2009 National Forum on Contaminants in Fish

The Governor Hotel • Portland, Oregon

November 2–5, 2009

Section II

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Section II-A
Welcome to the 2009 National Forum on Contaminants in Fish

Welcoming Remarks

Evelyn Washington, Associate Director of the Standards and Health Division (SHPD), the Office of Science and Technology

> Evelyn Washington is Associate Director of the Standards and Health Division (SHPD), the Office of Science and Technology. She joined SHPD in 2001. Ms. Washington has been with the EPA since 1988, a few years in the Office of Solid Waste, with most of her career in the Drinking Water program in the Office of Ground Water and Drinking Water. She served as a Branch Chief in charge of drinking water program implementation prior to joining SHPD. Ms. Washington earned a B.S. in Chemical Engineering from the University of Maryland at College Park in 1986.

Opening Statements

Good morning. I am Evelyn Washington, Associate Director of the Standards and Health Protection Division, in the Office of Science and Technology within the Office of Water. I am Denise Keehner's deputy and am here in her stead as she needed to attend a critical meeting in Florida concerning nutrient standards in the state. I am happy to be here and want to extend a warm welcome to all of you to our 10th National Forum on Contaminants in Fish. I would like to extend a warm welcome to Gail Shibley, Administrator of the Office of Environmental Public Health at the Oregon Department of Human Services.

Looking over the agenda, it is clear that the steering committee has succeeded in bringing together the principle investigators for many of the most important recent studies related to sampling and analyzing contaminants in fish and assessing and managing the risks and benefits of fish consumption. We can all agree that fish contamination issues continue to be prominent items in the national and international press, and this interest does not appear to be waning.

Opportunity to Get Lots Accomplished

We are at an important time with a supportive administration, and we are very excited about the many opportunities for accomplishing important things in the coming months and years. Our new Administrator, Lisa Jackson, reminds us of how EPA can be a force for good if we do our job well—and what can go wrong if we fall short. She stresses that environmental protection is about human protection … it's about community protection and family protection. It's about safeguarding public health in the places where we live, work, and play and safeguarding the food we eat and the water we drink. Right now, EPA has a lot to do to restore the country's faith in our ability to protect the air, water, and land.

The United States has to function as a leader in environmental science and protection to the world. Around the globe, other nations are looking to us for action. We just saw a great example of this. For years, our official policy was to oppose any binding international standards on mercury levels. Recently, our representatives at a global environment summit in Nairobi agreed to join an international treaty to lower the levels of mercury worldwide. Once we changed our policy and committed our support, other countries like China and India came to the table. This is the power we have to make a difference, to be the standard-bearer, and have a truly global impact. And that global impact is going to be played out at the local level.

Our focus on fish contamination, fish advisories, risk communication, etc.—all the things on the agenda here, all play out at the local level, but our work is very closely watched, and bench-marked, at the global level. I want to provide some general program overviews of the activities we have underway for the coming year.

Mercury

Much of what we do in some way relates back to mercury, which has been a problem for some time now, and unfortunately, will continue to challenge us well into the future. The Obama Administration announced this year its plan to regulate airborne mercury from coal plants and other sites. Administrator Jackson has vowed stricter EPA monitoring of the toxin—which continues to accumulate in streams, air, and fish. She recently said that mercury continues to be a concern for the Agency, whether we're talking about utility emissions or other sources, and that she expects EPA to continue to be active under that regulatory area.

The USGS report released in August of this year showed mercury contamination was found in every fish sampled from streams nationwide. EPA's own fish tissue study also found widespread mercury contamination. Both of these studies will be discussed later today.

Update on Implementation Guidance

EPA published the methylmercury criterion for human health as a fish tissue concentration in 2001. EPA is developing implementation guidance since we recognize the challenges a fish tissue criterion poses to states and tribes, such as calculating water quality permit limits and developing TMDLs. The guidance provides policy recommendations on how states and tribes can adopt the criterion into their WQS, revise the criterion based on local fish consumption data, perform monitoring and assessment, and develop permit limits by either translating the fish tissue criterion to a water concentration or by implementing a mercury minimization plans, without the need for translation to water. The guidance has been posted on EPA's website since January 2009. However, as is customary, the new Administration required that we confirm the continued appropriateness and applicability of the guidance document. The guidance has been in "under review" status since February 2009. We are close to resolving the issues raised during this review and expect to issue a final document within the next few months.

Perfluorinated Compounds

We are investing significant resources in analyses of perfluorinated compounds in order to be able to come out with a human health criterion. This is another in a series of problematic persistent organic compounds that have had useful applications in industry, but which have found their way into our food supplies. Tomorrow afternoon, Joyce Donohue will provide an update on Agency's work on perfluorinated compounds.

Focus On Determining the Occurrence of Contaminants

Release of the National Lake Fish Tissue Study

We are preparing to publish the results of a four-year fish contamination study of the concentration of 268 persistent, bioaccumulative, and toxic chemicals in fish tissue from lakes and reservoirs in the lower 48 states. Leanne Stahl will provide you with a much more detailed presentation on this study. In addition, EPA is conducting other statistically based national aquatic surveys that include assessment of fish contamination, such as the National Rivers and Streams Assessment and the National Coastal Assessment. Sampling for the National Rivers and Streams Assessment is underway, and results from this two-year study are expected to be available in 2011. Collection of fish samples for the National Coastal Assessment will begin in 2010.

Study of Pharmaceuticals and Personal Care Products (PPCPs) in Fish Tissue

As a relatively new focus, many have started looking at the general occurrence of known as well as unknown or "emerging contaminants" in our waterways. These emerging contaminants include Pharmaceuticals, as well as Personal Care Products. This group is considered by many to be a growing problem, as they are "product-based contaminants" that enter the environment through the use of products rather than through a manufacturing or industrial activity. Recent research indicates that pharmaceuticals occur widely in surface water, sediment, and municipal effluent. But there is very limited information available as to whether pharmaceuticals are accumulating in fish.

In this realm of emerging contaminants, we are now focusing on a group of compounds for which there is little information available. These Personal Care Products sometimes have complex properties and are not designed to be biologically active. We know that they are produced and discharged in very large quantities in our waterways. Preliminary reports tell us that these compounds are surviving existing water treatment technology, and we want to better quantify their presence down-stream from water treatment plants. John Wathen will go into the specifics of the study later today.

As you will hear later, we can conclude that PPCPs are imparted to fish tissue from wastewater. We can also conclude that the level of waste-water treatment ***really does matter***. And finally, we can conclude that the extent of occurrence of PPCPs in our national waters needs to be better understood.

Risk Communication

Study of the Awareness and Effectiveness of the Mississippi Delta Advisory

In 2007, in cooperation with FDA and the Mississippi Department of Environmental Quality (MDEQ), we initiated the development of a survey methodology and instrument for assessing the awareness and effectiveness of the Mississippi Delta fish consumption advisory issued by the MDEQ in 2001. We assembled a workgroup from EPA/FDA/MDEQ staff and a workgroup of local and national experts on survey development.

Specifically, we sought to determine:

1. The extent to which Delta sport and subsistence fishermen and their families were aware of the advisory and its recommendations;
2. The extent to which they have changed their fish consumption behaviors as a result of the Delta advisory; and
3. What their specific behavior changes were, such as amount of fish consumed, methods of fish preparation, species of fish consumed and avoided, and other parameters as determined by the workgroup.

We worked closely this past year with FDA to address some federal (OMB) requirements for conducting the survey. And, following testing of the instrument, EPA initiated the 1,000-person survey in September 2009. As of today, all 400 on-the-bank surveys have been completed and the 600 household surveys are underway. EPA plans to complete the surveys by the end of November and publish a report of findings in 2010. We are hopeful that others will be able to use the study as a model to develop their own surveys or advisory messages.

Study of Historical Mercury Advisory Sites

We believe it is important for us to, from time to time, go back and revisit our work to ascertain the effectiveness of our objective. So we decided to conduct a study of historical mercury advisory sites. We collected fish samples of target species from 100 sites across the country where mercury advisories were issued prior to 1996. We wanted to determine how those advisories compare to current mercury levels in fish. And we wanted to ascertain whether current mercury levels would affect current consumption advice for those waters.

EPA has very recently completed analyzing the data and developing a draft report. The study findings tell us, among other things, that a combination of the new tissue data and application of EPA's guidance on developing advisories could lead to a change in existing meal consumption advice at many of the historic mercury advisory sites across the United States. This past week EPA provided the data to those states that had waters included in the study. We are hopeful these states will review these new data over the coming months to determine whether of not their advisories for these waters need adjusting.

Toxicological Reviews of Polybrominated Diphenyl Ethers (PBDEs)

PBDEs are used as flame retardants in furniture foam, plastics for TV cabinets, consumer electronics, wire insulation, and backcoatings for draperies and upholstery. Since the last Forum, which was held in Portland, ME, EPA finalized and posted on the Integrated Risk Information System (IRIS) database, the human health assessments for four PBDE congeners in June of 2008. The prior assessments of mixtures are still included in IRIS. Joyce Donohue who was our lead in developing these reviews is here with us, and I am sure would be more than willing to discuss these PBDE reviews with you during breaks over the next few days.

New with this Forum is the Debate that we are hosting. This could be also thought of as a communication tool to impart information about environmental issues to debate audiences, to entertain and educate, and hopefully to encourage more participation in public discourse of the issues and taking action to protect the environment, and their family's health. I hope that you enjoy it.

Looking Forward

- We will continue to work with states, tribes, and other Federal agencies on developing a scientifically credible, practicable approach to assessing risks and benefits of fish consumption;
- We are committed to continuing with national-scale studies of contaminants in fish – with a focus on emerging contaminants;
- We will finalize and publish the report on the Mississippi Delta Study that could be used as a model for assessing the awareness and effectiveness of local advisories;
- And last – during FY10, we plan to conduct a review of EPA's National Listing of Advisories online database and public interface and to make any improvements to help ensure that the most accurate, timely information about local advisories is available to the public.

Again, I welcome you to the 10th National Forum on Contaminants in Fish and wish you happy and productive deliberations.

Welcome Address

Gail R. Shibley, Administrator, Oregon Department of Human Services, Office of Environmental Public Health

Gail Shibley is the Administrator of the Office of Environmental Public Health within Oregon's Public Health Division. Named to this Executive Service position in February 2003, she is responsible for assuring public safety in a wide array of environmental and regulatory public health efforts. This Office of Public and Environmental Health employs approximately 125 employees and oversees more than $44 million a biennium from almost 100 different funding sources.

An Oregon native, Ms. Shibley has worked in the private and public sectors and has served in the legislative and executive branches of federal, state, and local government. She was a Presidential appointee and served two cabinet Secretaries in the second term of the Clinton administration. In 1991, she made history as Oregon's first openly gay or lesbian legislator, serving 6 years in the Oregon House of Representatives, where she represented central portions of the city of Portland and Multnomah County.

Ms. Shibley began her public service career working for former U.S. Representative Jim Weaver (D-OR), serving as both legislative aide in Washington, DC, and as director of his Eugene, Oregon, office. After moving to Portland, she served as a senior manager in Portland's Office of Transportation under then-City Commissioner Earl Blumenauer, where she designed and ran Portland's Slow Down for Kids' Sake initiative.

A University of Oregon undergraduate, Ms. Shibley received a Loeb Fellowship in Advanced Environmental Studies from Harvard University and is now completing her degree at Lewis & Clark Law School, focusing on environmental and administrative law.

Welcome to Oregon!

Thank you to our valued partners, the EPA, for selecting Oregon to host this important conference.

The quality of both the substance and the logistics you will enjoy at this conference is the product of terrific work by many people, including Oregon's Deanna Conners, and I want to both acknowledge and thank her for her leadership in this impressive effort. She is an example of the fine expertise we are able to attract and retain here in Oregon's Environmental Public Health Office.

I also want to thank each of you who have determined it worth your considerable investment of time, money, and effort to travel here and learn from each other in this important work.

It is work we share with you, and our work is, in many ways, on display around the clock: The tap water that is Bull Run's finest; our land-use planning and attention to the health of our built environment; low-flush toilets at our airport; perhaps the plate of local seafood you will enjoy at dinner this evening.

In these and other Public Health efforts, we rely on our valued partners at the EPA and at Oregon's Department of Environmental Quality. Particularly as a small state, our inter-agency collaboration and partnership are essential, and I want to take advantage of this public forum to say a heartfelt "thank you" to them.

We have accomplished a great deal. But, as Administrator of Oregon's Environmental Public Health effort, I am acutely aware of significant needs and lack of capacity. For example, here in Oregon we do fish biomonitoring, but have no money for biomonitoring of people. What does that say about our priorities and ability to protect health? In addition, Environmental Public Health is routinely asked to participate as experts in policy and science panels – a role we both appreciate and value. Yet, we can provide only the thinnest help, because there is no funding attached to any request.

I also want to take advantage of this forum to state three truths that, I believe, hold the key for broader success. First, we have much to learn from each other – none of us has all the expertise needed to understand, mitigate, and prevent fish contamination. For example, the federal government has a powerful role that only it can play. Second, the federal government must demonstrate its commitment to the principle of federalism, as the President reinforced in a Presidential Memorandum earlier this year. The States must be allowed to truly be the laboratories of innovation, and the federal government should encourage and support our efforts. Third, the federal government should recognize state Public Health's unique expertise and the powerful contribution only it can make to this collaborative effort. Human health protection at the community scale must be built into each environmental protection effort, based on CDC/State Public Health research and analyses.

