Yakutat (reference site)	Total PAHs (ng/g, ww)
Coho salmon muscle (n = 6)	3.0
Mussels (n = 6)	3.0 ± 2.0
Butter clams (n = 9)	1.0 ± 1.0
Littleneck clams (n = 6)	0.8 ± 0.3

Chenega Bay (oiled site)	Total PAHs (ng/g, ww)
Pink salmon muscle (n = 3)	0.8
Mussels (n = 8)	640 ± 620
Butter clams (n = 9)	330 ± 340
Littleneck clams (n = 16)	120 ± 44

Tatitlek	**Smoked salmon**	**23,000 ng/g wet wt.**
Old Harbor	**Smoked salmon**	**7,900 ng/g wet wt.**



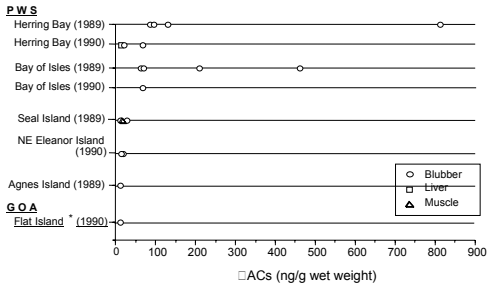
Bile PAHs in Marine Mammals



Sites 1-8 and 14 are located in Prince William Sound and remaining sites in Gulf of Alaska

* Indicates a marine mammal that was visibly oiled

PAHs in Marine Mammals



* Marine mammal from Gulf of Alaska, all others from Prince William Sound

PAHs and Seafood

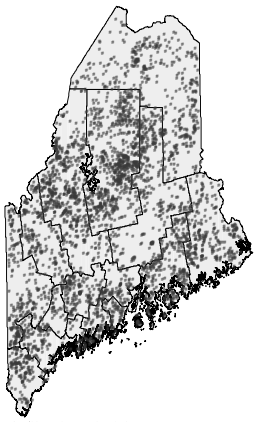
- **PAHs are toxic compounds, derived from a variety of sources, including oil spills and combustion of petroleum.**
- **Fish and invertebrates, when exposed to PAHs, readily assimilate them into their bodies.**
- **Fish efficiently metabolize PAHs, and excrete them from their bodies. It is very rare to detect significant amounts of PAHs in the tissues of fish.**
- **Invertebrates, however, are much less efficient metabolizers of PAHs, and PAHs are commonly found in these species in PAH-contaminated areas.**
- **While PAHs do not accumulate in fish, they have a number of adverse effects on the fish themselves.**

Current/Upcoming Issues with PAHs

- **PAH input into the environment is increasing in many areas**
- **Seafood Safety Standpoint:**
  - **fish (not a concern)**
  - **invertebrates (concern)**
- **Biological Effects Standpoint:**
  - **fish and invertebrates (concern)**
  - **Need to monitor the adverse effects (reproductive, sensory, physiological)**

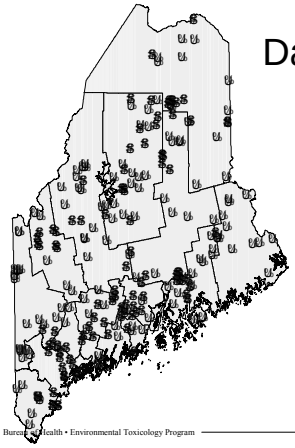
Setting Statewide Advisories based on upper percentile lake averages

Eric Frohmberg
Environmental Toxicology Program
Maine Bureau of Health



Problem

- 3000+ Lakes and Ponds in Maine.
- Need to make inferences based on data
- Use a mean concentration an upper percentile lake average estimate?



Data Sources

- REMAP – 1993 EPA Study
- 120 Random Lakes
- SWAT – 1994 to current – added 80 lakes
- $50,000 per year to support Hg Advisory

Implications in Choice of Statistic

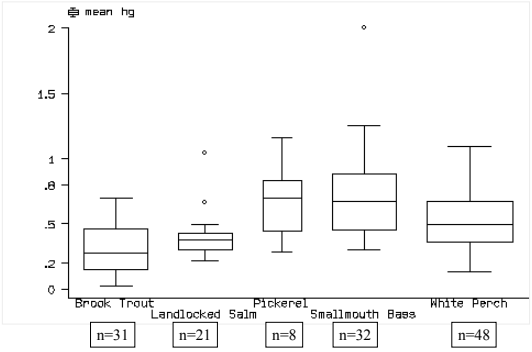
Mean Lake Concentrations

- **Average Population Weighted Exposure**
- **Assumes Random Fishing**

Upper Estimate of Lake Concentration

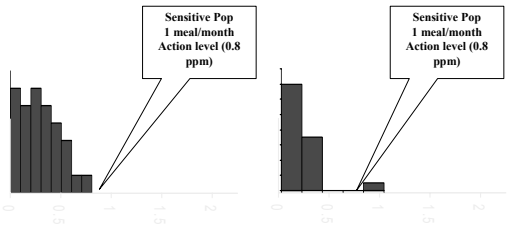
- **Reflects uncertainty**
- **Matches hypothesized exposure patterns**

Variation of Lake Average Hg by Species



Sample size represents number of lakes

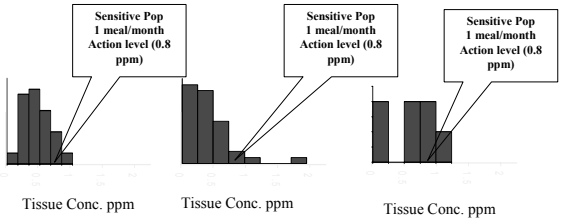
% of Lakes above Action Level



Brook Trout (n=31 lakes)

Landlocked Salmon (n=21 lakes)

% of Lakes above Action Level



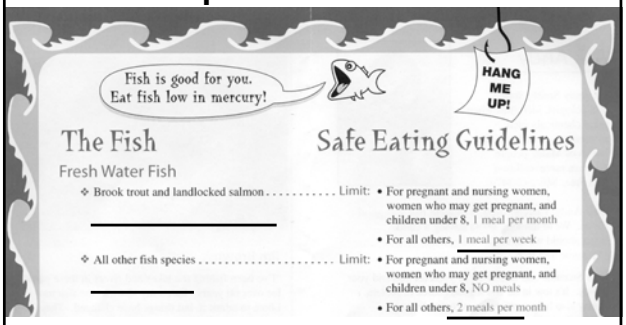
White Perch (n=47 lakes)

Smallmouth Bass (n=32 lakes)

Chain Pickerel (n=7 lakes)

Impact on Advice

Impact on Advice



Implications

Positive

- Reflects what we think we know about exposure
- Reflects uncertainty
- Provides incentive for testing

Negative

- Over protective for the vast majority of lakes

Use of Maine's Statewide Advisory in a Tribal Setting

Susan M. Peterson

Environmental Chemist

Aroostook Band of Micmacs Environmental Laboratory

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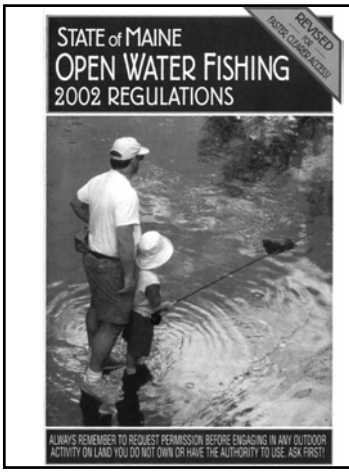
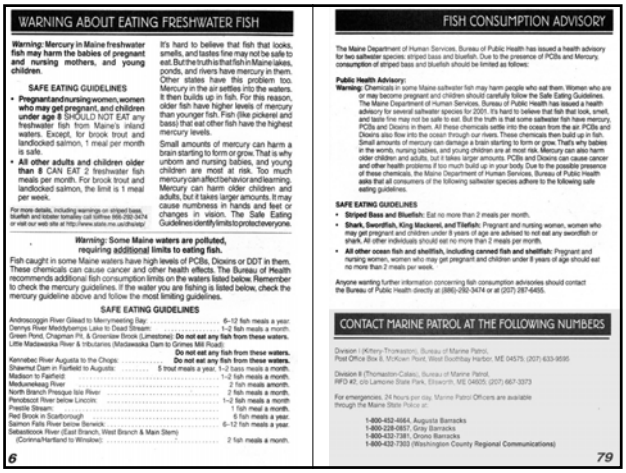
The Aroostook Band of Micmacs



The State of Maine Bureau of Health Fish Consumption Advisory

As taken from the 2002 Maine Department of Inland Fisheries and Wildlife Regulations



WARNING ABOUT EATING FRESHWATER FISH

Warning: Mercury in Maine freshwater fish may harm the babies of pregnant and nursing mothers, and young children.

SAFE EATING GUIDELINES

- **Pregnant and nursing women, women who may get pregnant, and children under age 8** SHOULD NOT EAT any freshwater fish from Maine's inland waters. Except, for brook trout and landlocked salmon, 1 meal per month is safe.
- **All other adults and children older than 8** CAN EAT 2 freshwater fish meals per month. For brook trout and landlocked salmon, the limit is 1 meal per week.

For more details, including warnings on striped bass, bluefish and lobster tomalley call (toll-free 866-292-3474 or visit our web site at http://www.state.me.us/dhs/etp/

It's hard to believe that fish that looks, smells, and tastes fine may not be safe to eat. But the truth is that fish in Maine lakes, ponds, and rivers have mercury in them. Other states have this problem too. Mercury in the air settles into the waters. It then builds up in fish. For this reason, older fish have higher levels of mercury than younger fish. Fish (like pickerel and bass) that eat other fish have the highest mercury levels.

Small amounts of mercury can harm a brain starting to form or grow. That is why unborn and nursing babies, and young children are most at risk. Too much mercury can affect behavior and learning. Mercury can harm older children and adults, but it takes larger amounts. It may cause numbness in hands and feet or changes in vision. The Safe Eating Guidelines identify limits to protect everyone.

Warning: Some Maine waters are polluted, requiring additional limits to eating fish.

Fish caught in some Maine waters have high levels of PCBs, Dioxins or DDT in them. These chemicals can cause cancer and other health effects. The Bureau of Health recommends additional fish consumption limits on the waters listed below. Remember to check the mercury guidelines. If the water you are fishing is listed below, check the mercury guideline above and follow the most limiting guidelines.

SAFE EATING GUIDELINES

Androscoggin River Gilead to Merrymeeting Bay:	6-12 fish meals a year.
Dennys River Meddybemps Lake to Dead Stream:	1-2 fish meals a month.
Green Pond, Chapman Pit, & Greenlaw Brook (Limestone):	**Do not eat any fish from these waters.**
Little Madawaska River & tributaries (Madawaska Dam to Grimes Mill Road):	**Do not eat any fish from these waters.**
Kennebec River Augusta to the Chops:	**Do not eat any fish from these waters.**
Shawmut Dam in Fairfield to Augusta:	5 trout meals a year. 1-2 bass meals a month.
Madison to Fairfield	1-2 fish meals a month.
Meduxnekeag River	2 fish meals amonth.
North Branch Presque Isle River	2 fish meals a month.
Penobscot River below Lincoln:	1-2 fish meals a month
Prestile Stream:	1 fish meal a month.
Red Brook in Scarborough	6 fish meals a year.
Salmon Falls River below Berwick:	6-12 fish meals a year.
Sebasticook River (East Branch, West Branch & Main Stem) (Corinna/Hartland to Winslow):	2 fish meals a month.

6

FISH CONSUMPTION ADVISORY

The Maine Department of Human Services, Bureau of Public Health has issued a health advisory for two saltwater species: striped bass and bluefish. Due to the presence of PCBs and Mercury, consumption of striped bass and bluefish should be limited as follows:

Public Health Advisory:

Warning: Chemicals in some Maine saltwater fish may harm people who eat them. Women who are or may become pregnant and children should carefully follow the Safe Eating Guidelines. The Maine Department of Human Services, Bureau of Public Health has issued a health advisory for several saltwater species for 2001. It's hard to believe that fish that look, smell, and taste fine may not be safe to eat. But the truth is that some saltwater fish have mercury, PCBs and Dioxins in them. All these chemicals settle into the ocean from the air. PCBs and Dioxins also flow into the ocean through our rivers. These chemicals then build up in fish. Small amounts of mercury can damage a brain starting to form or grow. That's why babies in the womb, nursing babies, and young children are at most risk. Mercury can also harm older children and adults, but it takes larger amounts. PCBs and Dioxins can cause cancer and other health problems if too much build up in your body. Due to the possible presence of these chemicals, the Maine Department of Human Services, Bureau of Public Health asks that all consumers of the following saltwater species adhere to the following safe eating guidelines.

SAFE EATING GUIDELINES

- **Striped Bass and Bluefish:** Eat no more than 2 meals per month.
- **Shark, Swordfish, King Mackerel, and Tilefish:** Pregnant and nursing women, women who may get pregnant and children under 8 years of age are advised to not eat any swordfish or shark. All other individuals should eat no more than 2 meals per month.
- **All other ocean fish and shellfish, including canned fish and shellfish:** Pregnant and nursing women, women who may get pregnant and children under 8 years of age should eat no more than 2 meals per week.

Anyone wanting further information concerning fish consumption advisories should contact the Bureau of Public Health directly at (866)-292-3474 or at (207) 287-6455.

CONTACT MARINE PATROL AT THE FOLLOWING NUMBERS

Division I (Kittery-Thomaston), Bureau of Marine Patrol,
Post Office Box 8, McKown Point, West Boothbay Harbor, ME 04575. (207) 633-9595

Division II (Thomaston-Calais), Bureau of Marine Patrol,
RFD #2, c/o Lamoine State Park, Ellsworth, ME 04605. (207) 667-3373

For emergencies, 24 hours per day, Marine Patrol Officers are available through the Maine State Police at:

1-800-452-4664, Augusta Barracks
1-800-228-0657, Gray Barracks
1-800-432-7381, Orono Barracks
1-800-432-7303 (Washington County Regional Communications)

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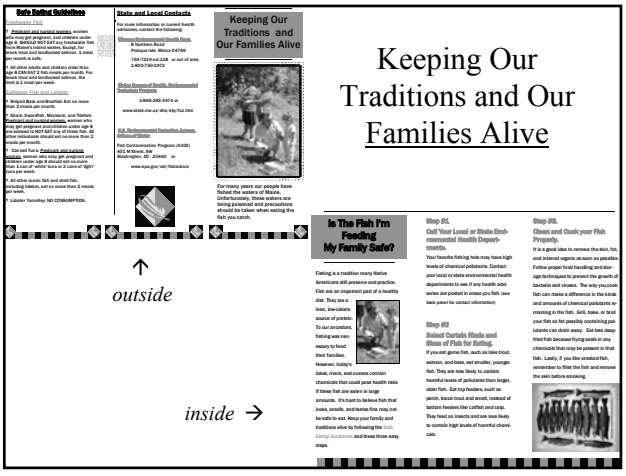


Safe Eating Guidelines

Freshwater Fish

- Pregnant and nursing women, women who may get pregnant, and children under age 8 SHOULD NOT EAT any freshwater fish from Maine's inland waters. Except, for brook trout and landlocked salmon, 1 meal per month is safe.
- All other adults and children older than age 8 CAN EAT 2 fish meals per month. For brook trout and landlocked salmon, the limit is 1 meal per week.

Saltwater Fish and Lobster

- Striped Bass and Bluefish: Eat no more than 2 meals per month.
- Shark, Swordfish, Mackeral, and Tilefish: Pregnant and nursing women, women who may get pregnant and children under age 8 are advised to NOT EAT any of these fish. All other individuals should eat no more than 2 meals per month.
- Canned Tuna: Pregnant and nursing women, women who may get pregnant and children under age 8 should eat no more than 1 can of 'white' tuna or 2 cans of 'light' tuna per week.
- All other ocean fish and shell fish, including lobster, eat no more than 2 meals per week.
- Lobster Tomalley: NO CONSUMPTION.

State and Local Contacts

For more information or current health advisories, contact the following:

Micmac Environmental Health Dept.
8 Northern Road
Presque Isle, Maine 04769
764-7219 ext.118 or out of area 1-800-750-1972

Maine Bureau of Health, Environmental Toxicology Program
1-866-292-3474 or
www.state.me.us/dhs/etp/fca.htm

U.S. Environmental Protection Agency, Office of Water
Fish Contamination Program (4305)
401 M Street, SW
Washington, DC 20460 or
www.epa.gov/ost/fishadvice

Keeping Our Traditions and Our Families Alive

For many years our people have fished the waters of Maine. Unfortunately, these waters are being poisoned and precautions should be taken when eating the fish you catch.

↑ *outside*

Keeping Our Traditions and Our Families Alive

Is The Fish I'm Feeding My Family Safe?

Fishing is a tradition many Native Americans still preserve and practice. Fish are an important part of a healthy diet. They are a lean, low-calorie source of protein. To our ancestors, fishing was necessary to feed their families. However, today's lakes, rivers, and oceans contain chemicals that could pose health risks if these fish are eaten in large amounts. It's hard to believe fish that looks, smells, and tastes fine may not be safe to eat. Keep your family and traditions alive by following the Safe Eating Guidelines and these three easy steps.

Step #1
Call Your Local or State Environmental Health Departments.

Your favorite fishing hole may have high levels of chemical pollutants. Contact your local or state environmental health departments to see if any health advisories are posted in areas you fish. (see back panel for contact information)

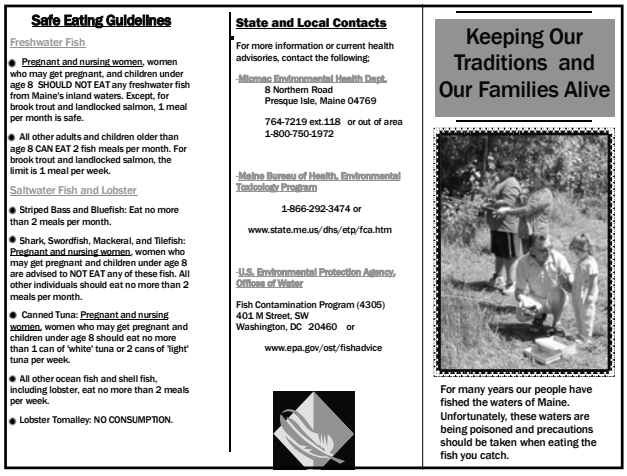
Step #2
Select Certain Kinds and Sizes of Fish for Eating.

If you eat game fish, such as lake trout, salmon, and bass, eat smaller, younger fish. They are less likely to contain harmful levels of pollutants than larger, older fish. Eat top feeders, such as perch, bass, trout and smelt, instead of bottom feeders like catfish and carp. They feed on insects and are less likely to contain high levels of harmful chemicals.

Step #3.
Clean and Cook your Fish Properly.

It is a good idea to remove the skin, fat, and internal organs as soon as possible. Follow proper food handling and storage techniques to prevent the growth of bacteria and viruses. The way you cook fish can make a difference in the kinds and amounts of chemical pollutants remaining in the fish. Grill, bake, or broil your fish so fat possibly containing pollutants can drain away. Eat less deep-fried fish because frying seals in any chemicals that may be present in that fish. Lastly, if you like smoked fish, remember to fillet the fish and remove the skin before smoking.

inside →



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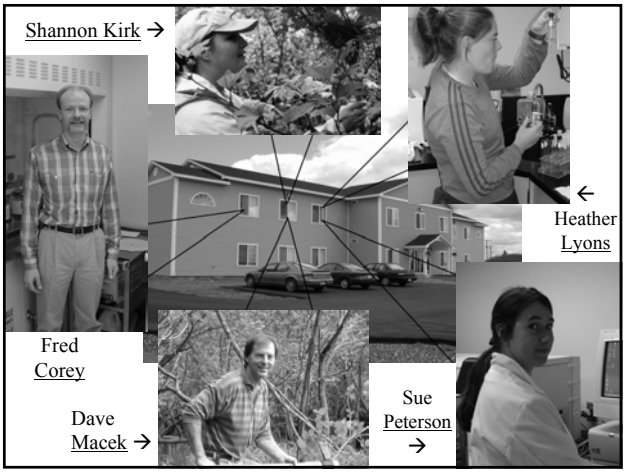
Plans for the Future

- anthropological research combined with elements of a consumption survey
- interviews with Tribal elders
- Tribal based risk assessment



MICMAC HEALTH DEPARTMENT

8 Northern Road
Presque Isle, Maine
04769
Ph: (207) 764 – 7219

E-mail: **fcorey@micmachealth.org** (Environmental Director) - or -
speterson@micmachealth.org (Environmental Chemist)

North Dakota's Fish Consumption Advisory:

A Statewide Advisory Based on Average Concentration

Presented by
Mike Ell, Environmental Scientist
ND Dept of Health
Bismarck, ND

October 22, 2002

Outline

- History
- Development of Current Statewide Advisory
- Considerations for the Future

History

- First fish collections for mercury analysis in 1991
  - Resulted in limited fish advisory for Devils Lake during the summer of 1991
- First published advisory occurred in March 1992
  - Included ten lakes and reservoirs, including Devils Lake, and two rivers

- Continued sampling with additional lakes and reservoirs added each year
- Peaked in the mid 90's with over 30 lakes and rivers and 20 species of fish listed
- Numbers declined through the late 90's due to limited sampling
  - Focus on Devils Lake and Lake Sakakawea
    - Predominant fisheries in the state
    - Research interest in mercury effects and lake manipulations

Statewide Advisory

- First issued in January 2001
- Rational
  - Mercury occurs in fish in all lakes, reservoirs, rivers, and streams in the state
  - For advise to be useful it shouldn't be complicated
- Based on standard assumptions and existing fish tissue data for all lakes and rivers
- Final advisory reduced to simple consumption advice

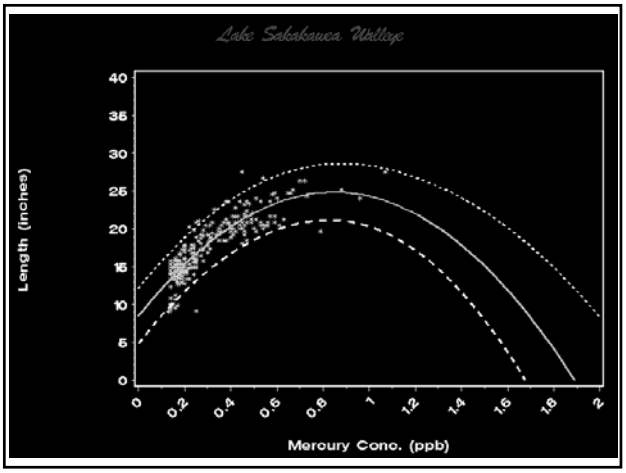
Dose Management for a Generic Statewide Fish Consumption Advisory

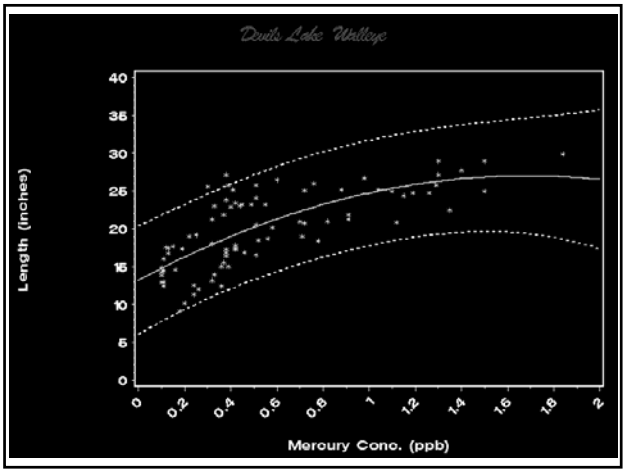
Assumptions

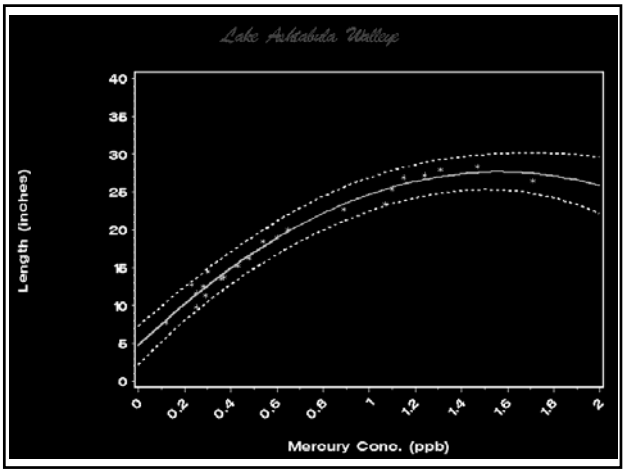
	EPA's RfD mg(MHg)/kg-bw/day	Body Weight kilograms	Average Meal Size ounces	Maximum Average Daily Dose mg(MHg)/day
Children under age 6	0.0001	20	4	0.002
Pregnant and nursing women	0.0001	60	8	0.006
Children between ages 6 and 15	0.0003	40	8	0.012
All other women	0.0003	60	8	0.018
All other men	0.0003	75	10	0.0225

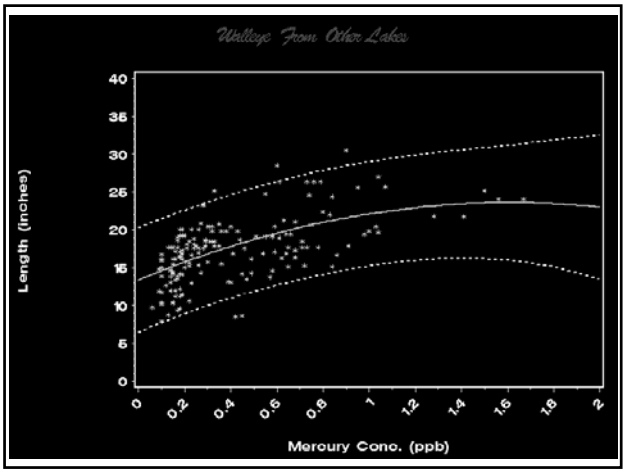
Dose Control

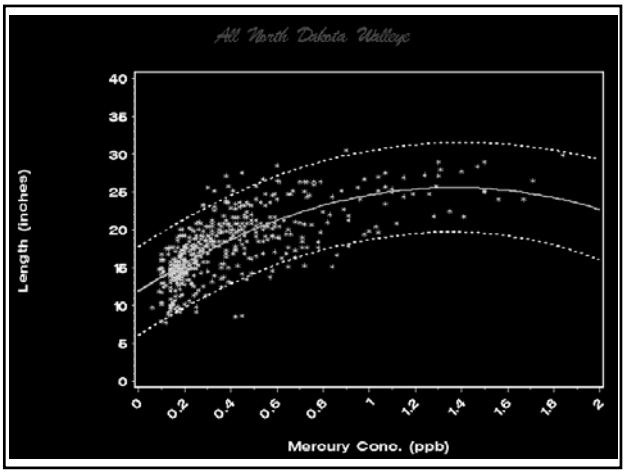
	Maximum Methyl-Mercury Concentration in Fish			
	8 meals/month	4 meals/month	2 meals/month	1 meal/month
Children under age 6	0.067	0.134	0.268	0.536
Pregnant and nursing women	0.101	0.201	0.402	0.804
Children between ages 6 and 15	0.201	0.402	0.804	1.608
All other women	0.302	0.603	1.206	2.413
All other men	0.302	0.603	1.206	2.413