To the extent it ever existed, the time for managing around the margins is past. The health of our people, our environment and the life with which we share it demand transformative change. I exhort you – us – therefore to be bold, to freely share ideas during our time together here, to dare to innovate, and to give real meaning to partnership.

Maybe just as important just now, I encourage you to make the time to shop and buy: Oregon has no sales tax so you can save money while you invigorate our economy and return home with full suitcases!

Section II-B
Regional Issues: Focus on the Northwest Region

Moderator:

Amy Kyle, University of California, Berkeley

Dr. Amy D. Kyle (Ph.D.) has a broad background in environmental health and policy with a particular interest in children and in persistent pollutants. At the University of California, Berkeley, she is the leader of a multi-disciplinary team working on methods for assessing and addressing cumulative impacts in communities, Director of Research Translation for an interdisciplinary research program in environmental health sciences and technology, founder of the Project on Science and Policy for Health and Environment, and co-investigator at the Center for Excellence in Environmental Public Health Tracking and the Center for Integrative Research on Childhood Leukemia and the Environment. Her research is about how science is interpreted in policy; the translation of scientific results and knowledge for policy and stakeholder audiences; and children's environmental health. Dr. Kyle teaches science students about public policy and how to participate in discussions that involve non-technical audiences. She works with many community-based organizations, non-governmental organizations, executive and legislative agencies, and academic partners. She was a founding member of the State Environmental Health Collaborative and works with many state environmental protection and public health agencies. She served for 5 years as Deputy Commissioner for the Alaska Department of Environmental Conservation, and previously worked for 3 governors on a variety of environmental, health, and natural resources issues. She received an M.P.H. and a Ph.D. in Environmental Health Sciences and Policy from the University of California, Berkeley, and a B.A. in Environmental Sciences from Harvard College. She was elected as Councilor to the Environment Section of the American Public Health Association and currently serves on the federally chartered Children's Health Protection Advisory Committee. She was an author of one of the first reports to point out the importance of contaminants in fish for women and children, in 1997.

Presentations

Reducing Toxins in Fish in the Columbia River Basin

Mary Lou Soscia, U.S. EPA, Region 10

Fish Consumption Rates in Oregon

Kathleen Feehan, Confederated Tribes of the Umatilla Indian Reservation DNR

Toxic Pollutant Reduction Initiatives in Oregon

Jennifer Wigal, Oregon Department of Environmental Quality

Human Health Assessment of Puget Sound Fish

Joan Hardy, Washington State Department of Health

Overview of Freshwater Fish Tissue Contaminant Monitoring in Washington State

Dale Norton, Washington State Department of Ecology

Washington State's Fish Advisories and the Healthy Fish Guide

Liz Carr, Washington State Department of Health

n-3 Fatty Acid Intake and Longitudinal Mercury Exposure from Fish Consumption within the Japanese and Korean Communities

Ami Tsuchiya, University of Washington

Reducing Toxics in the Columbia River Basin

Mary Lou Soscia, Columbia River Coordinator, Office of Water and Watersheds, Region 10, U.S. Environmental Protection Agency, Portland, OR

Biosketch

Ms. Mary Lou Soscia currently serves as the Columbia River Coordinator for EPA Region 10. In this role, she leads the Columbia River Toxics Reduction Strategy, which is a collaborative approach to reduce toxics in the Columbia River Basin. She is also leading the collaboration for the Oregon Water Quality Standards Fish Consumption Rate work efforts. She represents EPA in discussions on the role of the Clean Water Act in Federal Columbia River Power System decisions. Ms. Soscia has had over 30 years of experience with state, federal, and tribal government, specializing in watershed and river management issues. Ms. Soscia holds a B.S. in Geography from Virginia Tech and an M.S. in Geography from the University of Maryland.

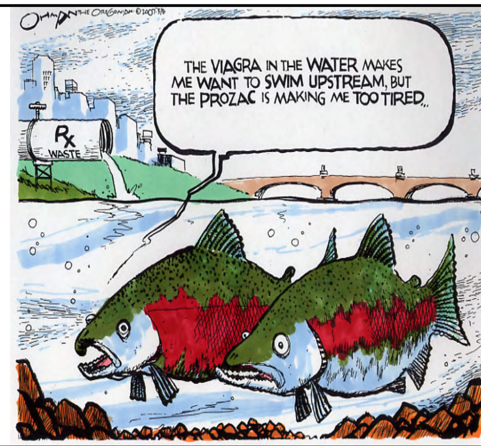
Abstract

This presentation will include information on the work efforts to reduce toxics in the Columbia River Basin. This information will include background and the EPA's perspective on this precedent-setting work effort, a description of the recently released Columbia River Basin State of the River Report for Toxics, and details on the development of the follow-up action plan.

Reducing Toxics in the Columbia River Basin

10th National Forum on Contaminants in Fish
November 2, 2009

Mary Lou Soscia
U.S. EPA – Region 10



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Today's Conversation

- **History of Columbia River Efforts**
- **Rising Concern over Toxics – Fish Consumption and Contamination**
- **Columbia River as a National EPA Priority**
- **Columbia River State of River Report for Toxics**
- **Action Plan and Next Steps**

Columbia River Basin

- ~ 260,000 sq miles
- 2 countries, 7 seven states, 22 Tribes
- Largest flow to Pacific in N. & S. America
- 8 million people – 1/3 in I-5 corridor
- > 370 major dams
- 13 endangered fish species

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Columbia River-Complex Issues

- Political Complexity
  - 4 states
  - 13 tribes
  - 9 federal agencies
  - Congress
- Economics
  - People
  - Agriculture/Forestry
  - Irrigation
  - Industry
  - Low cost power
  - Navigation/ Transportation
  - Irrigation
  - Fishing industry/ Recreation

10,000 Years of Tribal History

- **14 US Tribal Nations**
- **Salmon fishing – 10,000 years of history**
- **Tribal governments have been leaders in efforts to reduce toxics – for 20 years – only recently are we seeing progress**

History - EPA Columbia R. Efforts

- 1989 - Lower Columbia R Bi-State 1991 –
- EPA completes Dioxin TMDL
- CWA 303(d) Listings/TMDLS
- 1992 – Nat'l Study of Chemical Residues in Fish – high fish contamination in Columbia River
- 1994 - A Fish Consumption Survey of the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia R Basin

History – continued

- 1996 - Designation of Lower Columbia into EPA's National Estuary Program
- Superfund
  - Hanford - 1989
  - Portland Harbor - 2000
  - Lake Roosevelt - 2006 Tech Cominco Agreement
- 2000 - Bradford Is. Clean-Up - OR DEQ/Corps
- 2001 - EPA, ID, OR & WA sign agreement to begin work on Columbia/Snake River Temp/TDG TMDLs

History - continued

- 2002 - EPA Columbia R Basin Fish Contaminant Survey
- 2006 – EPA approves Snake River TMDL – temperature, DO, other parameters
- 2006 – EPA Large Aquatic Ecosystem
- 2006 – EPA, OR DEQ and CTUIR agree on FCR process for OR Water Quality Standards
- Many other work efforts underway
  - Hells Canyon Relicensing – 401 Certification

CWA 303d Listings

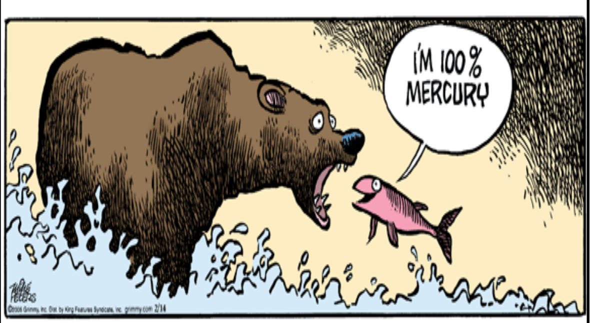
Columbia River

- Aldrin - WA
- Alpha BHC - WA
- Arsenic - OR
- Bacteria - WA
- Chlordane - WA
- DDT/DDE - OR/WA
- Dieldrin - WA
- Dissolved Oxygen - WA
- Mercury - WA
- PAHs - OR
- PCBs - OR/WA
- Temperature - OR/WA

Snake River

- Bacteria - ID
- Ammonia - ID
- Chlordane - WA
- DDT/DDE - WA
- Dieldrin - WA
- Dissolved Oxygen - ID/WA
- Mercury - ID/OR
- Nutrients/Phosphorus - ID/WA
- PCBs - WA
- Pesticides - ID
- pH - WA
- Sediment - ID
- TDG - ID
- Temperature - ID/WA
- Unknown Pollutants - ID

Toxics Are A Contemporary Issue



Mother Goose and Grimm – Feb. 14, 2006

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The Seattle Tim

Columbia River toxins moving up food chain

Mounting evidence has put river on shortlist of troubled U.S. waterways

Columbia River Press

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CRITFC Fish Consumption Study

- 1992 agreement - EPA/Yakama, Nez Perce, Umatilla and Warm Springs Tribes to better understand relationship of tribal fishing and exposure to contaminants
- First phase was a Fish Consumption Survey - CDC input in design
- 1994 Survey showed Tribal people consume higher amounts of fish than average US
- EPA used results of survey to revise water quality criteria methodology

2002 Fish Contaminant Survey

- 92 pollutants detected in fish consumed by tribes and other Columbia R consumers
- Fish taken from 24 Tribal fishing sites in Columbia River Basin - 1996 - 1997
- Anadromous: Fall/spring chinook, steelhead trout, smelt and Pacific lamprey;

  Resident: rainbow trout, mountain whitefish, white sturgeon, walleye, large scale sucker, bridgelip sucker
- PCBs, dioxins, furans, arsenic, mercury, and DDE, a breakdown product of DDT

Oregon WQS - Fish Cons Rate

- OR EQC submitted to 17.5 FCR to EPA 7/2004
- Umatilla Tribe raised concerns to EPA
- 2006 EPA, OR, Umatilla Tribe Agreement
- 10/2008 - OR EQC directed DEQ to enter rulemaking for 175 g/d (24 m/m) and develop a Toxics Reduction Strategy – Oct 2010
- OR DEQ said to EPA "Toxics Reduction is a Regional Issue"…….

Columbia River Toxics Reduction Strategy

- EPA committed to leadership
  - Lead collaborative effort in large river basin
  - Coordinate ongoing efforts
  - Increase monitoring and toxics reduction efforts
- In 2006 EPA designated the Columbia River a national priority – Large Aquatic Ecosystem
  – w/Chesapeake, Great Lakes, Long Island Sound, Gulf of Mexico, Everglades/S.Florida, and Puget Sound

Columbia River Strategic Plan Targets
2011 & 2014

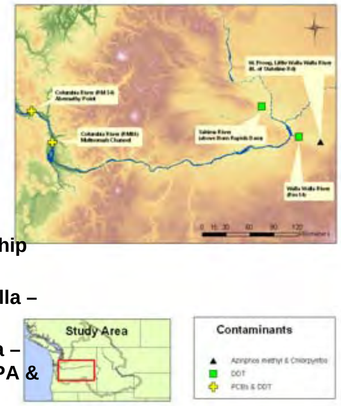
- Protect, enhance or restore 19,000 acres of wetland & upland habitat in Lower Columbia River watershed.
- Clean up 85 acres of known highly contaminated sediments in Lower Columbia River Basin including Portland Harbor
- Demonstrate a 10 % reduction in mean concentration of certain contaminants of concern found in water & fish tissue in Columbia River Basin.