Dose Management for a Generic Statewide Fish Consumption Advisory

Assumptions

	EPA's RfD mg(MHg)/kg-bw/day	Body Weight kilograms	Average Meal Size ounces	Maximum Average Daily Dose mg(MHg)/day
Children under age 6	0.0001	20	4	0.002
Pregnant and nursing women	0.0001	60	8	0.006
Children between ages 6 and 15	0.0003	40	8	0.012
All other women	0.0003	60	8	0.018
All other men	0.0003	75	10	0.0225

Dose Control

	Maximum Methyl-Mercury Concentration in Fish			
	8 meals/month	4 meals/month	2 meals/month	1 meal/month
Children under age 6	0.067	0.134	0.268	0.536
Pregnant and nursing women	0.101	0.201	0.402	0.804
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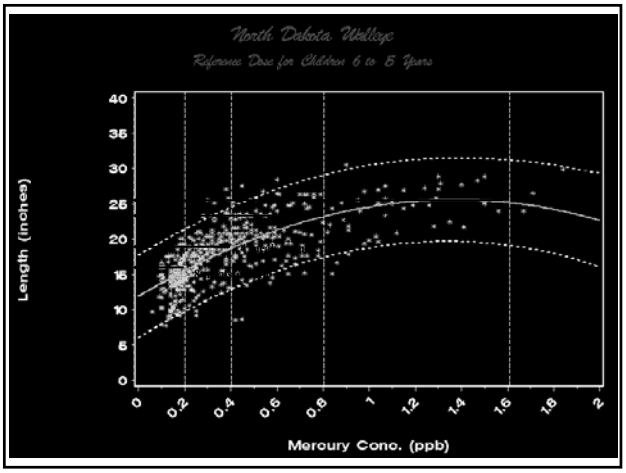


NORTH DAKOTA ADVISORY FOR HUMAN CONSUMPTION OF FISH

The chart applies to fisheries of the state; data for crappie, trout and white sucker are incomplete, and the fish in many lakes, reservoirs and rivers have not been sampled. It does not consider other human exposures of methylmercury (as mercury), such as eating ocean or other inland fish.

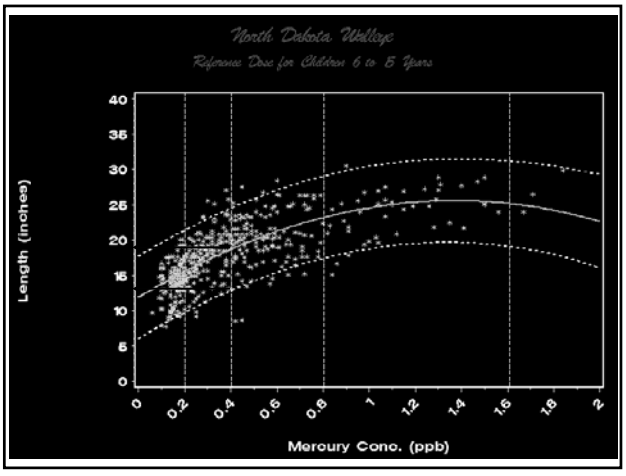
Meal frequencies: none -- no consumption advised
occasional -- occasional consumption, 1 to 2 meals per month, avoid eating whoppers
moderate -- moderate consumption, 2 to 4 meals per month
frequent -- frequent consumption, 4 to 8 meals per month

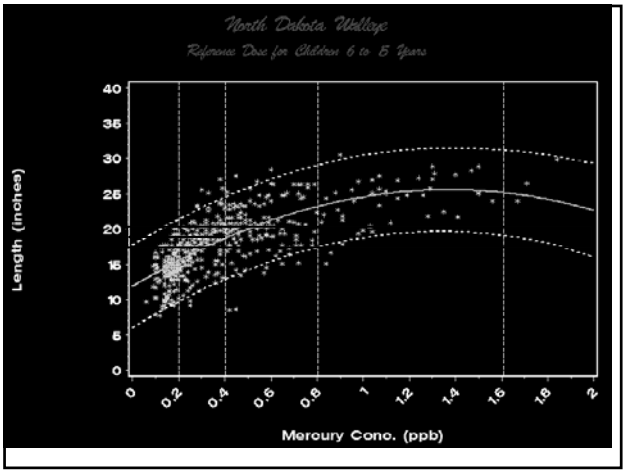
Summary: "children 5 & younger," pregnant women and nursing women can occasionally eat only smaller fish; and children over age 5 and all other adults can frequently eat smaller fish while limiting the meals of medium and larger fish.

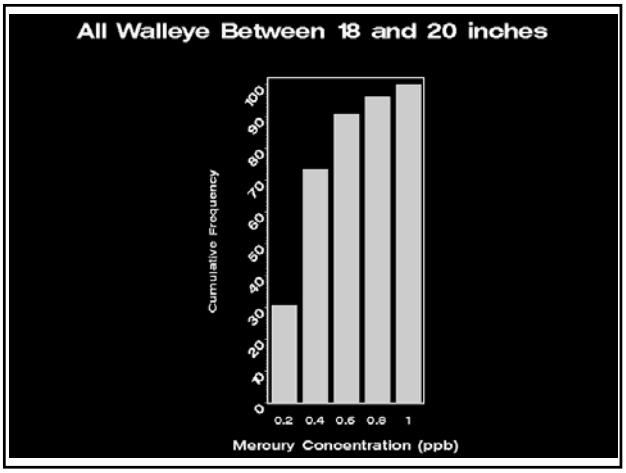
		Fish Size				
Fish Species		Smaller	or	Medium	or	Larger
BASS, largemouth smallmouth	Children 5 & younger	occasional		none		none
	Pregnant &nursing women	occasional		occasional		none
smaller sizes are less than 16 inches	Children over 5 & under 15	moderate		moderate		moderate
	All other people	frequent		moderate		moderate
BASS, white	Children 5 & younger	occasional		none		none
smaller sizes are less than 12 inches	Pregnant & nursing women	moderate		moderate		occasional
	Children over 5 & under 15	frequent		moderate		occasional
	All other people	frequent		moderate		moderate
CHINOOK SALMON	Children 5 & younger	moderate		occasional		occasional
smaller sizes are less than 19 inches	Pregnant & nursing women	moderate		moderate		occasional
	Children over 5 & under 15	frequent		moderate		moderate
	All other people	frequent		frequent		moderate
NORTHERN PIKE	Children 5 & younger	moderate		occasional		occasional
smaller sizes are less than 29 inches	Pregnant & nursing women	moderate		moderate		occasional
	Children over 5 & under 15	frequent		moderate		occasional
	All other people	frequent		moderate		moderate
WALLEYE CHANNEL CATFISH	Children 5 & younger	moderate		occasional		occasional
smaller sizes are less than 22 inches	Pregnant & nursing women	moderate		moderate		occasional
	Children over 5 & under 15	frequent		moderate		moderate
	All other people	frequent		moderate		moderate
YELLOW PERCH	Children 5 & younger	moderate		moderate		occasional
smaller sizes are less than 11 inches	Pregnant & nursing women	moderate		moderate		occasional
	Children over 5 & under 15	frequent		moderate		moderate
	All other people	frequent		frequent		frequent

Why Use The Mean Concentration?

- **Provides more flexibility to the consuming public**
  - **Give the public more opportunity to keep fish and to eat those fish**
- **While providing protection**







Considerations for the Future

- **Sample Design**
  - **Targeted vs Statewide Sampling**
  - **Probablistic Sampling**
- **Public Communication**

Note: The following slides are from the presentation by Bob Frey

MERCURY ADVISORIES – APRIL 11, 2001

- WAITED FOR NAS VALIDATION OF EPA RfD
- BASED ON EPA 1999 FACT SHEET
  EPA-823-F-99-016, SEPTEMBER 1999
- MODIFIED LEVELS SLIGHTLY FOR EASE OF USE
- CROSS-CHECKED WITH PCB ADVICE
- ISSUED NEARLY 80 NEW ADVISORIES

ADVISORY TRIGGERS

CATEGORY	PA	FACT SHEET
UNRESTRICTED	0 - 0.12	>0.08 – 0.12*
1 MEAL/WEEK	0.13 – 0.25	>0.12 – 0.24
2 MEALS/MONTH	0.26 – 0.50	>0.32 – 0.48
1 MEAL/MONTH	0.51 – 1.0	>0.48 – 0.97
6 MEALS/YEAR	1.01 – 1.9	>0.97 – 1.9
DO NOT EAT	> 1.9	> 1.9

* 8 MEALS/MONTH

DATA

551 MERCURY DATA POINTS
10 YEARS OF DATA

ADVICE	NUMBER	% OF SAMPLES
UNRESTRICTED	222	40
1 MEAL/WEEK	169	31
2 MEALS/MONTH	118	21
1 MEAL/MONTH	37	7
6 MEALS/YEAR	5	>1
DO NOT EAT	0	- -

DATA EXAMPLES

SPECIES	# SAMPLES	Hg RANGE mg/kg
WALLEYE	44	0.069 – 1.564
LARGEMOUTH BASS	54	0.078 – 0.99
SMALLMOUTH BASS	97	0.06 – 0.733
BROWN TROUT	75	0.007 – 0.856
CARP	50	0.04 – 0.576
CHANNEL CATFISH	37	0.027 – 0.78

SPECIES COMPARISONS

CATEGORY	WALLEYE	LARGEMOUTH	SMALLMOUTH
UNRESTRICTED	3 (7%)	8 (15%)	17 (18%)
1 MEAL/WEEK	13 (30%)	18 (33%)	33 (34%)
2 MEALS/MONTH	18 (41%)	19 (35%)	39 (40%)
1 MEAL/MONTH	5 (11%)	9 (17%)	8 (8%)
6 MEALS/YEAR	5 (11%)	0	0
DO NOT EAT	0	0	0

SPECIES COMPARISONS II

CATEGORY	WALLEYE	BROWN TROUT	CARP
UNRESTRICTED	3 (7%)	52 (70%)	29 (58%)
1 MEAL/WEEK	13 (30%)	19 (25%)	15 (30%)
2 MEALS/MONTH	18 (41%)	3 (4%)	5 (10%)
1 MEAL/MONTH	5 (11%)	1 (1%)	1 (2%)
6 MEALS/YEAR	5 (11%)	0	0
DO NOT EAT	0	0	0

STATEWIDE ADVISORY – APRIL 11, 2001

- EAT NO MORE THAN 1 MEAL/WEEK OF RECREATIONALLY CAUGHT SPORT FISH
- REASONS:
  - UNTESTED WATERS
  - UNTESTED SPECIES IN WATERS WITH ADVISORIES
  - CURRENTLY UNKNOWN CONTAMINANTS

TMDL IMPLICATIONS

- PA LISTS WATERS WITH ADVISORIES ON 303(d)
- HOW DO YOU HANDLE A STATEWIDE ADVISORY WATERS WITH ACTUAL DATA ARE TO BE LISTED

OPTION 1 – LIST ONLY WATERS WITH 2 MEALS/MONTH OR MORE RESTRICTIVE

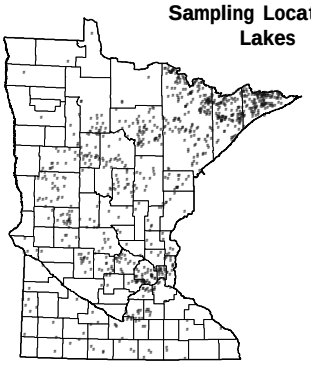
OPTION 2 – ALSO LIST WATERS WHERE ACTUAL DATA SHOW 1 MEAL/WEEK

Minnesota Statewide Fish Consumption Advice

Pat McCann
Minnesota Department of Health
October 22, 2002

Why have a Statewide Advisory?

- Can't test every water and every species
- Some level of Hg is in every fish we test
- Every water should some advice – particularly for the sensitive population
- Myth - the waters listed in the fish advisory are bad, others good
- Simplify the communication



Can existing data be used to predict untested waters advice?

- Yes and No – not with statistical rigor, but yes in a general sense
- High variability in meHg production
  - Predictors not completely understood or measured
- Sampling not designed for predictive purposes (selection bias and sample type consistency problems)

A "Weight of Evidence" Approach

- Data Analysis
  - Means and regression analysis
    - By species and geographic location
- Harvest rates
- Input from other state agencies
- Consistency with neighboring states
- Consistency with site-specific advice format

Safe Eating Guidelines: *General Population*

For adults who eat fish all year long*

Kind of fish	How often can you eat it?
Fish caught in Minnesota:	
Sunfish, crappie, yellow perch, bullheads	unlimited amount
Walleyes, northern pike, smallmouth bass, largemouth bass, channel catfish, flathead catfish white sucker, drum, burbot, sauger, carp, white bass, rock bass, other species	1 meal a week
Commercial fish:	
Limit the following species: shark, swordfish, tile fish, king mackerel	1 meal a month

* In general, adults who eat fish just during vacation or one season can eat fish twice as often as recommended in these guidelines.

Safe Eating Guidelines: *Special Populations*

For pregnant women, women who may become pregnant and children under age 15*

Kind of fish	How often can you eat it?
Fish caught in Minnesota:	
Sunfish, crappie, yellow perch, bullheads	1 meal a week
Walleyes shorter than 20 inches, northern pike shorter than 30 inches, smallmouth bass, largemouth bass, channel catfish, flathead catfish white sucker, drum, burbot, sauger, carp, white bass, rock bass, other species	1 meal a month
Walleyes longer than 20 inches, northern pike longer than 30 inches, muskellunge	**Do not eat.**
Commercial fish:	
• Shark, swordfish, tile fish, king mackerel	**Do not eat.**
• Other commercial species, including canned tuna	See MDH's brochure, *"An Expectant Mother's Guide to Eating Minnesota Fish,"* for guidelines.

Special Note: Please see the two tables on page 6 for exceptions to these guidelines. These exceptions are for eating fish from certain Minnesota waters known to have higher levels of contaminants. →

* There is no change in these guidelines for eating fish just during vacation or one season.

Precautions in these two tables apply ONLY to members of the special populations listed on page 5. Be sure to check BOTH tables.

Table 1 — Do Not Eat the Listed Fish More Than Once a Month

Lake Name	DOW ID*	Kind of Fish
Agate	21000200	Crappie
Albinson	09000200	Crappie
Bass	09010000	Bullhead
Benton	41000200	Crappie
Big Marine	82000200	Bullhead, Crappie
Bigfish	27012200	Bullhead
Bryant	27000100	Crappie
Butch	21000100	Bullhead, Crappie
Carlos	21000400	Bullhead
Cedar	09010000	Sunfish
Clark	09010000	Crappie
Dan	09000400	Crappie
Dayton (Hollow Rock)	56000400	Sunfish
Elysian	40000200	Crappie
Fawnskin (Crawling)	21000300	Bullhead
Fish	09000400	Crappie, Bullhead
Fogo	38000400	Crappie
Grove	03000200	Bullhead
Johnson	09011100	Crappie
Jouselme	62000100	Bullhead
Lewis	12000200	Sunfish
Little Rock	09000300	Crappie
Long Island	09000400	Crappie
Long	09010000	Bullhead
Lower Cormorant	09010000	Crappie
Minnewaska	61000400	Crappie
Minnie-Belle	61011000	Bullhead
Mosquito	09000400	Crappie
Nett	09000000	Sunfish
North Twin	09000400	Sunfish, Crappie
Otter	09010000	Crappie
Overland	10000100	Bullhead
Pepperton	10000100	Crappie
Pickerel	09000100	Sunfish
Pierce	09000400	Crappie
Redwood	04000400	Crappie
Sand Point	09000400	Crappie
Sand Point	09000400	Crappie
Silver	09000200	Sunfish, Crappie
Silver Island	10000100	Crappie
Spring	27000100	Sunfish
Stegal	09000400	Sunfish
Stump	04000400	Bullhead
Sunset	09000400	Bullhead
Tri-Town	11000100	Bullhead
Upper Cormorant	09010000	Crappie
Victoria	10000400	Bullhead
Virginia	09000400	Sunfish
Willow	21011100	Sunfish, Bullhead
White Iron	69000400	Crappie
Wolf	09010000	Crappie
Wynne	09000400	Sunfish
RIVERS		
Cedar River, above Austin		Bullhead
Mississippi River		
• Pool 2		Crappie
• Pool 3 (Spring Lake)		Sunfish, Crappie, Bullhead
• Diamond Lake		Crappie
• Little Falls to Lake Mille Lacs		Sunfish, Bullhead
St. Louis River, near Cloquet		Bullhead

* The DOW ID is the identification number for the lake as assigned by the Department of Natural Resources' Division of Waters.

Table 2 — Do Not Eat the Listed Fish

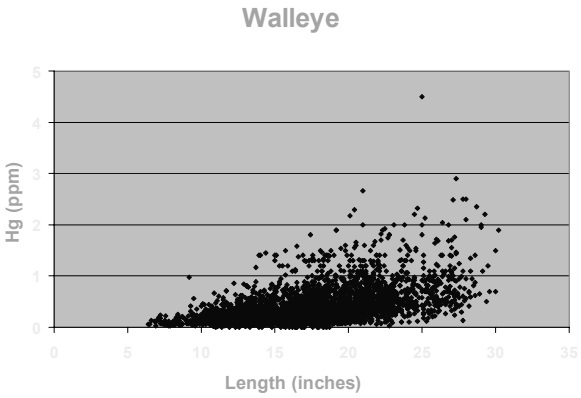
Lake Name	DOW ID*	Kind of Fish	Size
Andrew	09010000	Northern Pike	>15 in.
Big Bear	09011000	Northern Pike	>25 in.
Cut	09000400	Northern Pike	>25 in.
Gaby	09000400	Walleyes	any size
Gull	09000400	Northern Pike	>28 in.
Crane	09000400	Smallmouth Bass	any size
Crane	09000400	Sauger	any size
Crane	09000400	Walleyes	>15 in.
Dark	09010000	Northern Pike	>25 in.
Day	09000400	Walleyes	>15 in.
Deerlick	10000100	Lake Trout	>23 in.
Devils	09000400	Northern Pike	>25 in.
Ely	09000400	Northern Pike	>25 in.
Escanaba	09000400	Northern Pike	>25 in.
Eugene	09000400	Walleyes	>15 in.
Gull	10000100	Northern Pike	>25 in.
Gull	09000400	Northern Pike	>25 in.
Gull	09000400	Lake Trout	>23 in.
Hand	10000100	Northern Pike	>28 in.
Hunter	09000400	Walleyes	>15 in.
Little Trout	09000400	Northern Pike	>25 in.
Little Vermilion	09000400	Lake Trout	>28 in.
		Sauger	any size
Locator	09000400	Northern Pike	>25 in.
Loften	09000100	Largemouth Bass	>15 in.
Lown	09000400	Northern Pike	>25 in.
Lower Cormorack	09000400	Walleyes	any size
Moulton	01000400	Walleyes	any size
Northern	09000400	Walleyes	>15 in.
Pike	09000400	Walleyes	>15 in.
Pillsbury	19000400	Largemouth Bass	>15 in.
Pine	09000400	Northern Pike	>28 in.
Portsmouth	27010100	Northern Pike	>25 in.
Pelican	09010000	Largemouth Bass	>15 in.
Pickerel	09000100	Northern Pike	>28 in.
Pine Island Flowage	09000400	Northern Pike	>25 in.
Pokegama	09000400	Sauger	any size
Red Rock	10000100	Northern Pike	>25 in.
Rice	10000100	Lake Trout	>28 in.
Round	27000100	Walleyes	>15 in.
Ryan	09000400	Northern Pike	>15 in.
Sherman	09000400	Walleyes	>15 in.
Spring	09000400	Northern Pike	>25 in.
Spring	09010000	Northern Pike	>25 in.
Stegal	09000400	Northern Pike	>28 in.
Sucker	10000100	Crappie	
Tooth	09010000	Northern Pike	>15 in.
Trout	21000100	Walleyes	>15 in.
Upper Cormorack	09010000	Walleyes	>15 in.
Vermilion	09000400	Northern Pike	>25 in.
Winchell	10000400	Lake Trout	>28 in.
Winnie	10000400	Walleyes	any size
Wyman (Gabbro)	09000400	Northern Pike	>28 in.
		Walleyes	>15 in.
RIVERS			
Big Stone River		Walleyes	>15 in.
Mississippi River			
• Grand Rapids to Brainerd		Bowfin	>25 in.
		White Sucker	>28 in.
St. Louis River			
• Cloquet to French (Lac Shar)		Northern Pike	>15 in.
Whitefish River		Walleyes	>15 in.

Input from other Agencies

- Department of Natural Resources
  - Continue to provide site-specific advice
  - Concern about list of "bad" waters
  - Concern about future funding for monitoring
- Pollution Control Agency
  - In line with their trend and mechanistic work
  - TMDL list
  - Concern about future funding for monitoring
- Tourism
  - Concern about list of "bad" waters and impact on northern MN

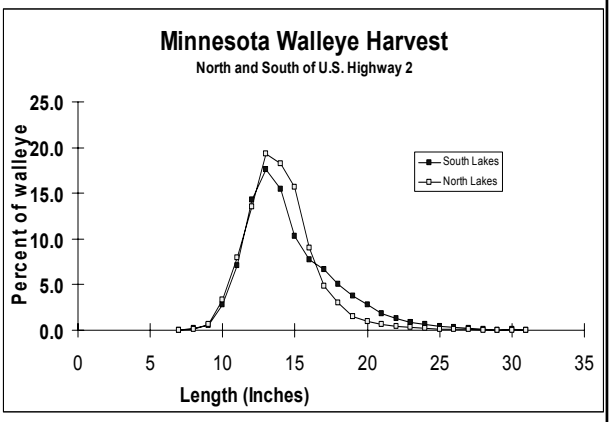
Meal Advice Categories – Mercury Women and Children

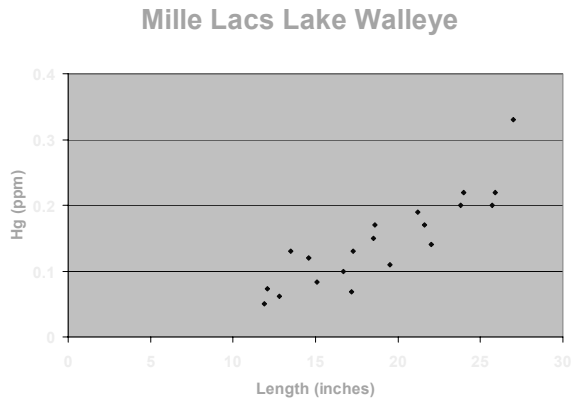
Unlimited consumption	< 0.05 ppm
1 meal / week	0.06 - 0.2 ppm
1 meal / month	0.21 - 1.0 ppm
Do not eat	> 1.0 ppm



Means Analysis

	N	Mean (µg/g)	Upper 95%CI on mean
All Walleye	3761	0.39	0.41
NE Walleye	2268	0.45	0.47
Not NE Walleye	1493	0.31	0.32





Communication

- General Statewide Advice
  - "Eat fish often?" and Mom's Guide brochures
  - MDH web site
  - DNR Fishing Regulations
- Site Specific Advice
  - MDH web site
  - DNR Lake Reports - web and hard copy

Eat fish often?

Most fish are healthy to eat. And fish are an excellent source of low-fat protein.

But any fish (store-bought or sport-caught) could contain contaminants such as mercury and PCBs that can harm human health — especially the development of children and fetuses.

The Minnesota Dept. of Health provides advice on how often fish can be safely eaten. The consumption guidelines below are based on mercury levels measured in fish from lakes across the state. Specific advice for waters where fish have been tested is on the DNR web site (www.dnr.state.mn.us) and in DNR lake survey reports.

Tips for reducing contaminants

1. Eat smaller fish. Large fish contain higher levels of contaminants.
2. Eat more panfish (sunfish, crappies) and fewer predator fish (walleyes, northern pike, lake trout).
3. Trim skin and fat, especially belly fat. Also, eat fewer fatty fish such as carp, catfish, and lake trout. PCBs build up in fish fat.

General Consumption Guidelines for fish caught in MN

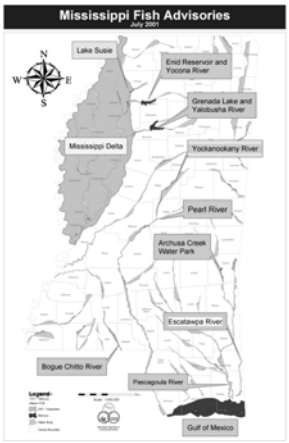
For Children and Women of Child-bearing Age	
Panfish	1 meal/week
Walleye < 20 inches	
Northern Pike < 30 inches	1 meal/month
All sizes of other species not listed	
Walleye > 20 inches	
Northern Pike > 30 inches	Do not eat
Muskellunge	
For Other Adults	
Panfish	Unlimited
All sizes of other species	1 meal/week

For more information, call the Minn. Dept. of Health at 651/215-0950 or toll-free 800/657-3908.

Regional Fish Advisory for the Mississippi Delta

MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY

Henry Folmar
October 21, 2002



Fishing is an important part of the culture in the Delta.

Most Delta fisherman eat what they catch.

DDT in the Delta is not a new problem.

- DDT was heavily used as a cotton insecticide beginning shortly after WWII.
- Decline in fish eating species like the Bald Eagle and Brown Pelican.
- Fish Advisories for Wolf, Mossy and Washington Lakes in 1970's.
- DDT was banned in 1972 and toxaphene in 1982.

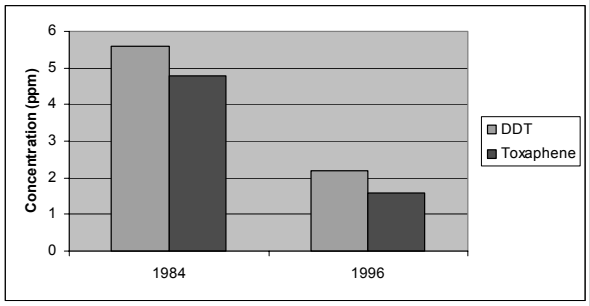
Recent studies show DDT and toxaphene levels in the Delta are among the highest in the country:

- USFWS - Yazoo R. @ Redwood - whole carp had highest DDT levels of 112 sites across the country.
- USFWS - Monitored pesticides in fish and wildlife on refuges around the country. Led to closure of Yazoo Refuge to Fishing.
- USGS - NAWQA Study - MS portion of Delta had highest levels of DDT and toxaphene in fish of any of their 230 sites nationwide.

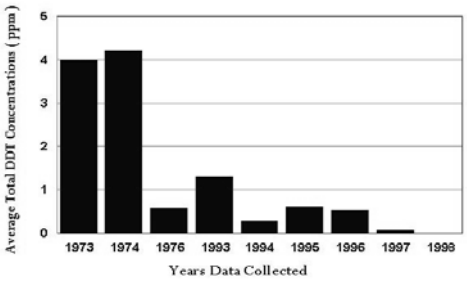
DDT and toxaphene levels in fish in the Delta are declining.