Columbia River

10% Reduction Monitoring Sites

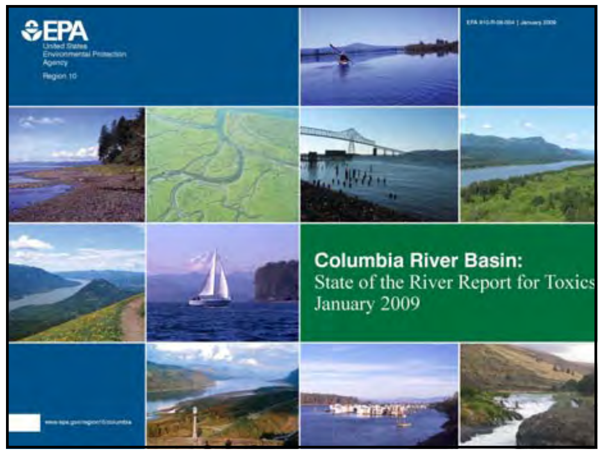
5 Sites - OR & WA

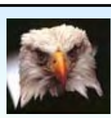
- OR Walla Walla – Chlorpyrophos & Azinphos methyl - Pesticide Stewardship Partnerships
- Yakima & Walla Walla – DDT – WA TMDLs
- Mainstem Columbia – PCBs and DDT – EPA & others



Columbia River Toxics Reduction Working Group Successful Collaboration

- Goal - prevent & reduce Columbia River toxics
- Coordinate future monitoring work
  - EPA/Oregon Mid-Columbia River Monitoring
  - USGS Monitoring – Lower Columbia
  - EPA Corvallis – Technical assistance on monitoring design
- Increase toxic reduction actions
- Led development of State of River Report





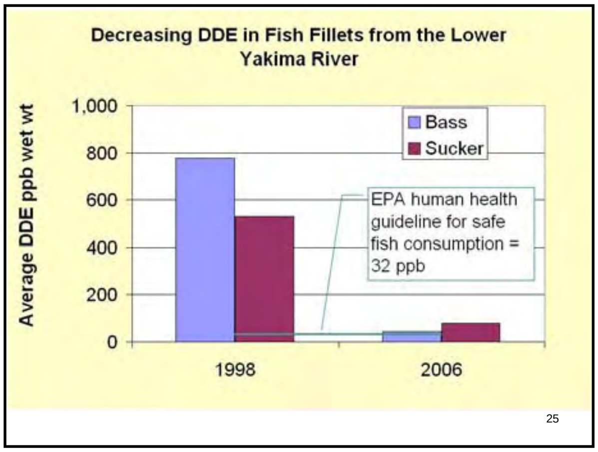
Contaminants & Indicators

- Focused on 4 contaminants, but recognize other contaminants of concern
  - **Mercury, PCBs, DDTs, and PBDEs**
- Identified indicator species to track over time

✓ **Juvenile salmon**
✓ **Resident fish**
✓ **Sturgeon**
✓ **Predatory birds – osprey and bald eagle**
✓ **Aquatic mammals – mink and river otter**
✓ **Sediment-dwelling shellfish – Asian clam**

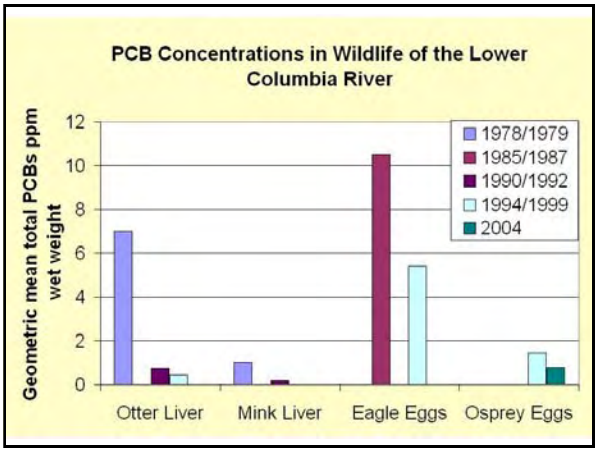
DDTs: Banned in 1972, still persists in the environment

- Primary source is agricultural soils in which DDT accumulated over 3 decades of regular use
- DDT levels have declined - still above levels of concern in some areas
- DDT fish consumption advisories continue
- Since 1970's - rebound in populations of fish eating birds - osprey & eagles



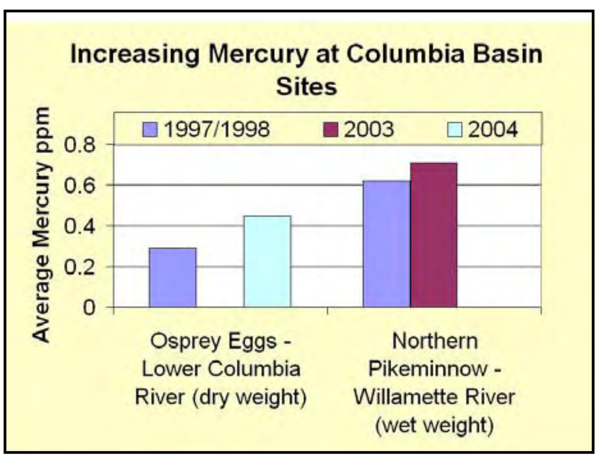
PCBs

- Levels have generally declined, but persist at levels of concern in many locations
  - **Spokane River: Decrease in concentrations in resident fish between 1992-2005**
  - **Lower Columbia: Decreasing concentrations in otter/ mink livers and osprey/bald eagle eggs between 1978 and 2004**
  - **Lower Columbia: Increasing as juvenile salmon travel down the estuary**



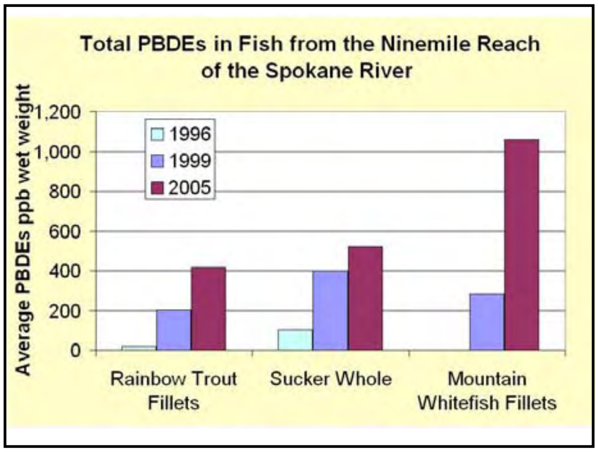
Mercury

- Mercury levels increasing in several species and most fish consumption advisories due to mercury
  - **Sources: Air deposition from outside Basin appears to be greatest source**
  - **Lower Columbia: Increasing levels in osprey eggs and resident fish between 1997 and 2004**
  - **Snake River: High concentrations in fish downstream of Owyhee River inflow from historic mining**



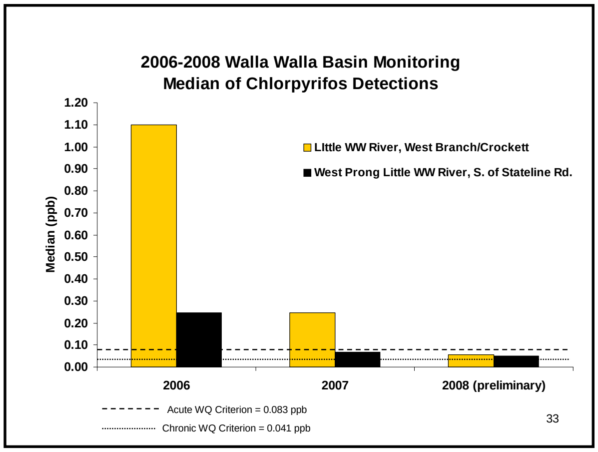
PBDEs

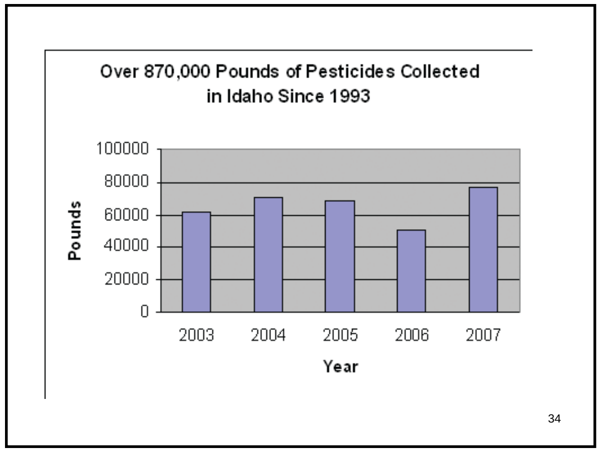
- Growing concern over flame retardants.
  - **Sources: limited information, but evidence that municipal wastewater may be significant pathway**
  - **Spokane River: Significant increase in fish tissue between 1996 - 2005**
  - **Lower Columbia: Increase in concentrations in osprey eggs between 2004 - 2007**



Toxics Reduction Activities

- States Regulatory Tools (e.g, TMDLs, WQSs, and NPDES)
- Federal & State Cleanups (e.g., Portland Harbor, Hanford, Lake Roosevelt, and Bradford Island)
- Improved farming practices (e.g, BMPs; Pesticide Stewardship Partnerships)
- State and local governments removing toxics from communities (WA banned PBDEs in 2007; Hg reduction strategies, medication take-back programs)
- Oregon and Nevada are reducing industrial mercury emissions (e.g, Boardman plant and Nevada gold mines)





Report Recommendations

- **Expand Toxics Reduction Initiatives**
  - Increase voluntary efforts – agriculture is key
- **Develop a Regional, Multi-Agency Monitoring and Research Plan**
  - Long term; evaluate indicators; data sharing site; loadings estimate
  - Major Data Needs in Snake River
- **Increase Outreach & Public Education**

Activities since SORR

- **Workshops - dialogue on reducing toxics**
  - Pendleton, OR, w/Umatilla Tribe – agriculture
  - Portland, OR – PCBS – "not a legacy – still in use"
  - Wenatchee, WA - agriculture
- **Working Group continues to grow & thrive**
  - Hood River, OR /June & Longview, WA/September
- **Developing monitoring prioritization process w/ 10 agencies**
- **Draft Acton Plan**
- **R10 Leadership – Large Aquatic Ecosystem Council**
  - Columbia River leadership in advancing watershed approach to toxics reduction

Columbia River Toxics Reduction Action Plan

5 Initiatives- Columbia River State of River Report
Critical ongoing actions & new actions for future $

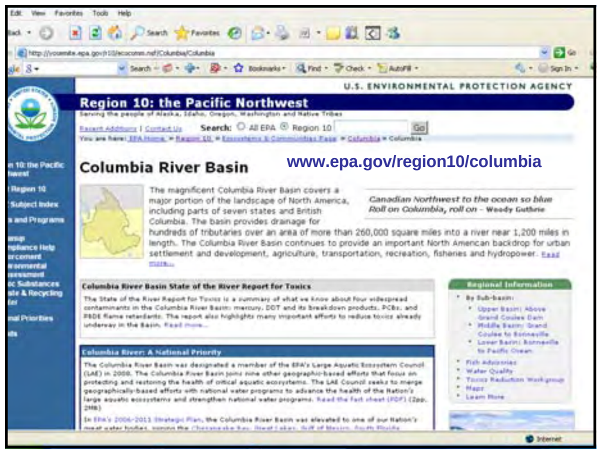
- Expand toxics reduction actions
- Develop monitoring process
- Develop a regional, multi-agency research program
- Develop a data management system
- Increase public education about the toxics problems and resource needs

Columbia Toxics Reduction Timelines

- OR DEQ Nov 17 Toxics Reduction Workshop
- Dec '09 – Draft Action Plan
- Jan '09 – Working Group Meeting
- Feb '10 PBDE Workshop – Portland
- Feb/Mar '10 – Data & Research Mtg – Portland
- April '10– Working Group Meeting
- June '10 – Workshop – Idaho/Snake River Basin

Next Critical Work Efforts

- Finalize & Implement Columbia River Toxics Reduction Action Plan
- Continue successful collaboration with partners – OR Toxics Reduction Strategy is leader
- Encourage R10 RA Leadership
- Work on increasing resources – innovative opportunities – pilot projects/demos



Questions and Answers

Q. There is documented synergistic toxicity of different toxics. How is this being addressed?

A. There are three major organophosphates in salmon populations that we are working on addressing. We are working in conjunction with Lower Columbia River Estuary Partnership (LCREP), states, and tribes to reduce these chemicals in our waters and fish, as well as talking to farmers and funding grants. Check back in a year for progress, or contact me if you have any advice or suggestions.

Fish Consumption Rates in Oregon

Kathleen Feehan, Confederated Tribes of the Umatilla Indian Reservation DNR

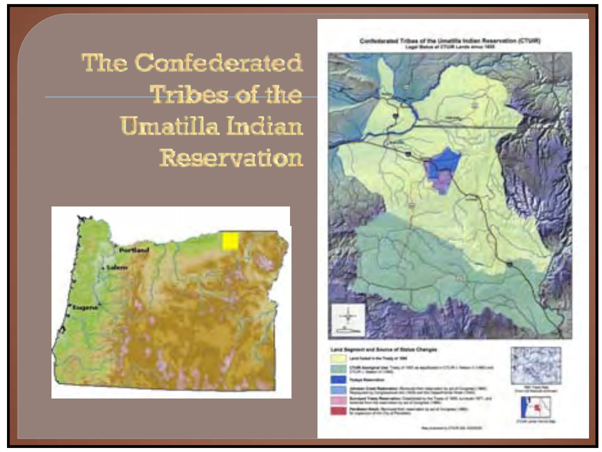
Biosketch

Ms. Kathleen Feehan, Senior Policy Analyst for the Department of Natural Resources of the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), has worked for Oregon tribal governments for the past 13 years. At CTUIR, her work focuses on protecting and restoring the natural resources necessary to support CTUIR people and culture. Over the past 5 years, Ms. Feehan has been the primary staff representative in CTUIR's work with both the Oregon Department of Environmental Quality (DEQ) and EPA Region 10 in increasing Oregon's fish consumption rate for toxic water quality criteria to better protect the health of fish consumers. Other work for CTUIR includes the development of the CTUIR Total Maximum Daily Load (TMDL) for Temperature and Turbidity, implementing the Water Quality Management Plan, and revising CTUIR's water quality standards for toxics. Previously, Ms. Feehan was the Environmental Coordinator for the Confederated Tribes of Grand Ronde, where she managed the tribes' environmental program. She represented Grand Ronde's interests in the Portland Harbor and McCormick and Baxter Superfund cleanup sites, managed National Environmental Policy Act processes, and participated in Endangered Species Act consultations on behalf of the tribes. Ms. Feehan also coordinated water quality and wetland assessment programs and established the tribes' community recycling center. She also is an enrolled member of the Confederated Tribes of Grand Ronde of Oregon.