- **Data from USFWS and MDEQ and other agencies show conditions are improving.**

Concentrations of DDT and toxaphene in whole carp from the Yazoo River at Redwood, MS (USFWS).



Average DDT concentrations in largemouth bass in the Delta 1973-1998 (MDWFP, MDEQ)



So if things are getting better, why all the fuss?

- The level considered to be safe has changed.
- FDA rescinded their action level for DDT in 1993.
- States were encouraged to begin using EPA guidance that was more protective.
- The Mississippi Fish Advisory Task Force led an effort to develop new criteria following the EPA guidance

Criteria Setting Process

- MS Fish Advisory Task Force (DEQ, DH, DWFP, DAC, and DMR)
- Followed EPA Guidance
- Technical Review Committee (UMC, MSU, USGS, USDA, USFWS, EPA, COE)

Mississippi Fish Advisory Criteria for DDT and Toxaphene

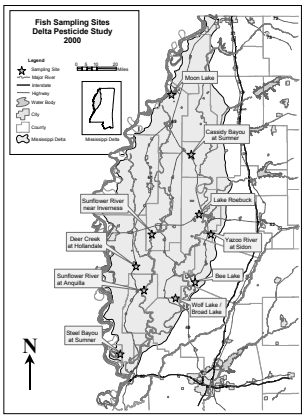
Fish Tissue Concentration (mg/kg)		
Consumption	DDT	Toxaphene
No limit	<1.0	<0.4
2 meals/month	1.0 - 5.9	0.4 - 1.9
No Consumption	≥6.0	≥2.0

The objectives of the Mississippi Delta Fish Tissue Study were to:

- Evaluate the concentration of DDT and toxaphene in edible tissue from 10 selected sites.
- Use these data to evaluate human health risks associated with eating fish.
- Develop a species concentration gradient for DDT and toxaphene that will help focus future monitoring efforts.

Sampling Sites

Mississippi Delta Fish Tissue Study 2000

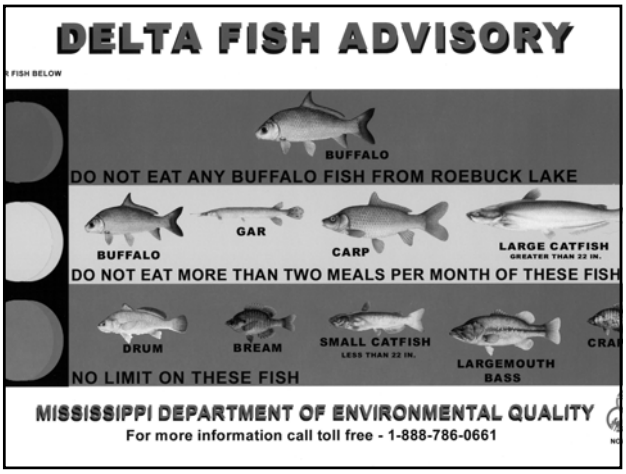


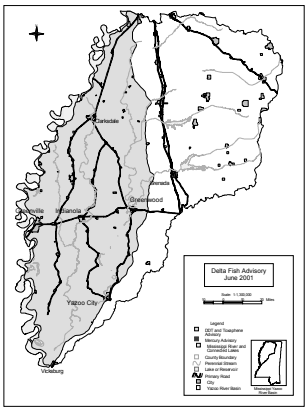
Good News:

- **All largemouth bass, bream, crappie, freshwater drum and all catfish less than 3lbs were below the criteria at all sites.**
- **66% of all samples were below the criteria for DDT.**
- **73 % of all samples were below the criteria for toxaphene.**
- **Farm raised catfish samples were below the criteria for both DDT and toxaphene.**

Bad News:

- **All ten sites had at least two samples that exceeded Mississippi's limit consumption criteria for DDT or toxaphene.**
- **7 of 9 Cassidy Bayou samples exceeded the criteria.**
- **7 of 13 Roebuck Lake samples exceeded the criteria, including 3 samples that were above the no consumption criteria.**
- **Some form of advisory was warranted at each site sampled**





Delta Fish Tissue Advisory Area

- Includes Mississippi Portion of Delta from Memphis to Vicksburg from MS River Levee to the bluff hills.
- Does not include MS River or connected oxbow lakes.

Outreach/Public Information

- News Conference in Jackson/Stoneville
- News Release
- Sampling Demo for TV and Print Media
- Radio and TV spots on Delta Area Morning Shows
- Call in shows on gospel and blues radio stations in and around the Delta
- Sent letters and posters to Delta Area Fish Markets and Grocery Stores

Outreach Efforts Cont'd

- Went door to door in some communities explaining advisories and answering questions.
- Participated in two Delta area Health Fairs (Greenville and Clarksdale).
- Participated in three Wildlife Expos in Greenville and Jackson
- Appeared on Mississippi Outdoors TV Show.
- Appeared on Listen to the Eagle, a statewide radio call in show.

Outreach Efforts Cont'd

- Sent letters, maps and brochures to all commercial fishermen in the state.
- Printed Advisories in MDWFP Outdoor Digest.
- Printed Signs for Roebuck Lake and rest of Delta.
- MDWFP and MDEQ put up signs at boat ramps and public fishing areas.
- Placed Maps, Brochures, Posters, and Advisory Table on MDEQ WebSite.
- Mailed letters, maps and brochures to 1400

Outreach Efforts (Cont'd)

- 16,000 Coloring books for distribution in schools, head start programs and other children's groups.
- Distribution of posters and brochures through WIC offices and county Health Departments in the Delta.
- Fish Advisory Brochure and Poster in Spanish.

Next Steps

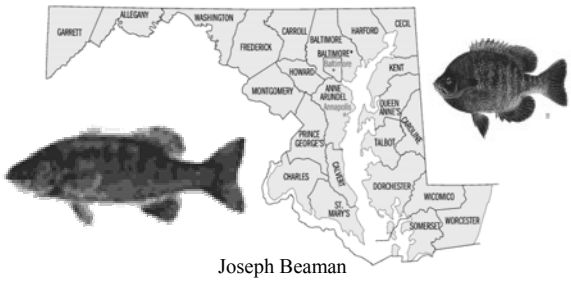
- Continue monitoring looking for hot spots and clean areas that can be removed from advisory.
- Continue Outreach Efforts.
- TMDL's by June 2003.

Questions?

Contact Information:
Henry Folmar
MDEQ Laboratory
1542 Old Whitfield Road
Pearl, MS 39208

601-664-3910
Henry_Folmar@deq.state.ms.us

Consumption Advisories Based On 8 Meals/Month



Joseph Beaman
Maryland Department of The Environment
2002 National Forum on Contaminants in Fish

Overview of MD RA Policies: Fish Consumption Advisories

- **Provide Guidance for Three Populations:**
  - General Population
  - Women of Child-Bearing Age (18-45 years of age)
  - Young Children (0-6 years of age)
- **Consider Carcinogenic/NonCarcinogenic Effects**
- **Meal Size (Wet Weight in oz)**
  - 8 Oz. - General Population
  - 6 Oz. - Women of Child Bearing Age
  - 3 Oz. - Children 0-6 Years of Age
- **Meal Thresholds For Allowable Fish Consumption**
  - Do Not Eat (Less Than 4 meals/year)
  - 4 – 11 meals per year
  - 1, 2, 4, or **8** meals per month (> 4 meals = 8)

Basis For 8 Meal/Month Advisory Recommendations

- POLICY DECISION Based on:
- Anecdotal knowledge exists for subsistence/frequent fish consumer populations in several areas of the State:
  - **Baltimore City**
  - **Urban MD near Potomac River**
  - **Eastern/Western Shores of the Chesapeake Bay**
- Was not based on Exposure Assessment data from fish consumer populations in MD.

Risk Assessment Equations

- Calculate acceptable concentration of contaminant in fish tissue
- $[PCBs] = \frac{RL \times BW \times LT \times T_{ap}}{CSF \times MS \times MF \times ED \times ((100 - \%\ loss)/100)}$
- $[\text{Methyl Mercury}] = \frac{RfD \times BW \times LT \times T_{ap}}{MS \times MF \times ED}$

What Does 8 Meals/Month Mean? Carcinogens

- **Resulting Threshold Ranges For 8 Meals/Month (i.e. PCBs)**
  - General Population 20 – 39 ppb
  - Women of Child Bearing Age 17 – 33 ppb
- **RA Parameters (Carcinogens)**
  - 1×10^{-5} Risk Level
  - Standard Population Bodyweights
  - 70 Year Lifetime
  - 30 Year Exposure Duration
  - Upper Estimate Cancer Slope Factor (PCBs = 2)
  - Cooking Loss (General Population Only)
  - Used Non-Carcinogenic Effects for Children (more conservative)

Consumption Thresholds - PCBs

Meals/Month	General Population	Women 18-45	Children 0-6
8 meals/month	20 - 38	17 - 32	13 - 25
4 meals/month	39 - 77	33 - 66	26 - 51
2 meals/month	78 - 155	67 - 133	52 - 103
1 meals/month	156 - 312	134 - 266	104 - 207
< 1 meal/month	> 313	> 267	> 208

What Does 8 Meals/Month Mean?
Non-Carcinogens

- **Resulting Threshold Ranges For 8 Meals/Month**
  - General Population 59 – 117 ppb
  - Women of Child Bearing Age 54 – 107 ppb
  - Children 0-6
    - PCBs 13 – 26 ppb
    - Mercury 32 – 64 ppb
- **RA Parameters (Non-Carcinogens)**
  - RfD (Mercury) = 0.1 ug/kg day; (PCBs .05 ug/kg day)
  - Standard Population Bodyweights, Meal Sizes
  - 70 Year Exposure Duration

Consumption Thresholds - Mercury

Meals/Month	General Population	Women 18-45	Children 0-6
8 meals/month	59 - 117	54 - 107	32 - 64
4 meals/month	117 - 235	107 - 215	65 - 129
2 meals/month	236 - 469	216 - 429	130 - 258
1 meals/month	470 - 939	430 - 858	259 - 519
< 1 meal.month	> 940	> 858	>519

Data Decision Rules: Advisories

- Generally, need a minimum of 5 fish (individual or composite) to establish advisory.
- For 2001, Advisories, only used data back to 1995.
- Calculate thresholds using Geometric Mean when sufficient individual or more than 1 composite exists.
- Less than 5 fish may be used when contaminant levels warrant advisories in the meal/year (< 1 meal/month) category and
  - Waterbody is confined (i.e. lake)
  - Fish species is resident (i.e. channel catfish, bullhead spp.)

MD Lakes/Impoundments

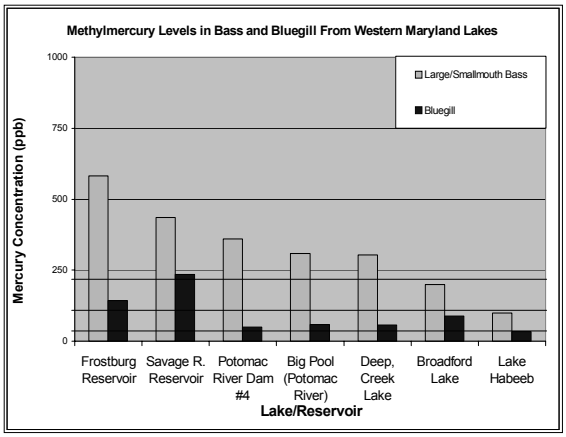
- Approx. 372 "Lakes" Total
- 1 or 2 Natural Lakes
- 30 Lakes > 100 acres
- 275 Lakes/Ponds < 1 – 20 acres

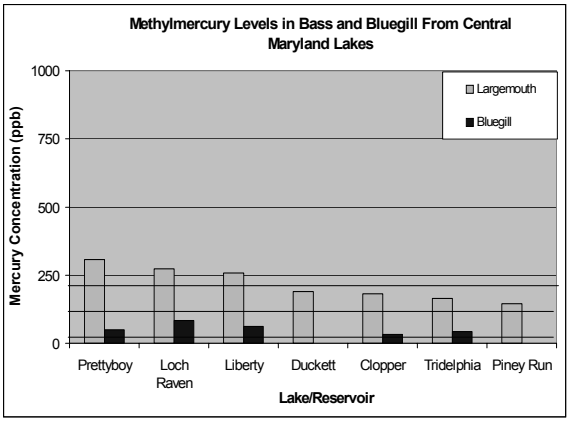
Data Supporting Hg Advisories: Statewide Lakes/Impoundments

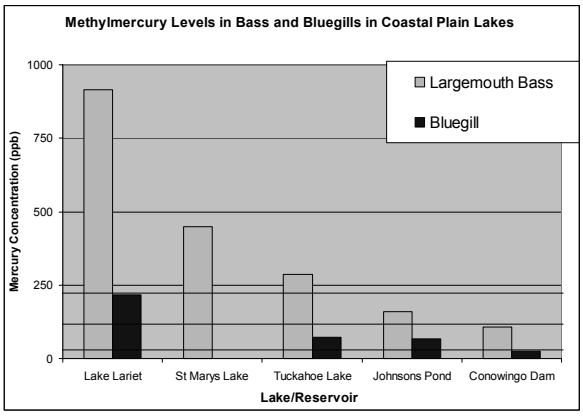
- **MD DNR Power Plant Research Initiative**
- **20 Lakes – Min size 80 acres**
- **Target SpeciesCollected**
  - Large/Smallmouth Bass
  - Bluegill/Sunfish
  - Black Crappie
- **10-15 individuals/species**
- **THg/MeHg Analyzed**

Setting the Statewide Advisory

- 19/32 (59.4%) of lakes/impoundments > 80 acres had sufficient data to generate consumption advisories for bass, bluegill, and/or crappie
- 13/32 (40.6%) > 80 acres of lakes/impoundments had sufficient data to generate consumption advisories bluegill.
- First, geometric mean MeHg (or T Hg when MeHg not available) were calculated for individual waterbodies.
- The average of the geometric means was calculated and used to determine the appropriate level for the advisory, based on EPA risk assessment methodology for mercury





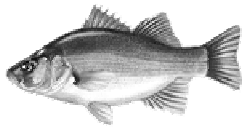


Data Summary for Statewide Advisories

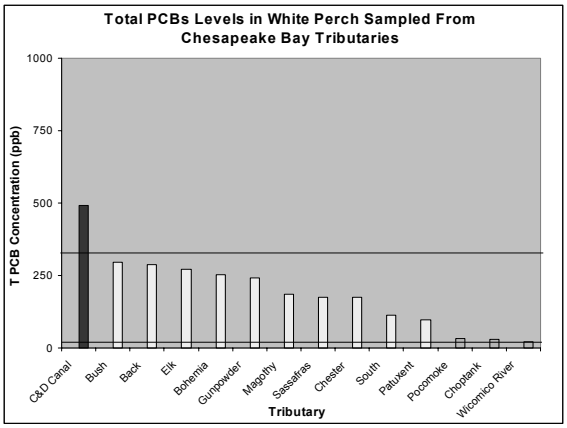
- Lakes/Impoundments
- 13 Lakes
- 181 Ind. Bluegill Sampled
- Average MeHg = 61 ppb
- STD = 29.8 ppb
- Min: 24 ppb; Max: 133 ppb

- Rivers & Streams
- 6 Rivers/Streams
- 29 Bass Sampled – Composites (4-5 fish)
- Average MeHg = 60.7 ppb
- STD = 40.4 ppb
- Min: 47 ppb; Max 123 ppb
- Advisory was conservative based on trends observed in rivers
- Additional sampling needed

PCB Advisories: 8 Meals/Month



- White Perch Only
- Lower Eastern Shore Rivers Only
  - Choptank
  - Nanticoke
  - Pocomoke
- Average 27.6 ppb
- Std. Dev. 5.2 ppb
- 30 Fish Sampled – 2 composites of 5 per river



Potential Advantages of the 8 Meal/Month Advisory

- Provides information to fish consumers (including subsistence populations) as to the locations and species of fish that can be consumed frequently without increased risk of health effects.
- Provides some assurance that fish species with recommendations based on 8 meals/month have relatively "low" (based on risk assessment procedures) concentrations of bioaccumulative contaminants.

Potential Disadvantages of the 8 Meal/Month Advisory

- Unintended negative consequences:

- Some consumers may stop eating fish if there is an advisory of any type, thereby negating the benefits of fish consumption, even though contaminant levels were relatively low.
- Fish Consumption Advisories may cause unintended and potentially unnecessary negative impacts on recreational and/or commercial fisheries. **(RFF Report)**
- Potential Regulatory Disadvantages (TMDLs)
- Confusion in interpretation of advisory information

Outstanding Issues

- Exposure Assessment:

- Currently conducting mail surveys among MD licensed anglers and interviews in urban areas

- Assessment Questions:

- What are the proper fish consumption levels at which to assess risk in the State? Do we need to go to 8 meals? Higher or Lower?
- How should we categorize/group populations in areas with fish consumers?

Impacts of Fish Contamination in the Columbia River Basin

- Fish Contamination Study
- Fish Advisory Issues

Columbia River Basin

Member Tribes of the Columbia River Inter-Tribal Fish Commission (CRITFC):

- Nez Perce
- Umatilla
- Warm Springs
- Yakama

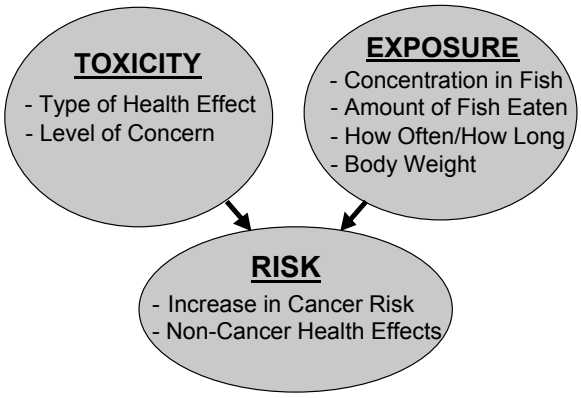
Total of 14 Tribes in the Columbia River Basin

Purpose of Fish Contamination Study

To Evaluate the Likelihood that Native American Tribal Members may be Exposed to High Levels of Contaminants through Consumption of Columbia River Basin Fish.

Phase 1: Fish Consumption Survey 1990-1994 (CRITFC)

Phase 2: Fish Contamination Survey 1996-2002 (USEPA)



Phase 1

Fish Consumption Survey

(CRITFC, 1990-1994)

The Fish Consumption Survey was Designed to Answer the Questions:

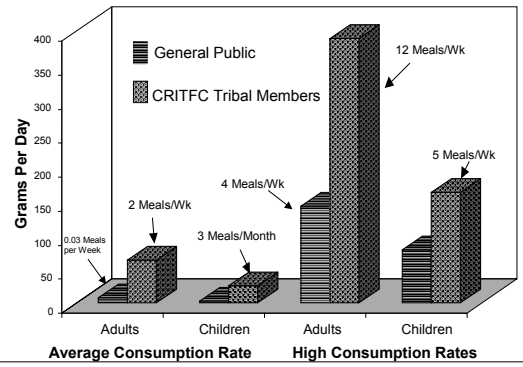
Are Tribal Members Eating More than the National Average (6.5 Grams) used by USEPA?

Are Tribal Members Adequately Protected by Water Quality Standard Based on the National Fish Consumption Rate?

Percent of Each Species in Hypothetical Multiple Species Diet (CRITFC Study)

Salmon	**28%**
Rainbow Trout	**21%**
Mountain Whitefish	**7%**
Eulachon	**16%**
Lamprey	**16%**
Walleye	**3%**
White Sturgeon	**7%**
Largescale Sucker	**2%**

1994 Fish Consumption Survey Results



The Fish Consumption Survey was Designed to Answer the Questions:

Are Tribal Members Eating More than the National Average (6.5 Grams) used by USEPA?
Yes. Adults 58.7 Grams, Children 19.6 Grams.

Are Tribal Members Adequately Protected by Water Quality Standard Based on the National Fish Consumption Rate?
Probably Not. More Study Needed.

Phase 2

Fish Contamination Survey

(USEPA, 1996-2002)

The Fish Contamination Survey was Designed to Answer the Following Questions:

Are the Fish Contaminated?

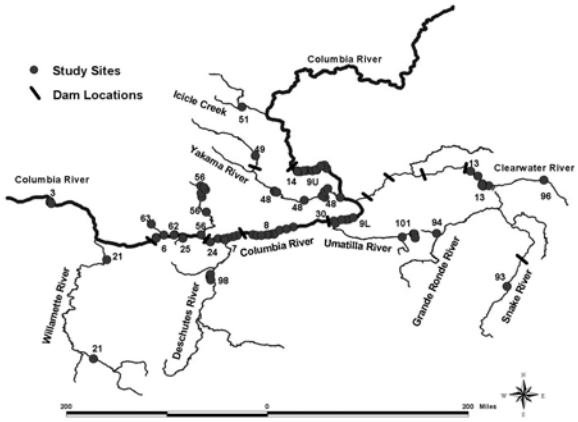
Is there a Difference in Contaminant Concentrations Among Species and Location?

Are the Tribes Exposed to a Higher Risk?

This Fish Contaminant Study was Not Designed to Evaluate:

- People's Health
- Intergenerational Risks
- Rates of Disease
- Sources of Chemicals
- Multiple Exposures

The Study Design was not Random.



Columbia River Basin Study Sites

Fish Sampling

Gillnetting for Salmon

298 Fish Samples from 3 Replicates per Site.

26 Sample Locations on Mainstem Columbia River & 14 Tributaries.

Samples Obtained for Tribal Fishers and from Hatcheries.

Sturgeon at Hanford K Ponds

Resident Species:

- White Sturgeon
- Mountain Whitefish
- Rainbow Trout
- Walleye
- Bridgelip
- Largescale Sucker

Steelhead

Anadromous Species:

- Spring Chinook
- Fall Chinook
- Coho
- Steelhead
- Eulachon (Smelt)
- Pacific Lamprey (Eels)

Various Sample Analyses:

- 145 Whole body, 132 Fillet & 11 Egg Samples.
- Fillet with Skin (Except White Sturgeon).
- Composites Samples (Except White Sturgeon).

Steelhead Fillet

Analyzed for 132 Chemicals (92 Detected)

USEPA Scientist

21 Pesticides
16 Inorganics (Mercury, Arsenic)
3 Aroclors
13 Dioxin-like PCBs
17 Chlorinated Dioxins & Furans
22 Semivolatiles, eg PAHs

Toxicity Assumptions for Chemicals Contributing the Highest Risks

Central Nervous System
Mercury
Arsenic

Cardiovascular
Arsenic

Keratosis
Arsenic

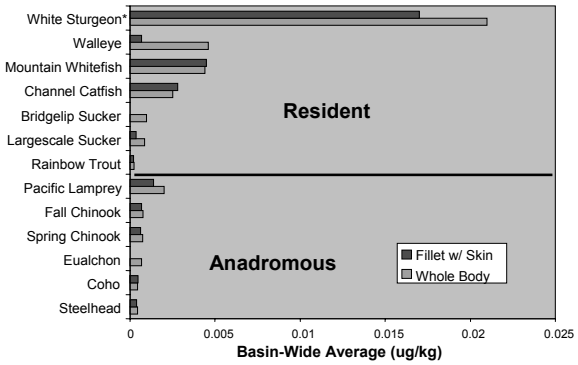
Immune System
Aroclors

Reproductive System
Mercury

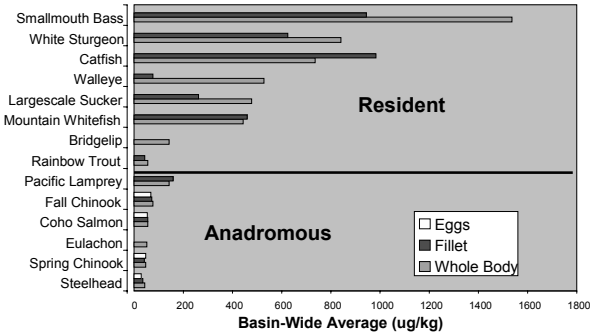
Liver
DDT/DDE/DDD

Cancer
Dioxins/furans (B2)
Dioxin-like PCBs (B2)
Inorganic Arsenic (A)
DDT/DDE/DDD (B2)

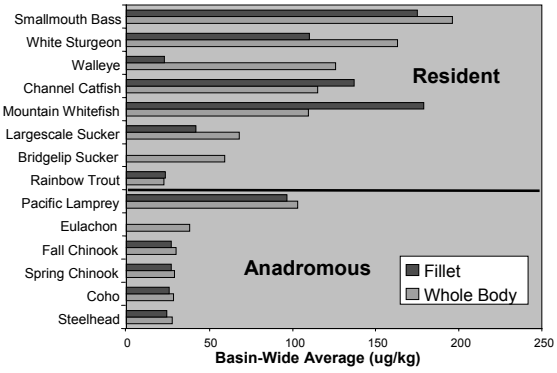
Dioxin (2.3.7.8 TCDF)



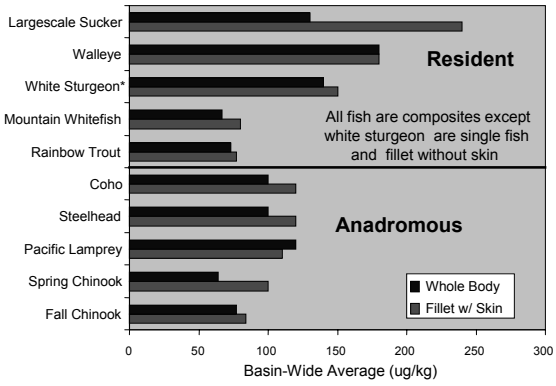
Pesticides



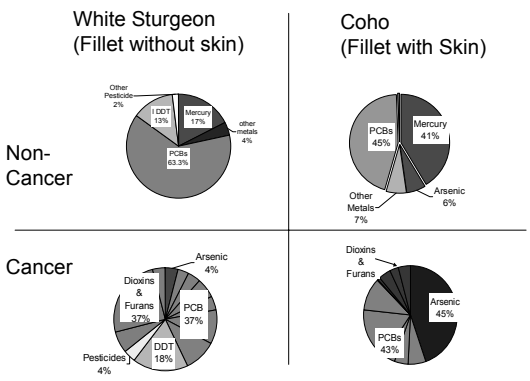
Aroclors



Mercury



Percent Contribution of Chemicals to Health Effects



Mixed Diet Results

CRITFC Tribal Data
Average Fish Consumption, 70 Years Exposure

	Percentage of Hypothetical Diet	Consumption Rate (grams/day)	Cancer Risk	Noncancer Effects (HI)
Salmon	27.7	17.5	6×10^{-5}	0.6
Rainbow Trout	21.0	13.3	4×10^{-5}	0.3
Mountain Whitefish	6.8	4.3	9×10^{-5}	0.7
Eulachon	15.6	9.9	3×10^{-5}	0.1
Lamprey	16.3	10.3	1×10^{-4}	0.7
Walleye	2.8	1.8	4×10^{-6}	0.1
White Sturgeon	7.4	4.7	7×10^{-5}	0.6
Largescale Sucker	2.3	1.5	9×10^{-6}	0.1
Totals	**100.0**	**63.2**	**4×10^{-4}**	**3.2**
			$< 10^{-6}$ Problem	**> 1 Problem**

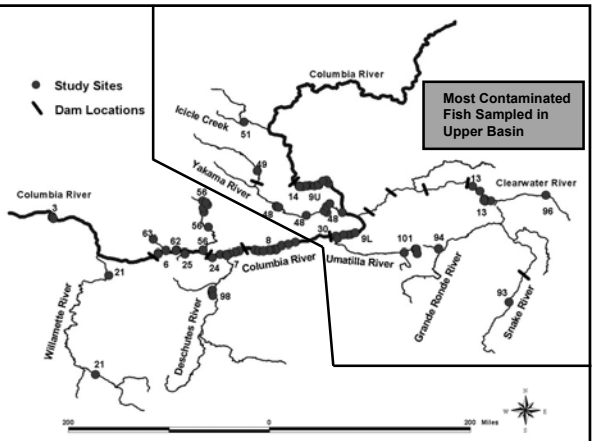


Figure 1-1. Columbia River Basin Study Sites

The Fish Contamination Survey was Designed to Answer the Following Questions:

Are the Fish Contaminated?
Yes.