Abstract

Fishing and eating fish are a fundamental part of tribal community and tradition. A more accurate understanding of the amount of fish eaten by tribal people has emerged in the Pacific Northwest in recent years through several separate studies. The studies demonstrate that familiar government assumptions about exposure to toxic chemicals through fish consumption may seriously underestimate the toxic exposure that tribal people actually face when eating fish in accordance with their culture and heritage. These studies require regulators to re-examine long-established assumptions about fish consumption and associated health risks. The Confederated Tribes of the Umatilla Indian Reservation are working with the Oregon Department of Environmental Quality to revise Oregon water quality toxic criteria to improve health protection for fish consumers. Oregon's fish consumption rate will be updated from 6.5 grams per day (about two 8-ounce fish meals per month) to 175 grams per day (22 fish meals per month). The tribe believes this is an essential first step toward incorporating a realistic assessment of fish consumption into regulation that will, over time, result in state waters that are fishable for the people who actively eat fish.

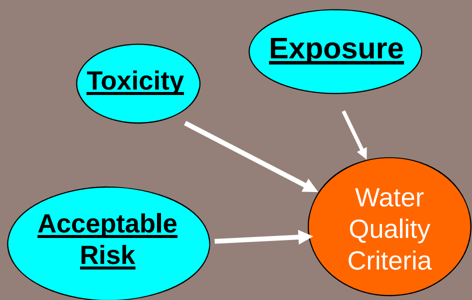

Re-evaluating Fish Consumption
Good Science, Water Quality Criteria and Protecting Fish Consumers


The Confederated Tribes of the Umatilla Indian Reservation


DNR's First Foods Mission Statement
To protect, restore, and enhance the First Foods – water, salmon, deer, cous, and huckleberry – for the perpetual cultural, economic, and sovereign benefit of the Confederated Tribes of the Umatilla Indian Reservation.


Human Health Criteria Must Protect the Beneficial Use
Criteria must protect the designated use - fishing & fish consumption.

Risk and Water Quality Criteria



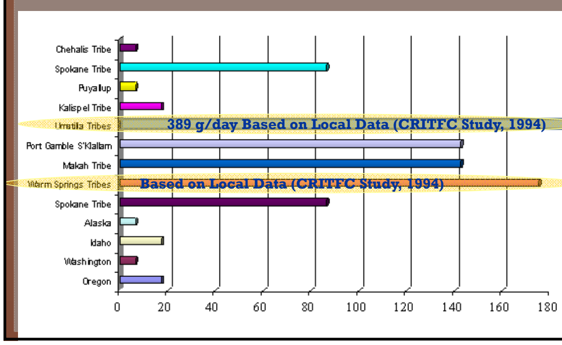
Water Quality Criteria

$$WQC = Toxicity \cdot \left[\frac{BW}{DI + (FCR \cdot BCF)} \right]$$

Goal - Setting toxic pollutants criteria to protect human health

- Tribal consumption survey provided info on fish consumption 204 children (ages 5 and younger).
- 70% of children eating fish at end of the first year of life.
- 26% at 6 months – fish is a first food
- Tribal children rate estimated 19.6 g/day
- Nationally 8% women of child bearing age with mercury levels exceed EPA reference level 5.8 mg/L blood
- Largest correlation was with amount of fish ingested
- Native Americans, Pacific Islanders, and Asians had the highest levels

National Minimum Default Fish Consumption Rate & Regional Comparison



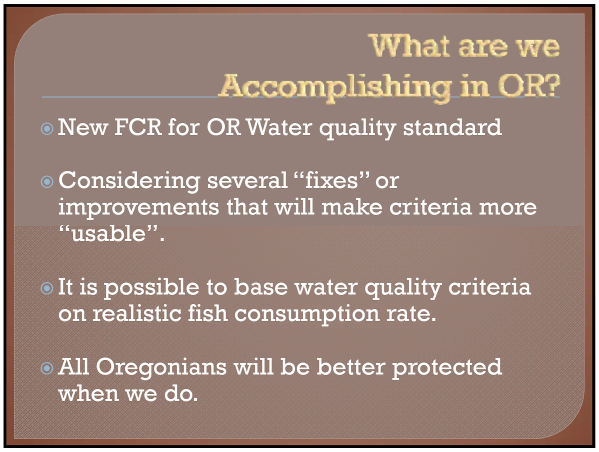
Fish Consumption Rates

	statistic grams per day					
	mean	median	75%	90%	95%	99%
Current WQ criterion rate				17.5		
Columbia River Tribes	**63**	**40**	**60**	**113**	**176**	**389**
Squaxin Island Tribe	62	29	79	141	221	332
Tulalip Tribe	72	45	85	186	244	312
Asians & Pacific Islanders	117	78	139	236	306	NA
U.S. General Population fish consumers	127	99	NA	248	334	519
Suquamish Tribe	214	132		489	NA	NA

Fish Consumption Assumptions

EPA NATIONAL MINIMUM DEFAULT VALUE

95 TH PERCENTILE CRITFC STUDY


What are we Accomplishing in OR?
New FCR for OR Water quality standard
Considering several "fixes" or improvements that will make criteria more "usable".
It is possible to base water quality criteria on realistic fish consumption rate.
All Oregonians will be better protected when we do.


What have we learned?
States, tribes and other risk assessors need to consider best available data about tribal FCRs when making regulatory and RA decisions
WA FCR
6.5 grams/day
Less than 1 fish and shellfish meal per month


Contact - Resources
Kathleen Feehan,
Senior Policy Analyst
kathleenfeehan@ctuir.com
541-966-2357
Human Health Focus Group Report - June 2008
Oregon Fish and Shellfish Consumption Rate Project
http://www.deq.state.or.us/wq/standards/fishfocus.htm

Toxic Pollutant Reduction Initiatives in Oregon

Jennifer Wigal, Oregon Department of Environmental Quality, Standards and Assessments Section

Biosketch

Ms. Jennifer Wigal is the manager of the Standards and Assessments Section at the Oregon Department of Environmental Quality (DEQ). Since 2008, she has managed Oregon's Water Quality Standards programs, the Water Quality Assessment program (including the development of the Clean Water Act section 303(d) impaired waters list), and DEQ's development of its "priority persistent pollutant list" (also known as Senate Bill 737). Prior to joining DEQ, Ms. Wigal worked for 10 years at EPA in Washington, DC, in the Water Quality Standards program. Ms. Wigal holds an M.S. in Environmental Engineering from Johns Hopkins University and a B.S. in Civil Engineering from Washington State University.

Abstract

The State of Oregon has several efforts underway to address toxic pollutants in the state's surface waters. One of these efforts is focused on revising the state's water quality standards to reflect a fish consumption rate of 175 grams per day. Once adopted, this will be the highest fish consumption rate used by any state's water quality standards. In another effort, the State is developing a "Priority Persistent Pollutant List" of pollutants that have a potential to persist or bioaccumulate in the environment, in addition to being toxic. This list will likely include both familiar pollutants and other pollutants that have not typically been addressed by regulatory programs. This presentation will present an overview of both of these efforts and describe their relationship and relevance to fish consumption advisories and related issues.

Water Quality Program 1

Toxic Pollutant Reduction Initiatives in Oregon

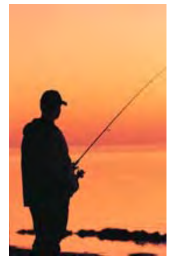
Jennifer Wigal

Oregon DEQ

November 2, 2009

National Forum on Contaminants in Fish
Portland, Oregon

Water Quality Program



What do ***fish advisories*** have to do with ***water quality standards?***

State Agency Programs Addressing Toxics in Fish

System | Intervention Strategy | Agency Activities

Contaminant Sources → Water → Fish → People

"Upstream" Prevention

Prevention-based toxics reductions:
- Water Quality Standards Development and Implementation
- Toxics Monitoring (water, fish tissue)
- Priority Persistent Pollutants (SB 737)

Behavioral-based interventions to prevent exposures to toxics:
- DHS Fish Consumption Advisory Program
- (outreach provided in part by ODFW "Oregon Sport Fishing Regulations")

"Downstream" Reactive

Water Quality Program

Oregon's Water Quality Standards

- Revising water quality standards targeted at human health protection
  - New fish consumption rate = 175 g/day
  - Based on local and regional data
  - Standards derived to protect people who eat fish and shellfish
- Will be highest fish consumption rate of any state (and consequently, the most stringent values)

Water Quality Program 5

Our Approach

- Partnerships
  - Confederated Tribes of the Umatilla Reservation
  - EPA
- Stakeholders
  - Advisory Committees
  - Members include: Environmental Organizations, Municipal WWTPs, Tribes, Industry
- Internal Coordination
  - Connecting with other programs targeting toxic pollutants

---

Water Quality Program

WQS Revisions Will Not Solve All Toxics Problems

- Implementing WQS with a focus on traditional sources in traditional ways will not result in removal of the most important toxics from the environment
- WQS pollutants do not represent all of the toxic pollutants of concern

Water Quality Program 7

DEQ State of Oregon Department of Environmental Quality

Where We're Headed

- Oregon's Environmental Quality Commission directed DEQ to approach toxics reduction broadly
- Discussions focused not only on criteria recalculations, but also
  - Cost-effective, environmentally meaningful standards implementation
  - NPDES permitted sources – augmenting end-of-pipe treatment with other actions (e.g., source reduction)
  - Other sources of toxic pollutants
  - Connections to other toxics reduction efforts

Water Quality Program

DEQ State of Oregon Department of Environmental Quality

- WQS part of reducing and preventing risks
- Complementary to other programs in addressing contaminants of concern

Water Quality Program

DEQ State of Oregon Department of Environmental Quality

Related Activity: Priority Persistent Pollutants (Senate Bill 737)

Water Quality Program

DEQ State of Oregon Department of Environmental Quality

SB737 – What is it?

- Concerned with toxic pollutants in Oregon's <u>waters</u>
- State Statute—Not related to federal statutes or requirements
- Focus = Toxics Reduction
- List development for priority persistent pollutants first of its kind

Water Quality Program

DEQ State of Oregon Department of Environmental Quality

Priority Persistent Pollutants (SB737)

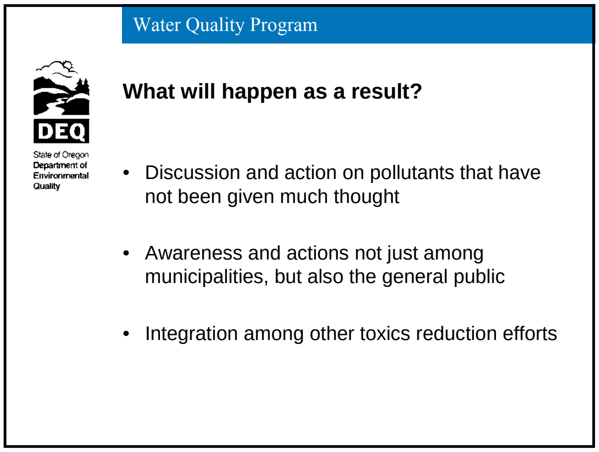
- Statute requires DEQ to:
  - Develop a list of priority persistent bioaccumulative toxics (Final List October 2009).
  - Report to the Legislature on all sources of priority persistent pollutants and identify opportunities for source reduction by June 2010.
- Requires Oregon's 52 large municipal wastewater treatment plants to:
  - Develop toxics reduction plans by July 2011 for pollutants in effluent above trigger levels.

Water Quality Program

DEQ State of Oregon Department of Environmental Quality

Developing the Priority Persistent Pollutant (P³) List

- Identify chemicals that meet defined characteristics
  - **T**oxicity and *either*
  - **P**ersistence or
  - **B**ioaccumulation
- DEQ will look to confirm presence in sediment, water or fish tissue and/or likelihood of presence in Oregon waters
  - P3 List incorporates some information
  - Efforts on source identification will result in additional information (Report due June 2010)


Water Quality Program
DEQ
State of Oregon Department of Environmental Quality
What will happen as a result?
• Discussion and action on pollutants that have not been given much thought
• Awareness and actions not just among municipalities, but also the general public
• Integration among other toxics reduction efforts

Questions and Answers

Q. *You stated that new water quality standards (WQS) should take effect in 2011. How will this affect Superfund cleanup?*

A. WQS are already a part of the Applicable or Relevant and Appropriate Requirements (ARARs). Under the Model Toxics Control Act (MTCA) Cleanup Regulation, cleanup levels are based on estimates of the “reasonable maximum exposure” (RME), so risk assessment was done to take the RME, 175 g/day for sensitive populations, into account.

Q. *When we acknowledge that some populations have higher consumption rates than others, it can be a double-edged sword, since increased restrictions on fish advisories can make WQS stricter. Are you taking body weights into consideration as well?*

A. We have not looked at body weights; however, fish advisories would not be affected by screening values. Both Oregon Department of Environmental Quality (DEQ) and Oregon Department of Human Services (DHS) are working together to keep contaminants out of fish.

Q. *Do you have radionuclide data and have you looked at low income groups?*

A. WQS do not include radionuclides, because the Clean Water Act does not address radionuclides. We capitalized on existing data for our assessment, which in our state was tribal fish consumption data and water quality data.