Is there a Difference in Contaminant Concentrations Among Species and Location? Yes.

Are the Tribes Exposed to a Higher Risk?
Yes.

Conclusions

Resident Fish More Contaminated than Anadromous Fish.

Tribal Members Eat Significantly More Salmon than Resident Fish.

Fish Consumption Risk Much Higher for Tribal Members than for the General Population.

Conclusions (continued):

USEPA Concludes the Columbia Basin Fish Contamination Results are Similar to other Large River Basins in the US.

Stressing this USEPA Conclusion Downplays the Importance of Addressing this Critical Issue for Tribes in the Columbia River Basin.

Issues to Address while Considering a Fish Advisory in the Columbia River Basin

Cultural Importance of Salmon

Treaty Fishing Rights

Tribal Fishery at Celilo Falls

Treaties of 1855 Guaranteed "the Right of Taking Fish at All Usual and Accustomed Places"

This Means Taking Fish that will Nourish, Not Harm, the Health of our Bodies.

Human Health

Traditional Diet vs. Toxic Fish

Personal Health of Tribal Members is the Highest Priority of Tribal Governments.

Fish Preparation Methods May be an Issue.

Personal Health = Physical, Mental, Spiritual & Cultural

Fish Health

Research & Analysis Needs are Substantial (Pathology, Toxicology, etc.).

Hagerman Lab in Idaho is Currently Being Built.

Fish Health Issues Tends to Get Lost in the Shuffle.

Economic

Tribal Fisher Selling Salmon to the Public

Economic Benefit to Tribal Members is Significant (~$2M Annually).

Major Tribal Effort is Underway to Increase the Fishery Value.

Recent USEPA Report has Impacted Tribal Ability to Market Salmon.

Environmental Clean-Up

Hanford Nuclear Reactor

Past Hanford Contamination

Identification of Contamination Sources.

Legal Issues: ESA, CWA, Treaties with Tribes.

Political Process.

Environmental Justice.

Partnering with Environmental Organizations.

Tribal Limitations in Addressing the Risks and Benefits of Eating Salmon:

- Understanding Results
- Communicating to Tribal Members
- Coordinating Inter-Tribal Efforts
- Action to Clean Up the Water
- Lack of Funding

Dietary Benefits and Risks in Alaskan Villages

Principal Investigator:

•**Mike Brubaker, Aleutian/Pribilof Islands Assn.**

Regional Research Coordinator:

•**Sue Unger, Aleutian/Pribilof Islands Assn.**

St. Paul Coordinators:

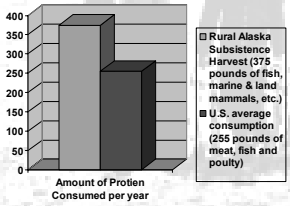
•**Aquilina Lestenkof, Phil Zavadil & Blair Powless**

Atka Coordinators:

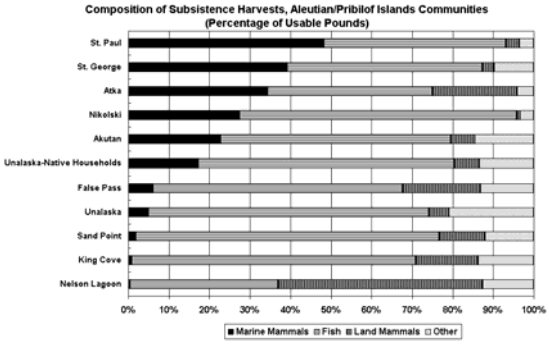
•**Ray Golodoff & Margaret Lokanin**

Subsistence Use in Alaska

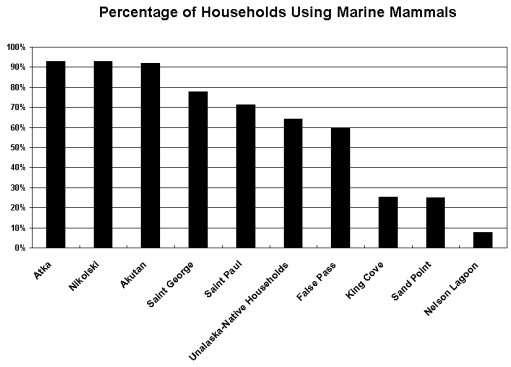
- 229+ tribes in Alaska
- Main subsistence food is fish- about 65 percent (salmon, halibut, herring, whitefish, cod, and Dolly Varden, etc.)



Subsistence Use in the Aleutian/Pribilof Region



Marine mammal use in the Aleutian/Pribilof Region



Purpose of Study:

- To encourage healthy dietary choices by raising awareness about rural diet and the risks and benefits unique to foods consumed in Atka and St. Paul.

Key Questions

- Is our traditional food safe to eat?
- What are the benefits of eating traditional foods? Risks?
- What are the benefits/risks of changing from a traditional diet to a more store-bought diet?

Benefits and Risks of Traditional Foods

Community Goal:

• Restore and maintain health lifestyles and cultural connection for this and future generations to achieve holistic community health* in Atka and St. Paul.

* *Community health* is defined as a natural interplay among cultural, physical, environmental, economic, spiritual, social and emotional forces.

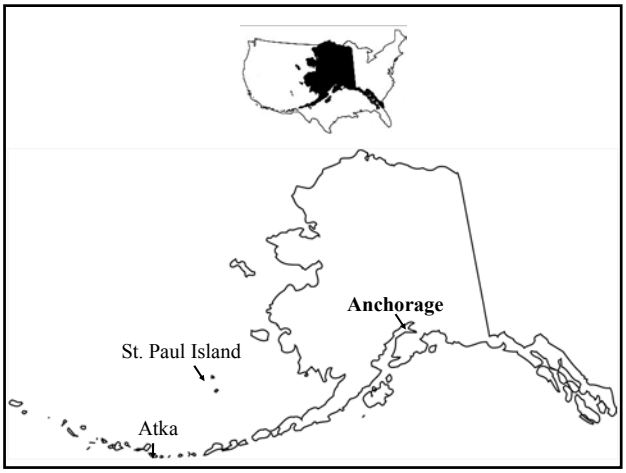
Hypotheses:

• Traditional foods are safe to eat and are an important part of a nutritious balanced diet.

• Maintenance of traditional diet enhances community cohesion, cultural connection and community and individual health.

• Increasing substitution of traditional foods with commercial foods in the diet are resulting in negative health effects.

• Many factors are influencing the collection, use and benefits of traditional foods.



How were study sites chosen?

St. Paul:

Study showing high content of Persistent Organic Pollutants in Northern Fur Seal

Dramatic changes in diet

Highest rate of increase in diabetes in State

Access to store foods

Atka:

Results from Persistent Organic Pollutants Study in 5 Aleutian and Pribilof Villages.

Proximity to Amchitka Island

High subsistence use area

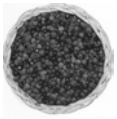
First communities to enroll in Maternal Cord Blood Sampling Program

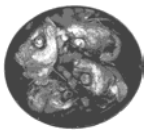
Unique Partnership

A/PIA	**Tribal Gov't of St. Paul**	**Atka IRA Council**	**UAA-Institute for Circumpolar Health**
Dept. of Environ. Conservation	**Dept. of Health & Social Services**	**Dept. of Fish and Game**	**Alaska Native Health Board**
Alaska Native Tribal Health Consortium	**US Environmental Protection Agency**	**U.S. Fish and Wildlife Service**	**Local Village Advisory Groups in St. Paul/Atka**

Process

- ***Dietary Surveys***: Finding out what foods people in the community are eating and *how much.*





Process (cont.)

- ***Sampling:*** Traditional foods that are collected for subsistence will be sampled.

Process (cont.)

- ***Analysis:*** Testing sampled traditional foods for contaminants *and* nutrients

Process (cont.)

Education/Communication:

- Village Advisory Groups
- Public Meetings
- Working with the School
- Technical Advisory Team
- Film Project

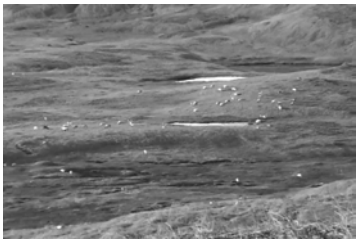
Project Objectives

The benefit-risk assessment for dietary choices will be designed to improve the understanding of and communicate:

- Pollutant levels in traditional foods
- Nutritional value of traditional foods
- Pollutant levels in commercial foods
- How to select and prepare foods to reduce exposure
- Ways to select a quality blended diet to enhance personal and community health.

Project Assumption

Objectives are based on assumptions that the *nutritional and cultural benefits of traditional foods are essential to holistic community health.*



"Diabetes and high blood pressure and all of that is a concern because of our diet change. We have nowadays more junk food available to us. Lack of exercise and more soda pop and sweets are available…"

"… It changes the way things used to be."

-Sally Swetzof, Atka

"…What does it (seal) have that makes me better able to live in this environment that is very windy, that is very wet and damp a lot of the time?"

-Aquilina Debbie Lestenkof, St. Paul

Overview of the Benefits of Fish Consumption

Judy Sheeshka, PhD, RD
University of Guelph
Guelph, Ontario

Outline

- Fish in 'healthy diets'
- Omega-3 fatty acids (n-3 FA) in fish
- n-3 FA in growth & development
- n-3 FA, fish & chronic disease
- Summary

- Benefits depend on:
  - Amount consumed
  - Species
  - Food displaced
- Generally, fish valued for:
  - High quality protein
  - 'Good' fatty acids, esp. n-3 FA
  - Vitamins & minerals

Protein quality = relative proportions of essential amino acids & their availability to the body

- Animal foods have 'complete' proteins
- Plant foods have 'incomplete' proteins
- Egg protein highest quality, then fish
- Look at total day's intake, not food substituted

Fish vs. other 'protein foods' (150 gram portions)

	Rainbow Trout	Perch (mixed)	Chicken breast (no skin)	Hot Dog
% kcal PRO	24 %	26 %	27 %	15 %
% kcal FAT	37 %	33 %	34 %	52 %
% kcal CHO	39 %	41 %	39 %	33%
total Kcal/d	1148	1099	1171	1396

Fat

- New dietary reference intakes (DRIs, 2002) recommend:
  - 20-35% of total calories from fat
  - Low saturated fat
- Saturated fatty acids (SFA) – mostly in meats, baked goods, high-fat dairy
- SFA – raise serum LDL cholesterol ('bad')

- Mono & poly-unsaturated fatty acids (MUFA & PUFA) – fish, veg oils, nuts
- MUFA & PUFA lower serum LDL ('bad') & raise HDL ('good' cholesterol')
  = lower risk of heart disease

	Lean Fish	Fatty Fish	Beef	Chicken
SFA	25%	25%	40-45%	30-35%
MUFA	25%	50%	50%	35-40%
PUFA	50%	25%	5-10%	25-30%

Omega-3 Fatty Acids

- Type of PUFA found in fish, flaxseed oil
  - DHA 22:6n-3
  - EPA 20:5n-3
- Amts in lean fish = 0.3 - 0.5 g/100 g fish
- Amts in fatty fish = 0.8 - 1.0+ g/100 g fish
- Fish from colder waters – more n-3 FA

N-3 FA (g/100 g fish)

	C20:5 EPA	C22:6 DHA
Bass, mixed-species	0.305	0.458
Coho salmon	0.401	0.658
Rainbow trout	0.468	0.560
Fresh-water drum	0.295	0.368

N-3 FA (g/100 g fish)

	C20:5 EPA	C22:6 DHA
Channel catfish	0.100	0.137
Northern pike	0.042	0.095
Walleye	0.110	0.288
Yellow perch	0.101	0.223

N-3 FA & Mercury

	EPA & DHA g/100 g fish	Mercury Mean ppm
Bass, mixed-species	0.763	0.46 - 0.52
Northern pike	0.137	0.36
Walleye	0.398	0.43 – 0.77
Yellow perch	0.324	0.25 - .040

N-3 FA & Contaminants

- Fattier, predatory fish (e.g., swordfish, king mackerel):
  - Higher n-3 FA but also higher mercury, PCBs where these a problem
- Halibut, pollock, catfish, sablefish, herring lower in mercury, modest amts n-3 FA

Farmed vs Wild Fish

- Debate re: n-3 FA in farmed vs wild fish
- Type of feed important
- Farmed fish have higher total fat, so n-3 as % of total FA is lower
- But appears that n-3 FA /100 g farmed fish same as for wild fish