Human Health Assessment of Puget Sound Fish

Biosketch

Joan Hardy, Washington State Department of Health, Olympia, WA

Dr. Joan Hardy (Ph.D.) has been a toxicologist with the Washington State Department of Health since 1990. She holds a B.A. in Biology from Whitman College, an M.S. and Ph.D. from the School of Fisheries and Aquatic Sciences, University of Washington, and received a post-doctoral fellowship with Fisheries and Oceans, Canada, in British Columbia. Most of her research has been associated with lakes, nutrients, phytoplankton, zooplankton, or contaminant issues. Her recent work is focused on research, education, and tracking human and animal illnesses associated with toxic cyanobacterial blooms in Washington lakes, with preliminary data showing bioaccumulation of microcystins in fish muscle tissue. She was the lead Department of Health toxicologist investigating contaminant bioaccumulation in Puget Sound fishes and associated risks for human consumers of these fishes.

Abstract

Over the past decade, the Washington State Department of Fish and Wildlife collected fish tissue data to determine long-term trends in contaminant levels in Puget Sound fish. Concentrations of many contaminants were measured in muscle tissue (without the skin) from English sole, four species of rockfish, and two salmon species as part of the Puget Sound Assessment and Monitoring Program (formerly Puget Sound Ambient Monitoring Program). Based on tissue concentrations, frequency of detection, and toxicity, the Washington Department of Health (DOH) concluded that two of the contaminants are of potential public health concern: polychlorinated biphenyls (PCBs) and mercury (Hg). DOH assessed these data to address potential health impacts to humans who eat marine fish from Puget Sound. Findings showed that Hg contamination of rockfish species in Puget Sound was primarily related to where they live and to fish age, Hg concentrations were highest in yelloweye rockfish, age-adjusted Hg levels were higher in rockfish from urban areas of central Puget Sound than in those from non-urban areas of Puget Sound, and PCBs were elevated in rockfish from urban bays compared with those from near- and non-urban areas. The findings also showed that English sole from urban areas had higher contaminant levels (i.e., PCBs and Hg) than those from near-urban and non-urban areas, older fish also tended to have higher Hg levels, Puget Sound coho salmon tended to have lower PCB and Hg levels than Chinook salmon, and resident Chinook salmon (also known as blackmouth) from Puget Sound tended to have higher PCB levels than migratory Chinook salmon. Blackmouth do not migrate to the open ocean. Based on contaminant concentrations in fish and on estimates of consumption by the recreational community, DOH determined that frequent consumers of certain fish may be exposed to contaminants above a level of concern. Meal limit guidance for Puget Sound rockfish, bottomfish, and salmon was calculated and consumption advice for the public was provided.

PUBLIC HEALTH
ALWAYS WORKING FOR A SAFER AND HEALTHIER WASHINGTON

Portland, Oregon
November 2, 2009

2009 National Forum on Contaminants in Fish

Eat Fish, Be Smart, Choose Wisely

Human Health Assessment of Puget Sound Fish

Washington State Department of Health

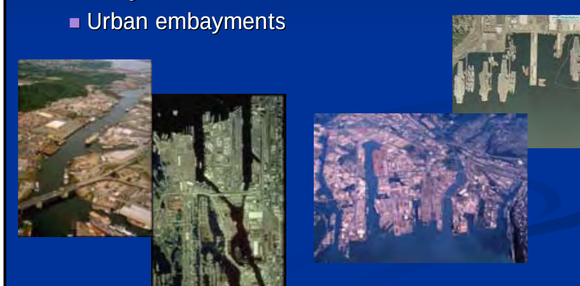
Joan Hardy
Toxicologist
Office of Environmental Health, Safety and Toxicology

Department of Health (DOH) Background

- Office of Environmental Health, Safety and Toxicology (OEHST)
- What does OEHST do?
  - Technical assistance to Local Health Jurisdictions
  - Food safety
  - Zoonotic diseases
  - Human health assessments

Puget Sound

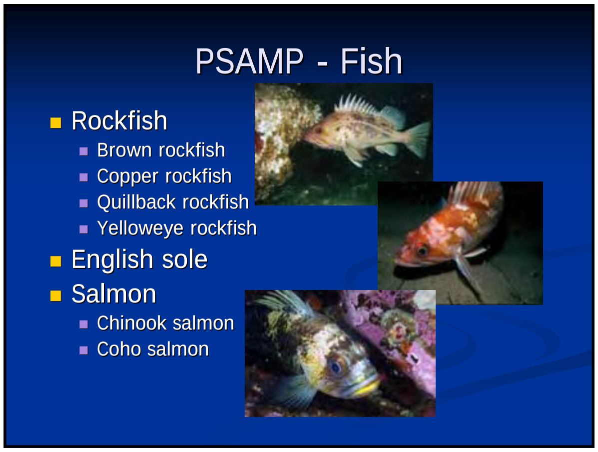
- History of chemical contamination
  - Urban embayments

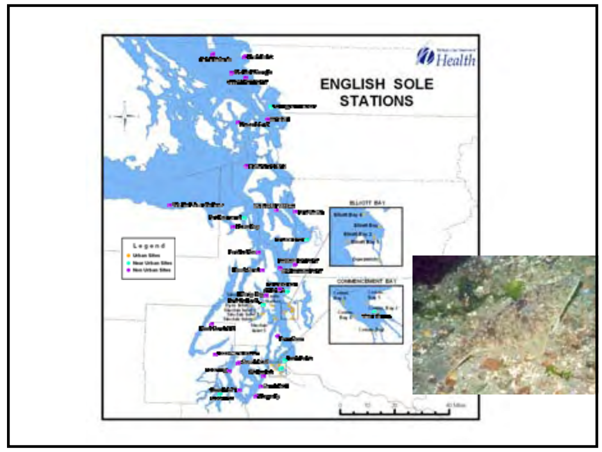


Puget Sound

Puget Sound Assessment and Monitoring Program (PSAMP)

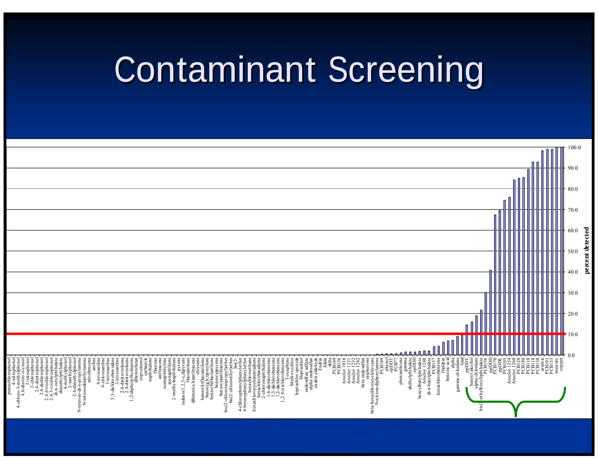
- Began in 1988
- Purpose
  - Monitor long-term contaminant trends
    - Biological Resources
    - Physical Environment and Habitat
    - Nutrients and Pathogens
    - Toxic Contaminants

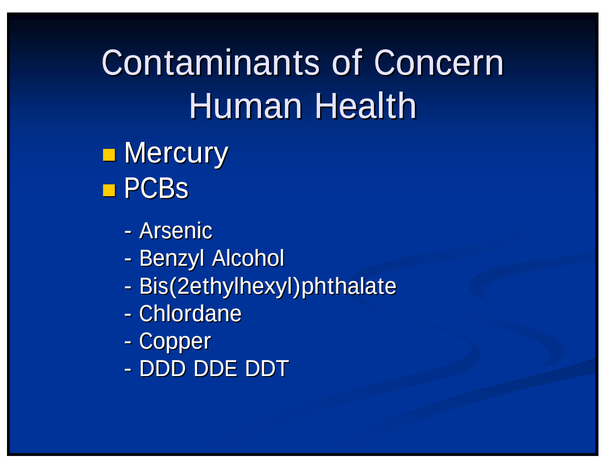

PSAMP - Fish
Rockfish
Brown rockfish
Copper rockfish
Quillback rockfish
Yelloweye rockfish
English sole
Salmon
Chinook salmon
Coho salmon


Health
ENGLISH SOLE
STATIONS
Legend


Health
Salmon
Stations
Nooksack River
Skagit River
Strait of Juan de Fuca
Puget Sound
Legend
Rivers
Mixed Stock
Hatcheries/Net Pen
Duwamish River
Nisqually River
Deschutes River


Step 1
Determine contaminant concentrations
in Puget Sound fish


Contaminant Screening
percent detected


Contaminants of Concern
Human Health
Mercury
PCBs
- Arsenic
- Benzyl Alcohol
- Bis(2ethylhexyl)phthalate
- Chlordane
- Copper
- DDD DDE DDT

Hg and PCBs in PS fish

	Hg (ppm)	PCBs (ppb) Total Aroclors
Rockfish	0.287	55.3
Urban	0.368	134
Near-urban	0.225	45.1
Non-urban	0.218	5.8
English Sole	0.060	38.6
Urban	0.072	73.6
Near-urban	0.053	17.2
Non-urban	0.051	9.3
Chinook	0.093	54.0
In-river	0.096	50.2
Marine	0.082	73.2
Coho	0.039	31.8
In-river	0.038	31.1
Marine	0.051	34.4

AGE - Hg
Length is not a good predictor of age
Anglers rarely target a single species
Species may be difficult to identify

LOCATION - PCBs

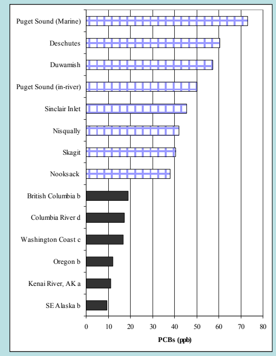
LOCATION - PCBs
- Urban
- Near-Urban
- Non-Urban

AGE - Hg

Chinook - Higher contaminant values
Higher trophic level
Diet/life history/age
Fat content

Coho - Lower contaminant levels
Trophic level
Fat content
Age/life history

PCB levels in Puget Sound Chinook vs Washington coast, Alaska, Oregon, and British Columbia (solid bars)



Step 2

Estimate the amount of Puget Sound fish eaten by public

Consumption Surveys

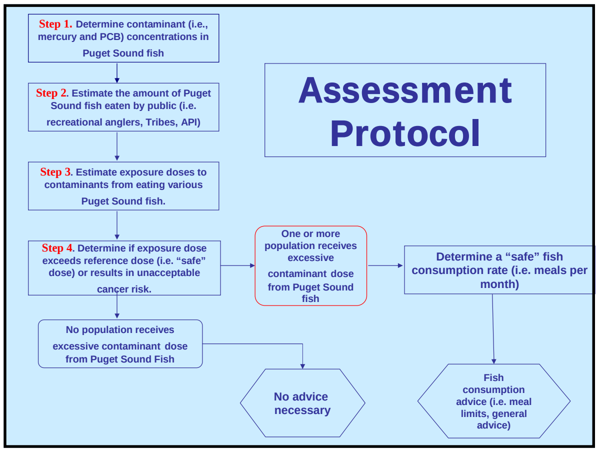
- Tribes
  - Suquamish
  - Tulalip
  - Squaxin Island
- Recreational
- Asian & Pacific Islanders

Step 3

Estimate exposure doses to contaminants from eating various Puget Sound fish

Step 4

Determine if exposure dose exceeds reference dose (i.e. “safe” dose) or results in unacceptable cancer risk



How Do We Develop a Fish Advisory?

- Calculate meal limits
  - 8-oz meals per month or week
  - Based on PCBs, Hg, and additive endpoints
- Consider benefits of eating fish
- Create a clear message

Rockfish Meal Limit Calculations

Location	Average Mercury concentration (ppm)	Average PCB concentration (ppb)	Calculated meals per month based on mercury	Calculated meals per month based on PCBs	Calculated meals per month based on additive endpoint
Non-urban locations	0.218	5.8	3.7	28	3.4
Near-urban locations	0.225	45.1	3.6	3.6	2.2

Puget Sound Rockfish

Rockfish consumption advice is based on contaminant levels in brown, quillback, and copper rockfish from Puget Sound. In addition to contaminant concerns, non-tribal harvest of yelloweye and canary rockfish is prohibited for conservation purposes.

Puget Sound Rockfish

Marine Area/ Location		Rockfish Species	Consumption Advice	Exceptions
6 thru 13	All Puget Sound Marine Areas	Yelloweye Rockfish*	No consumption	None
6 thru 13	All Puget Sound Marine Areas	Canary Rockfish*	No consumption	None
6	East Juan de Fuca Strait	Rockfish	No more than 1 meal per week	None
7	San Juan Islands	Rockfish	No more than 1 meal per week	None
8.1	Deception Pass, Hope Island & Skagit Bay	Rockfish	No more than 1 meal per week	None
8.2	Port Susan/Port Gardner	Rockfish	No more than 1 meal per week	Yes
	Mukilteo-Everett/ Port Gardner	Rockfish	No more than 2 meals per month	
9	Admiralty Inlet	Rockfish	No more than 1 meal per week	None
10	Seattle-Bremerton	Rockfish	No more than 1 meal per week	Yes
	Elliot Bay	Rockfish	No consumption	
	Sinclair Inlet	Rockfish	No consumption	
11	Tacoma-Vashon	Rockfish	No more than 1 meal per week	None
12	Hood Canal	Rockfish	No more than 1 meal per week	None
13	South Puget Sound	Rockfish	No more than 1 meal per week	None

* Non-tribal harvest of yelloweye and canary rockfish is prohibited for conservation purposes.