Summary of Nutritional Benefits

- Fatty fish comparable to lean meats & skinless poultry in:
  - amount of protein, fat, cholesterol
  - quality of protein
- <u>But</u> proportions of SFA, MUFA & PUFA better in fish
- Cheese, processed meats & eggs have more fat & cholesterol
- Plant foods (e.g., pasta, rice) have poorer quality protein

Summary of Nutritional Benefits

- Only fish have n-3 FA
  - Levels higher in cold water, fatty fish
  - Predatory high fat fish may be high in mercury (e.g., king mackerel, swordfish)
  - Fish with modest amts n-3 FA & low mercury: halibut, catfish, yellow perch

Omega-3 FA in Growth & Development

- cell membranes of retina, brain & central nervous system
- important during 3rd trimester pregnancy to 12 mos. of age
- during pregnancy & lactation, fish in mother's diet provides n-3 FA to baby
- controversy over need for n-3 FA in commercial infant formulas

- Faroe Islands Study - women who ate more marine animals & fish during pregnancy had longer gestations & heavier babies
- Clinical study of Danish women found similar results (Olsen et al., 1992)
- Inuit women had lower blood pressure at end of pregnancy (Popeski et al., 1991)

N-3 FA, Fish & Chronic Disease

- Heart Disease – Prospective Studies
  - Overall, results suggest 1-2 fish meals/wk may reduce risk of CHD & all-cause mortality
  - N-3 FA reduce triglycerides, but effects on LDL, HDL & total cholesterol inconsistent

- Heart Disease – Secondary Prevention
  - DART & GISSI studies of MI survivors
    - fish meals (2x/wk for 2 yrs) or n-3 FA pills (1 g/d) lowered mortality rates
  - Von Shacky (1999) – intervention to halt progression of CVD; 6 g/d n-3 FA for 3 months, then 3 g/d for 21 months
    - modest effect on disease progression but LDL increased

Issues

- Different cardiac endpoints
- Mechanism not yet known
- Some effects don't increase with dose
- Lean fish produce same effects as fatty fish
- N-3 FA pills vs amt n-3 FA in fish
- Studies mostly well-educated men

Health Recommendations

- American Heart Assoc. (2000) recommends

  "eat at least 2 servings of fish per week"

- FDA (2000) allows '*qualified*' health claim
  - "Scientific evidence about whether n-3 FA may reduce the risk of CHD is suggestive, but not conclusive."

Cancer & Stroke

- Case-control studies provide evidence that small amts of fish may be protective against certain cancers, esp. in GI tract

- Stroke – depends on whether ischemic or hemorrhagic; results mixed, but evidence of lower mortality from ischemic stroke

High blood pressure

- Several studies suggest that adding fish to diets can lower blood pressure, esp. in combination with low fat, low sodium, weight loss diets & exercise

- NHLBI (Oct. 2002) – re: n-3 FA pills "lower blood pressure only slightly in individuals with hypertension"

Type II Diabetes Mellitus

- Concern that fish worsens blood sugar levels
- CARDIA study (Daviglus, 2002) – moderate amts of fish don't raise blood glucose levels
- Some researchers say amt of fat in diet is important – fish added to 30% fat diet ok

Conclusions

- All fish contain n-3 FA, critical during pregnancy & 1st year of life
- Not clear if n-3 FA provide CHD benefits, since lean fish also associated with lower mortality rates & only 1-2 meals/wk needed
- People with Type II Diabetes may benefit from eating more fish as part of a low-fat diet, with blood glucose levels monitored

'Take Home' Messages

- Regardless of whether effects are due to fish or n-3 FA, consistent finding that eating *no fish is a health risk*
- 1-2 meals/wk appears to provide CHD benefits; more fish $\neq$ more protection from chronic disease
- N-3 FA in fat tissues, Hg in muscle tissues; can choose lower Hg, higher n-3 FA species

Use of Quality Adjusted Life Years to Assess Risks and Benefits of Fish Consumption

Scott Bartell, PhD Candidate UC Davis

Mike Bolger, PhD US FDA

Clark Carrington, PhD US FDA

Elaine Faustman, PhD UW

Denise LaFlamme, MS WA Dept of Health/UW

Robert Lee, MS Univ. of Calgary

Rafael Ponce, PhD UW

Eva Wong, PhD Student UW

Risks and Benefits of Fish or Seafood Consumption

Benefits

- **High nutritional quality**
- **(Often) inexpensive**
- **(Often) easily obtained**
- **Associated with variety of health benefits**
  - Cardiovascular disease
    - Antiatherogenic
    - Antithrombotic
  - Neurodevelopment
- **Socio-cultural associations**

Risks

- **May contain harmful environmental toxicants**
  - Heavy metals
    - Methylmercury
    - Cadmium
  - Organochlorine compounds
    - Pesticides
    - PCBs
- **Risk substitution**

Decision Context/Problem

How can one conduct environmental health policy analysis when disparate health endpoints are at risk?

Public health policy and fish consumption

Ideal policy tool would

- allow consideration of both risks and benefits
- be transparent, rigorous, theoretically well-founded
- allow consideration of uncertainties, correlations
- be flexible and allow updating with new information

Available Tools

- Risk analysis (compare disease incidence to identify best policy)
- Benefit-cost analysis (do the benefits of implementing policy outweigh costs?)
- Cost-effectiveness analysis (which policy option has highest effectiveness per unit cost?)

⇨ In any analysis, you need similar "units"

Risk analysis (compare disease incidence to identify best policy)

Comparisons of risk not sufficient for health policy decision making

- Using risk and “ignoring” consequences assumes consequences are equivalent
- This assumption is hidden in the comparison

When Are "Health Endpoints Equivalent"?

1. An individual is ambivalent between the two health effects (QALY, willingness to pay/accept)
2. Health effects have comparable duration (workdays lost, life years lost)
3. Health effects have comparable cost (disability cost, Medicare reimbursement cost, insurance cost)
4. Health effects have comparable population impact (hospitalization rates, mortality rates)

Characteristics of QALYs

- **QALYs disaggregate health effects**
  - Duration of impact (life years) [Life tables]
  - Quality of life (0-1, death-perfect health) [Surveys]
- **In simplest form, QALYs assume:**
  - Duration and quality of life are independent
  - Linear and constant exchange between duration and quality of life

0.5 years of perfect health = 1 year of 50% health

QALYs cont.

- **Assess preferences/aversions for different health states**
  - Including symptoms, pain, functional impairment
  - Preferences scaled (typically 0-1)
    - 0 is death
    - 1 is optimal health
- **QALY scale data combined with the duration of impact**

QALYs

- **Extensive literature**
- **"QALY" search on Medline = 1600 articles**
- **Cost-effectiveness comparisons of**
  - Alternative therapeutic/surgical regimens
  - Screening programs
  - Disease burden
  - Training programs

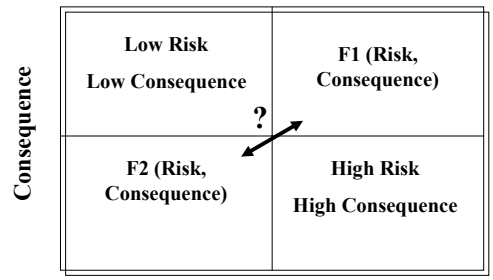
Estimating net benefit/risk

1. Use measure of equivalency (e.g., QALYs) to adjust the dose-response functions

2. Normalized dose-response functions can be directly compared

3. Normalized dose-response functions can be combined to get a 'net health impact'

Risk



Use of QALY Weights with Dose Response Models for Public Health Decisions:
Case Study of the Risks and Benefits of Fish Consumption
Risk Anal 2000 20(4):529-42

Quality adjusted life years (QALYs) and dose-response models in environmental health policy analysis -- methodological considerations.
Sci Total Environ 2001 274(1-3):79-91

Analytical (not so) Small Print

- Analysis performed as a case example
- Although realistic data used in derivation, not intended as a definitive analysis
- A number of assumptions made that need careful consideration

1) Problem definition

- **Net health impact of eating fish**
  - Single benefit and risk endpoint considered
  - Risk: Neurodevelopmental delay from prenatal MeHg exposure
  - Benefit: Reduced risk of fatal MI with eating fish
- **Population selection**
  - General population of 100,000
  - 100,000 women of child-bearing age and their children

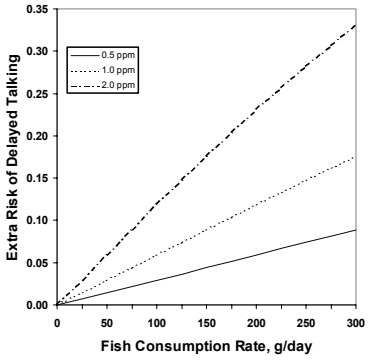
2) Data collection

MeHg intake

- **Evaluated 0-300 g/day fish intake rate**
  Includes 99th percentile of heavy fish consumers in lower 48 states
- **Fish MeHg concentrations**
  Assumed 0-2 ppm MeHg

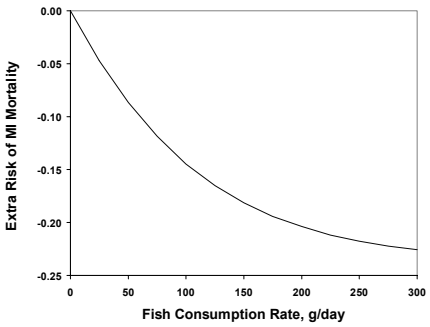
3) Modeling Risks

- **Used Marsh et al. (1987) data**
- **Weibull dose-response model (US EPA)**
- **Estimated risk of neurodevelopmental delay from MeHg in fish**
  - Specify quality of life factor using survey data (0.9)
  - Assume lifetime impact at reduced quality of life
  - Life table approach used to estimate expected lifespan
  - Assume MI risk and neurodevelopmental delay risk are independent



4) Modeling Benefits

- **Use CDC data**
  - Estimated lifespan using age- and gender-specific mortality rates by all causes and MI
- **Used Daviglus et al. (1997) to estimate benefits of fish consumption (Logistic excess risk model)**
  - Modify age-specific MI mortality rates by RR and estimate lifespan by gender
  - Assume male-only RRs apply to females, constant across age groups
  - Assume quality of life drops from 1 to 0 with MI (1=life, 0=death)



Risk-Benefit Analysis

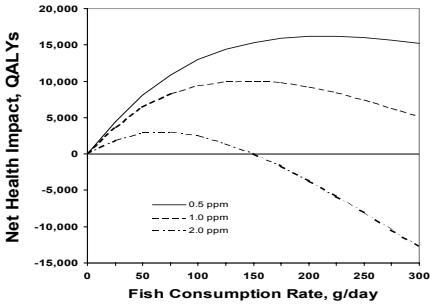
Aggregate risks/benefits of fish consumption

- Assuming equivalent health impacts
- Assuming QALY-weighted health impacts
- In a population of 100,000 (all ages, both genders)
- In a population of 100,000 child-bearing aged women and their children

- No discounting, effect of discounting, and all life years are equivalent

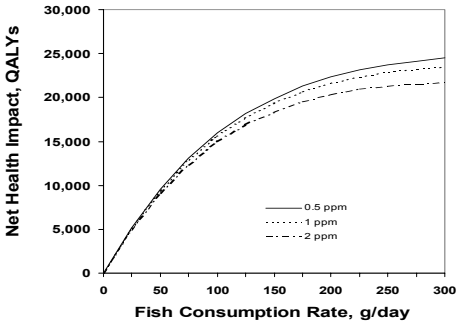
Net Health Impact, 100,000 men and women

Equal QALY weights



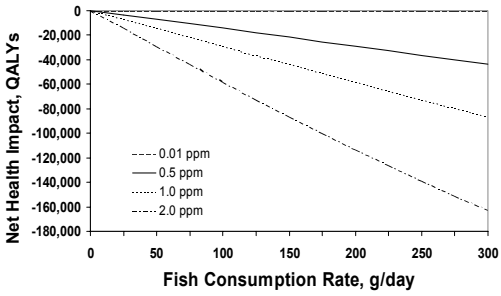
Net Health Impact, 100,000 men and women

Unequal QALY weights



Net Health Impact 100,000 women (15-44 y.o.) and their children

Unequal QALY weights



Conclusion

- **Under given model assumptions**
  - Population-wide restrictions on fish consumption would do more harm than good
  - Recommendations to limit fish intake during pregnancy would do more good than harm

Method Robustness

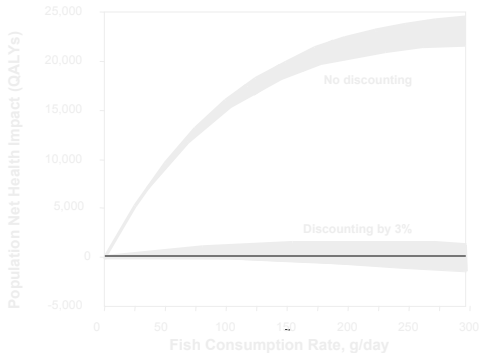
- Amenable to sensitivity and uncertainty analysis
  - Fertility rate, age distribution, gender comp.
  - QALY weights
  - Dose-response modeling
- Amenable to discounting, forecasting
- Can consider multiple benefits/risks
  - Endpoints appropriately weighted
  - Can incorporate correlations

Requirements/assumptions

- Requires
  - Data on health effects
  - Dose-response
  - Age-specific rates
  - Duration of effects
- Extrapolation of data from animals uncertain
- Requires quality of life weights for each considered endpoint

Parting words

Any aggregation/comparison of disparate health effects will require a weighting scheme

To ignore weighting is to assume that consequences are equivalent

Effect of Discounting