English Sole & Other Flatfish

The following advice applies to consumption of Puget Sound flatfish including English sole, starry flounder, and rock sole. No restrictions means you can eat 2 to 3 meals per week.

Puget Sound English Sole & Other Flatfish*

Marine Area/ Location		Consumption Advice	Exceptions
6	East Juan de Fuca Strait	No restrictions	None
7	San Juan Islands	No restrictions	None
8.1	Deception Pass, Hope Island & Skagit Bay	No restrictions	None
8.2	Port Susan/Port Gardner	No restrictions	Yes
	Mukilteo Ferry Dock to City of Everett	No more than 2 meals per month	
9	Admiralty Inlet	No restrictions	None
10	Seattle-Bremerton	No restrictions	Yes
	Duwamish Waterway	No consumption	
	Elliott Bay	No more than 2 meals per month	
	Eagle Harbor	No more than 1 meal per week	
	Port Orchard Passage	No more than 1 meal per week	
	Sinclair Inlet	No more than 1 meal per month	
11	Tacoma- Vashon	No restrictions	Yes
	Inner Commencement Bay	No more than 2 meals per month	
	Outer Commencement Bay	No more than 1 meal per week	
12	Hood Canal	No restrictions	None
13	South Puget Sound	No restrictions	None

*Recommendations for consuming other bottomfish such as lingcod, are not included in the above advice.

Estimated PCB Levels

- No data for Bellingham Bay, Budd Inlet, Everett Harbor, and Port Angeles.

$[mPCB] = e1.64*[sPCB]0.35*e0.13*Age$

Where:

- mPCB = concentration of PCBs in muscle as sum of 3 Aroclors, ng/g, wet wt.,
- sPCB = concentration of PCBs in sediments as sum of 3 Aroclors, ng/g, dry wt.,
- Age = fish age in years.

Estimated PCB Levels in E. sole based on Matched PCB Sediment Concentrations

Location	Sediment N	Sediment PCB concentration (ppb, dry wt.)	Predicted E. sole concentration (ppb, wet wt.)	Meals per month
Bellingham Bay	45	14.8	29.9	5
Budd Inlet	9	13.9	29.3	5
Everett Harbor	33	355	91.0	2
Port Angeles	22	12.7	28.3	6

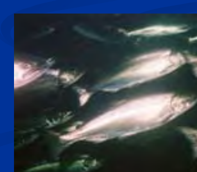
Puget Sound Salmon

Puget Sound Salmon		All Puget Sound Marine Areas
Marine Area	Salmon Species	Consumption Advice
6 thru 13	Chinook	No more than 1 meal per week
6 thru 13	Chinook (Blackmouth)	No more than 2 meals per month
6 thru 13	Coho*	No restrictions
6 thru 13	Chum, Pink, Sockeye**	No restrictions

* High-end consumers (more than 2 meals per week) should follow DOH's fish preparation recommendations.
** Chum, pink, and sockeye salmon were not sampled as part of PSAMP. Data from other sources show that these species tend to have low PCB levels.

Chinook Salmon Recommendations

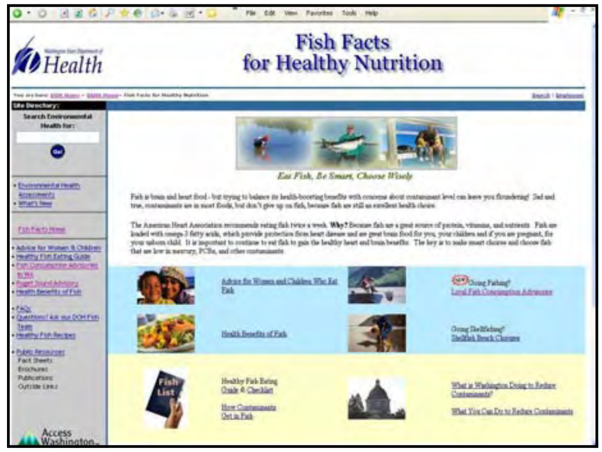
- Puget Sound Chinook salmon may be consumed once (eight ounces) per week.
- Anglers who catch resident Chinook salmon (blackmouth) in the Puget Sound winter fishery should limit their consumption to two eight-ounce meals per month.

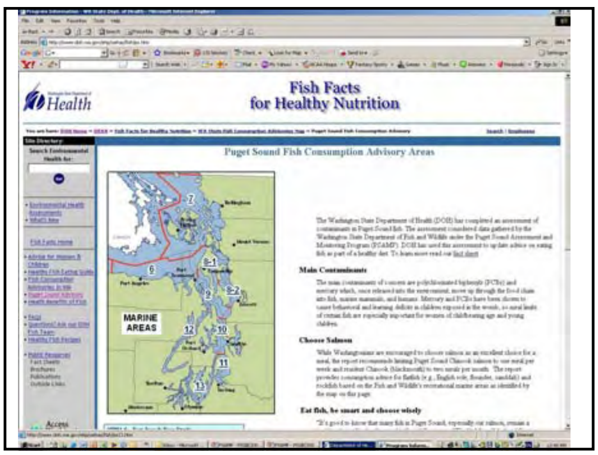


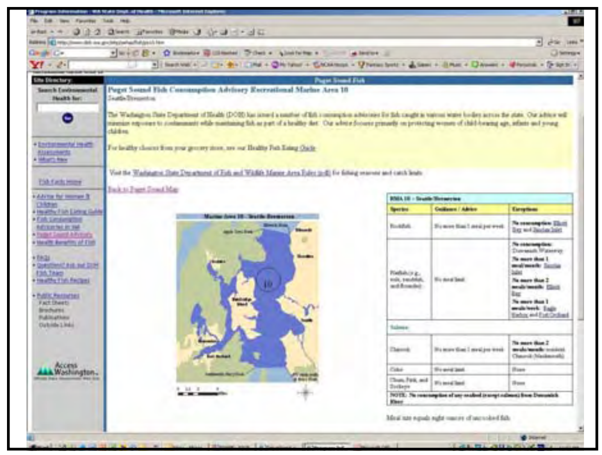
Consumption Advice for All Fish

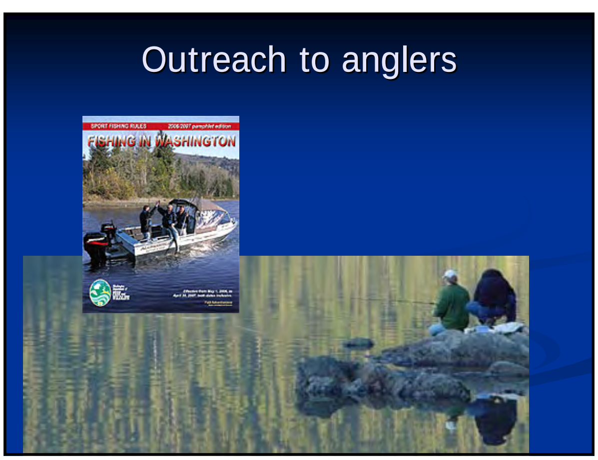
- General advice
  - Choose fish with lower contaminant levels
  - Grill, bake or broil/ remove skin
  - Choose a variety of species

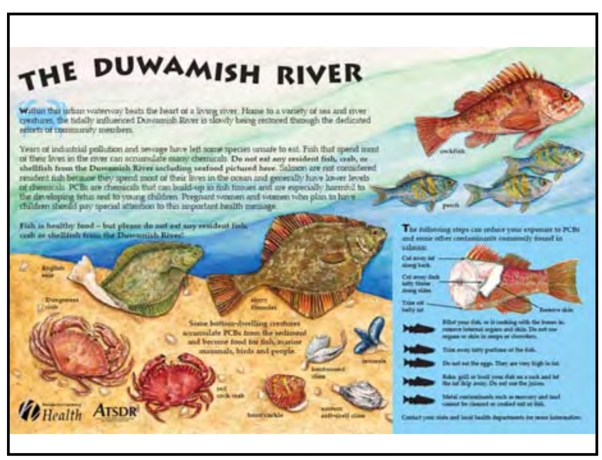

Risk Communication
Media
Signs
Internet
Printed materials
Health care providers
Tribes and local health jurisdictions
Community groups
AVOID


Health
Fish Facts
for Healthy Nutrition
Eat Fish, Be Smart, Choose Wisely


Health
Fish Facts
for Healthy Nutrition
Puget Sound Fish Consumption Advisory Areas
MARINE
AREAS




Outreach to anglers
FISHING IN WASHINGTON


THE DUWAMISH RIVER
Health
ATSDR

Data Gaps

- Obtain contaminant data in crab, shrimp, and bivalves
- Confirm levels in chum, pink and sockeye
- Obtain dioxin/furan data in PS species
- Assess PBDE levels in fish species
- Conduct a "market basket" survey of PCBs

Puget Sound Partnership

- A community effort of citizens, governments, tribes, scientists and businesses working together to restore and protect the Sound
- Goal is to make P.S. healthy again.
- Roadmap to get it done is the "Action Agenda"

PugetSoundPartnership
our sound, our community, our chance

Eat Fish

- American Heart Association – 2 meals/wk
- Eat a variety of fish, especially oily fish
- Benefits
  - Reduces cardiovascular disease risk
  - Beneficial effects on fetal development

Resources

- State of Washington
  - http://www.doh.wa.gov/fish
  - http://www.doh.wa.gov/ehp/oehas/fish/ps.htm

PUBLIC HEALTH
ALWAYS WORKING FOR A SAFER AND
HEALTHIER WASHINGTON

Eat Fish, Be Smart, Choose Wisely
November 2, 2009

Questions and Answers

Q. *Did you use developmental additive effects in developing the final advice for PCBs and mercury?*

A. We did. It was used in final advice, rounding up or down in communication materials. We also looked at additive effects with respect to DDT.

Q. *What methodology did you use for the PCBs and mercury?*

A. The methodology is based on Agency for Toxic Substances and Disease Registry (ATSDR) with added reference doses (RfDs). Please contact me if you'd like a copy of the report.

Q. *Have you looked at the efficacy of the program (i.e., how many people use the communication materials)? Are you reaching low-income groups?*

A. We had many talks with Native American tribes and Northwest Indian Fisheries Commission (NWIFC) to obtain and incorporate input on technical and outreach processes. We also want to determine if other groups are being reached in outreach, such as young anglers and retirees.

Q. *Have you looked at dioxin-like PCBs?*

A. We briefly reviewed Toxic Equivalencies (TEQs). At first, our lab's aroclor limits were set too high, but we did look at 15 aroclor equivalents in the second half. Additional research into dioxin-like PCBs is a future goal.

Q. *Reaching consumers at the point of sale is really important. Are there any plans to extend work with specialty markets or other point of sale locations? Also, are there any plans to translate the guides into other languages besides Spanish?*

A. Yes, but our plans are contingent on funds. The results suggest we need to do so.

Overview of Freshwater Fish Tissue Contaminant Monitoring in Washington State

Dale Norton, Washington State Department of Ecology

Biosketch

Mr. Dale Norton manages the Toxics Studies Unit within the Washington State Department of Ecology's Environmental Assessment Program, which is the department's primary scientific research and monitoring division. In this capacity, Mr. Norton is responsible for overseeing a wide variety of monitoring programs for toxic chemicals, including such statewide activities as freshwater fish tissue monitoring; trend monitoring for persistent, bioaccumulative, and emerging contaminants; TMDL studies for toxic pollutants; surface water pesticide monitoring; and the Puget Sound Toxics Loading Analysis. Mr. Norton received his B.S. in Marine Resources from Huxley College of Environmental Studies, Western Washington University, in 1980. Over the past 29 years at the Department of Ecology, he has served as lead scientist on a wide variety of environmental research and monitoring programs. Much of this work has focused on fate, transport, and bioaccumulation of toxic contaminants in marine and freshwater aquatic systems.

Abstract

During the 1980s and 1990s, a number of studies found toxic contaminants in fish, water, and sediment throughout freshwater areas in the State of Washington. As a result, the Washington State Department of Ecology established the Washington State Toxics Monitoring Program (WSTMP) in 2000 to address the problem of toxic contaminants. Resident fish is an important indicator of contaminant levels in the environment. Between 2001 and 2008, the WSTMP has collected and analyzed 268 fish tissue samples from 129 sites for variety of contaminants. Nearly 55,000 results are now available electronically in the Washington State Department of Ecology's Environmental Information Management database from this program. This department and the Washington State Department of Health are also developing strategies to address persistent, bioaccumulative, and toxic (PBT) chemicals in our environment. These strategies involve learning more about the sources, uses, risks, and fate of PBT chemicals.

An overview of historical and current fish tissue monitoring activities by the Washington State Department of Ecology will be presented, along with significant findings from the past decade of monitoring for mercury, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and other persistent and emerging contaminants.

Washington State Department of Ecology Environmental Assessment Program

- Ecology is 1 of 11 natural resource agencies in Washington
- 1500 employees in Ecology
- EAP is monitoring and assessment branch of Ecology
- 140 employees in EAP
- Staff dedicated to long-term FW fish monitoring= 6
- Annual budget for long-term FW fish monitoring= $1,000,000

30 Years of Freshwater Fish Monitoring in Washington

Year	Activity
1979	**Basic Water Monitoring Program Begins**
1985	Yakima River Chlorinated Pesticide Study
1988	Lake Roosevelt Contaminant Studies
1989	**Lake and Reservoirs Water Quality Assessments**
1990	Spokane River PCBs in Fish Studies
1992	**Washington State Pesticide Monitoring Program**
1997	1st TMDL for Toxics, Yakima River Chlorinated Pesticides (Aquatic Life)
1998	Occurrence of PBDEs in WA Fish
1998	Lake Whatcom Mercury in Fish Study
2001	**Washington State Toxics Monitoring Program**
2002	National Lakes Sampling in WA
2003	Statewide Mercury in Fish Baseline Assessment
2005	**Mercury Trends Monitoring in Fish**
2005	Statewide PBDE in Fish Baseline Assessment
2006	Yakima River Chlorinated Pesticide and PCB Human Health TMDL
2008	National Rivers and Streams Sampling in WA
2008	Statewide PFC Baseline Assessment

Basic Water Monitoring Program Begins (1979-1989)
Lakes and Reservoirs Monitoring Program (1989 and 1994)
WA. State Pesticide Monitoring Program (1992 to 1995)
WA. State Toxics Monitoring Program (2001 to present)
Mercury Trends in Fish (2005 to Present)

1979 1985 1990 1995 2000 2005 2009

Current Monitoring

<u>Overall Approach</u>

- Screen for Problems (exploratory)
- Conduct Focused Studies (source ID and need for advisories)
- Trend Monitoring (targeted and rotating)

<u>Washington State Toxics Monitoring Program (Long-Term)</u>

- Exploratory Component: Fish Tissue
- Organic Trends: Semi-Permeable Membrane Devices
- Mercury Trends: Fish Tissue

<u>Focused Studies</u>

- Typically 1-3 years in duration

Permits

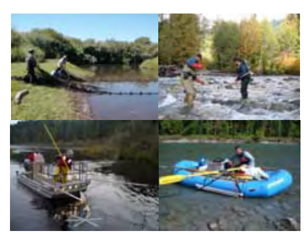
State Agencies	Lead Time	Renewal
Washington State Department of Fish and Wildlife	4-6 weeks	Annual
Washington State Parks and Recreation Commission	1 month	Annual

Federal Agencies	Lead Time	Renewal
US Fish and Wildlife Service	9 months	5 years/annual amendments
NOAA Fisheries	6-9 months	5 years/annual amendments
National Parks	1 month	Varied lifespan/annual
National Recreation Areas	1 month	Varied lifespan/annual

Other	Lead Time	Renewal
"Permissions"(tribes, cities, USFS, PUDs, and private landowners)	4-6 weeks	Annual

Collection Methods

- Boat electro-fishing (larger rivers and streams)
- Backpack electro-fishing (small streams)
- Gill nets
- Beach Seine
- Fyke nets
- Set lines
- Hook and line



Washington State Toxics Monitoring Program Exploratory Sampling (2001 to 2008)

WSTMP Sampling Sites (2001 to 2008)

Overview
- 15-20 sites per year
- 3-5 species per site
- Mercury, Chlorinated Pesticides, PCBs , PBDEs, and Dioxins/Furans
- Other data- age, length, weight, and sex

Site Selection Factors
- Lack of historical data
- Importance for fishing
- Cooperation with other monitoring efforts

Organic Trends
(Initiated 2007)

Overview
- 12 sites per year
- Fall (low flow) and Spring (high flow)
- Passive samplers (SPMDs)
- Chlorinated Pesticides, PCBs , PBDEs, and PAHs

Site Selection Factors
- Fixed stations (targeted)
- Range of land use types (background, urban, agricultural and mixed use)

Mercury Trends

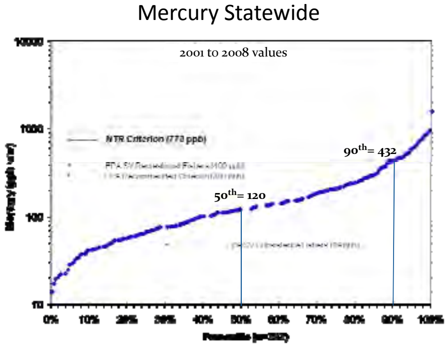
- Six sites per year for 5 years
  Repeat sampling at 5 year intervals
- Four years completed (2005 – 2008)
  Sampling for 5th year underway
- Ten individuals used for trends assessment
  Target species: LMB, SMB and WAL
- Three additional composites of 2 other species
  Evaluate alternative species with low contaminant levels for advisories

Focused Study Examples

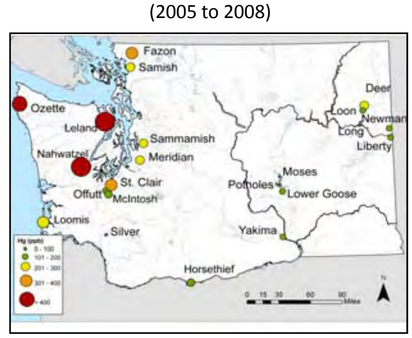
- **Statewide**
- Mercury Baseline
- PBDE Baseline
- Perfluorinated Compounds Baseline
- Background Levels of PCBs and Dioxins in Fish
- Hatchery Fish and Feed

- **Other**
- Potholes Reservoir (Dieldrin)
- Spokane River Osprey and Fish (PBDEs)
- Cyanobacteria Toxins in Fish
- TMDLs (Chlorinated Pesticides and PCBs)
- TMDL Effectiveness
- Mercury and Small Scale Mining
- Arsenic Speciation in Similkameen River Fish
- Lake Ozette Mercury Loading

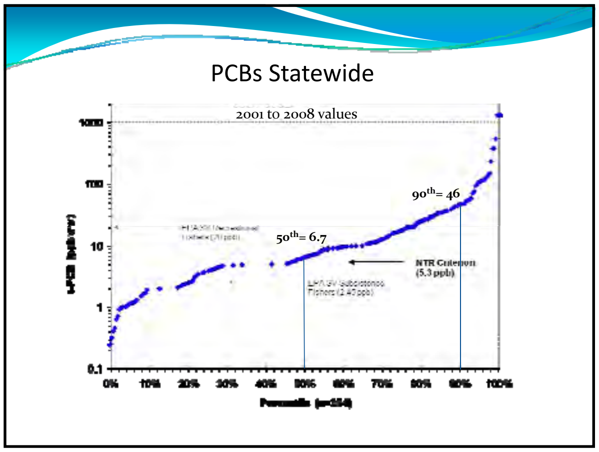
Mercury Statewide

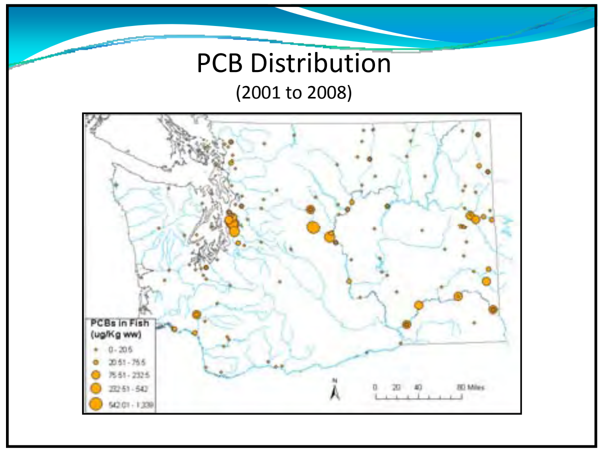


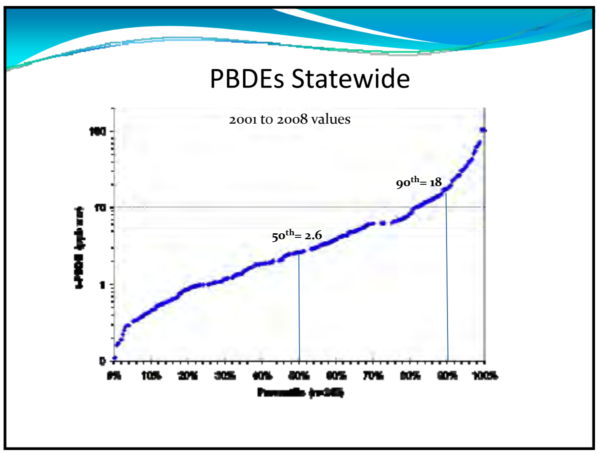
Mercury Distribution
(2005 to 2008)

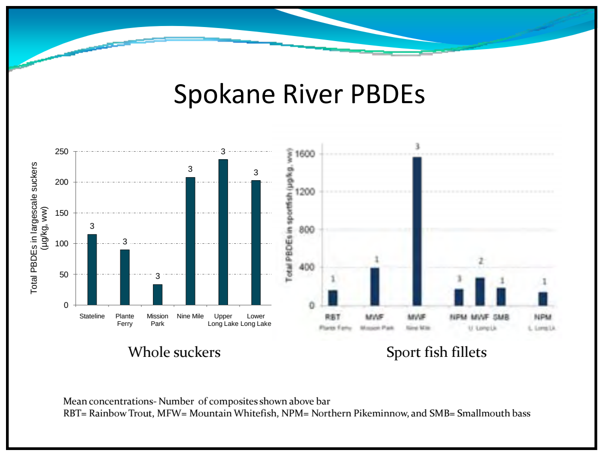


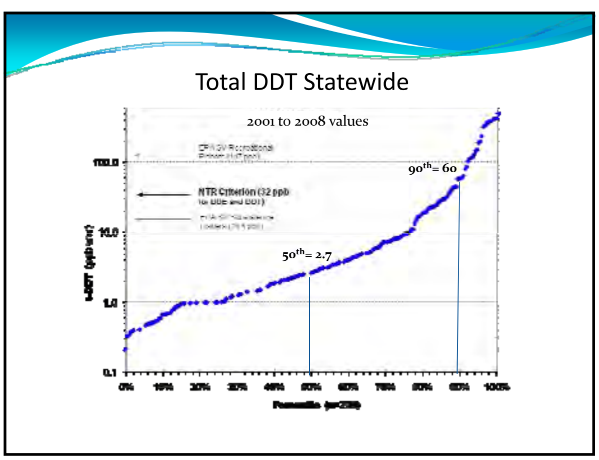
Concentrations normalized to "standard sized" 356 mm bass. Calculated using linear regression from 10 individuals from a water body.

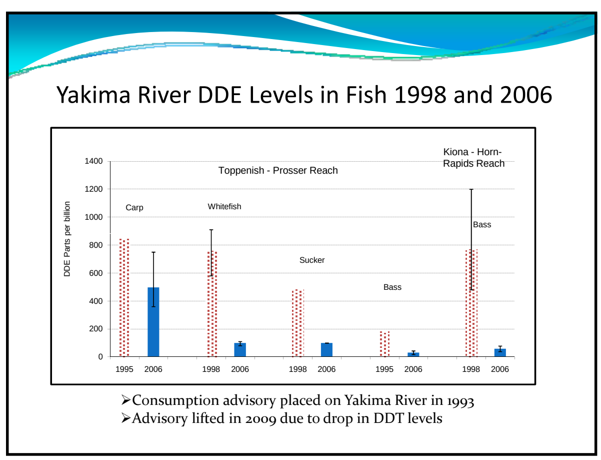

PCBs Statewide
2001 to 2008 values
90th= 46
50th= 6.7
NTR Criterion (5.3 ppb)
1000
100
10
1
0.1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%


PCB Distribution
(2001 to 2008)
PCBs in Fish (ug/Kg ww)
0 - 20.5
20.51 - 75.5
75.51 - 232.5
232.51 - 542
542.01 - 1,209
0
20
40
80 Miles


PBDEs Statewide
2001 to 2008 values
90th= 18
50th= 2.6
100
10
1
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%


Spokane River PBDEs
Total PBDEs in largescale suckers (ug/kg, ww)
Total PBDEs in sportfish (ug/kg, ww)
Stateline
Plante Ferry
Mission Park
Nine Mile
Upper Long Lake
Lower Long Lake
RBT
MWF
MWF
NPM
MWF
SMB
NPM
Whole suckers
Sport fish fillets
Mean concentrations- Number of composites shown above bar
RBT= Rainbow Trout, MFW= Mountain Whitefish, NPM= Northern Pikeminnow, and SMB= Smallmouth bass


Total DDT Statewide
2001 to 2008 values
NTR Criterion (32 ppb
90th= 60
50th= 2.7
100.0
10.0
1.0
0.1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%


Yakima River DDE Levels in Fish 1998 and 2006
DDE Parts per billion
Toppenish - Prosser Reach
Kiona - Horn-Rapids Reach
Carp
Whitefish
Sucker
Bass
Bass
1400
1200
1000
800
600
400
200
0
1995
2006
1998
2006
1998
2006
1995
2006
1998
2006
➢Consumption advisory placed on Yakima River in 1993
➢Advisory lifted in 2009 due to drop in DDT levels

Future Activities

- Revise monitoring plan for exploratory fish component (implement summer 2010)
- Update organic trends monitoring program(implement spring 2010)
- Revisit mercury sites (5 year rotation) to evaluate trends (summer 2010)
- Final report for perfluorinated compounds baseline study

Contact and Resources Information



- Washington State Toxics Monitoring Program
  Keith Seiders: keith.seiders@ecy.wa.gov
- Mercury Trends
  Chad Furl: chad.furl@ecy.wa.gov
- Environmental Information Management System
  http://www.ecy.wa.gov/eim/
- Department of Ecology Publications
  http://www.ecy.wa.gov/pubs.shtm
- Environmental Toxics Monitoring by Ecology Webpage
  http://www.ecy.wa.gov/programs/eap/toxics.html

Questions and Answers

Q. The sampling data don't appear to include surges by climate change. Can you identify any trends or changes in contaminants created by glacial inflow?

A. We were not specifically targeting long-term changes related to climate change.

Q. Did you isolate or suspect a source for the PCBs in Spokane?

A. There are potentially increases around the primary discharge point from city of Spokane municipal sewer plant and at the Idaho border, but we are still trying to analyze the data.

Q. What is your opinion on semi-permeable membrane devices? Do you think they could be instrumental in speeding up the permitting processes for organic contaminants?

A. The membrane devices work well for certain contaminants and you can leave them in the field for a month and retrieve information. However, if you are trying to characterize background levels, it's a challenge. The devices generate a dissolved concentration and a model translates this number to bioaccumulation.

Washington State's Fish Advisories and the Healthy Fish Guide

Liz Carr, Washington State Department of Health

Biosketch

Ms. Liz Carr is the Fish Advisories Coordinator for the Office of Environmental Health, Safety and Toxicology, Washington State Department of Health, and has been involved in the development of the Fish Advisories Program for Washington State. She received her B.S. in Marine Biology and M.S. in Environmental Studies from The Evergreen State College. With 17 years of experience managing marine-related scientific research projects and environmental and public health programs, Ms. Carr is interested in the intersection of science, advocacy, policy, and program development. Previously, she worked for the state government as a fisheries biologist and for non-governmental organizations in the areas of Antarctic research and ecological economics.

Abstract

Fish consumption is the primary exposure pathway to mercury, polychlorinated biphenyls (PCBs), and chlorinated pesticides for most Washingtonians. With close recreational and cultural connections to the Puget Sound and the state's many rivers and coastal shorelines, many Washington State residents enjoy and consume both sport-caught and commercially available fish. Results from the 2004 and 2005 Behavioral Risk Factor Surveillance System surveys conducted by the Washington State Department of Health (DOH) indicated that in 2004, 74% of adults reported that they ate fresh or frozen fish bought at the store or from a restaurant in the past month compared with 16.5 % who said they ate sport fish in the past month. In 2005, 57.3% of adults reported eating fresh fish that was purchased at a grocery store or fish market in the past month. To address this exposure pathway, DOH measured mercury, PCBs, and polybrominated diphenylethers (PBDEs) in commercial fish from grocery stores across the state. Based on this information, DOH developed a Healthy Fish Guide designed to increase public awareness of the many commercial fish choices that are low in contaminants, identify fish that should be avoided due to high mercury levels, communicate the benefits of eating fish, and remind consumers that eating fish at least two times a week is important for heart and brain health. The guide is the cornerstone for the Healthy Fish Choices Grocery Store Pilot Project, which provides information to consumers at the point of purchase. Additional information is provided regarding which fish should be avoided due to being overfished, farmed, or caught using methods harmful to marine life and the environment, as well as information on recreational fish advisories. Preliminary results from the pilot survey (N = 75) indicated that 56% of the survey participants noticed the materials, and 62% of those who noticed the materials read them. At one store, 76% of the survey participants noticed the materials. The Healthy Fish Guide is also distributed statewide by public request and through Women, Infants, and Children (WIC) clinics; Child Profile; local health departments; health practitioners; and non-governmental agencies.

Washington State's Fish Advisories and the Healthy Fish Guide

Liz Carr MES
Dave McBride MS
WA Department of Health
Office of Environmental Health, Safety, and Toxicology
Fish Consumption Advisories Program
November 2, 2009

Overview

- Recreational and Commercial Fish Consumption Advisories Program.
- Research efforts which support the development of the Healthy Fish Guide.
- Healthy Fish Choices Grocery Store Pilot Project and Survey.

Fish Advisories Program

WADOH recommends that all Washingtonians eat fish two times per week as part of a healthy diet.

Eat Fish, Be Smart, Choose Wisely

We determine if fish from the waters of Washington state are safe to consume, and if the fish you buy are safe to eat.

Meal Limits
- How much fish you can safely eat per week or month.
- Recreational & commercial fish.

Checklist on how to Reduce Your Exposure to Contaminants
- Eat a variety of fish and eat smaller fish.
- Cleaning and cooking techniques to reduce toxins.

Health Benefits Statement

Why are we concerned?

- Eating fish is the main way that people in WA State are exposed to methylmercury and PCBs.
- Washington State data show that 5% of women still get too much methylmercury in their diet from eating fish.
- The 2004 Federal Mercury in Fish and Shellfish Advisory was shown to confuse people.

Recreational Fish Advisories

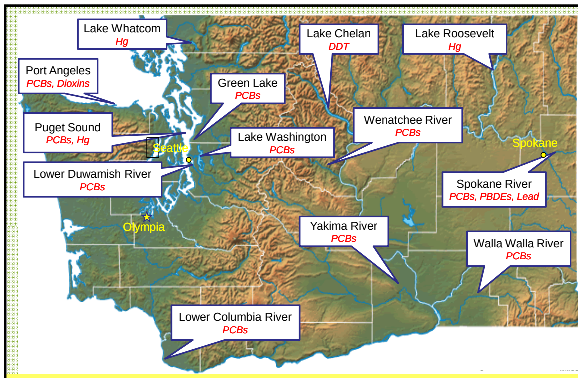
Sport- caught

13 Advisories (includes Puget Sound)
- Waterbody specific
- Species specific

Statewide Fish Consumption Advisory for Mercury

- Recreational Species:
  Northern pikeminnow – Do not eat (2009)
  Smallmouth & largemouth bass- 2 meals per month (6/03)

  Target population: women who are or may become pregnant, nursing mothers, and young children.



Statewide Mercury Advisory:
Northern Pikeminnow: DO NOT EAT
Largemouth and Smallmouth bass: 2 meals per month

Commercial Fish Advisories

Strategy: **Broaden Federal advice on store-bought fish. Result the Healthy Fish Guide.**

What we know:
- The public is confused about which fish are safe to eat.
- Fish are high in health benefits.

What we didn't know:
- How much fish and which fish species the public was eating.
- Where were they consuming fish from.
- What level of contaminants are in these fish.

Our goal: To encourage the public to eat at least two fish meals per week as part of the American Heart Association's recommendations.

DOH studies that supported our goal:
- Behavioral Risk Factors Surveillance System (BRFSS).
- Analysis of Chemical Contaminant Levels in Store-Bought Fish.
- Human Health Evaluation of Contaminants in Puget Sound Fish.

Washington State

BRFSS Results (2002, 2004, 2005)

- Ongoing telephone survey (CDC).
- Collects information about health behaviors, attitudes, and knowledge.
- Added questions on fish consumption and advisory awareness.

Consumption	% who ate fish in past 30 days (all participants) (95% CI)	Mean times per month (consumers) (95% CI)
Any fish	88%	6.46
Store-bought fish Restaurant meals inc. N=6347		4.56
Sport-caught fish N=6409		2.88
Canned tuna		3.27
All 3 fish types		10.08

Types of fresh fish eaten from stores in past 30 days

Salmon 44%
Halibut 20%
Cod 13%
Tuna (fresh) 6%
Sole 4%
Catfish 3%
Tilapia 3%
Snapper 2%

Analysis of Chemical Contaminant Levels in Store-Bought Fish from Washington State

Dave McBride, MS Jim VanDerslice, PhD
Denise Laflamme, MS, MPH
Asnake Hailu, Dr PH Liz Carr, MS

Objective: To characterize levels of mercury and PCBs in canned tuna and fresh fish sold in grocery stores.

- Species chosen based on frequency of consumption and expected contaminant levels.
- Fish Tested: Catfish, cod, flounder, halibut, red snapper, pollack, salmon, tuna (canned light/white).
- Expanded analysis to PBDEs.

Conclusions

- Mercury was most frequently detected
  - 7 out of 9 species had det. freq. > 90%
  - Canned white tuna had highest mean (357 ppb)
  - Hg levels resulted in more restrictive meal recommendations in 6 out of 9 species
- PCBs – only halibut, red snapper, & salmon had det. freq. >10%
  - Salmon had highest mean (32 ppb)
  - PCB levels more restrictive in catfish and salmon
- Levels of PBDEs measured in fish sold in Washington State grocery stores are similar to levels previously reported
  - BDE-47 most frequently detected in fish

Where to from here?

DOH research determined fish preferences, consumption frequency, contaminant levels in WA fish, and where people are getting their fish.

Outcome:

Point of Purchase Strategy

- ➢ Healthy Fish Guide
- ➢ Healthy Fish Choices Grocery Store Pilot Project
- ➢ Survey of the Pilot Project

Healthy Fish Choices Grocery Store Pilot

- Partnered with Thurston County Health. Displayed in 3 stores and 2 co-ops.
- Social Marketing approach- worked with store managers.
- Identified the benefits and barriers.
- Unexpected outcomes:
  - Stores wanted to provide this info.
  - They were aware of California Prop 65 and wanted this to be a voluntary effort.
  - Stores wanted sustainable fish choices included: (Seafood Watch, Environmental Defense, and NOAA Fish Watch).

Grocery Store

Point-of-Purchase Survey

Purpose: To find out whether shoppers who bought fish noticed the Healthy Choice materials, what they noticed, and what influenced their fish purchase.

- Pilot survey
  - Wanted to track fish sales data, but they were not available.
- In-store survey of shoppers who bought fish.
- Conducted at 3 grocery stores (total of 75 customers).
  - 2 were full service seafood counters
  - 1 packaged seafood area
- Administered by health department staff.
- Participants given a $5 gift card.
- Survey included 10 questions about materials.
- Demographic information also collected.

Results – POP Materials

	Noticed Materials	Top 3 Notice	Full Service	Packaged
All N=75 49 women 26 men	57% (43) 2 or more 46 % (20)	Stickers Package 22% Healthy Fish Guide 23% Fish List Decal 18%	66% (33)	40% (10)
Women	55% (27)	Stickers 25% Healthy Fish Guide 18%	Guides 40% Fish List 40% 30%	Stickers 100% Guide 17% FSS Decal 17% (6)
Men	65% (17)		46% 38% 38%	Stickers 100% Guide 50% FL Decal 25% (4)

Seafood purchased
Top 3: Salmon, shrimp, cod

- Liked it
- Price
- Wild, not farmed

Conclusions: Survey and Pilot

Survey Summary

- > half people surveyed noticed at least one item.
- Most noticed: Healthy Fish Guide, Healthy Fish List Guide Decal, and Healthy Choice stickers.
- Message most remembered "Fish is a Healthy Choice".
- 26% said the materials helped them with their choice.
- Survey informed us which materials work best.

Survey Limits

- Surveyed after one month displayed.
- Only surveyed 3 stores, all in predominantly white areas.
- Stores not randomized.
- Not able to survey people who did not purchase fish that may have been discouraged.

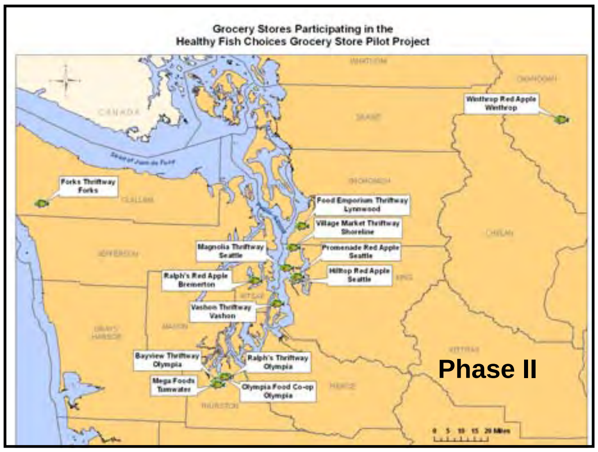
Recommendations

- Translate into other languages and test (different population meal sizes, types of fish etc).
- Partner and share resources with other states to develop consistent messaging (OR has adopted/modified the guide).
- Live document; needs updating via additional fish testing and sustainability research.

PILOT PROJECT – Other Observations

- Store managers and staff were receptive to the information.
- Approach did not turn people away from fish (of those surveyed).
- Anecdotal positive, thankful responses; liked graphics.

Now in 13 stores mainly around Puget Sound.



Comments from Stores

This program provides great information to customers in a format that is easy to understand. I believe it is something that we have, and need to continue, to make part of our every day operation.

Kevin Stormans, Stormans Inc.

This information not only educates the customer- but also the store employees. In today's health conscious society it is important for the retailer to provide the customer with accurate easy to understand information about the food they are purchasing.

Rich Stites, Northwest Meat & Seafood Consultants
(In retail grocery business for 38 years)

We here feel very strongly that this pilot helps train our customer base in the value and health importance of eating more seafood.

Ken Grasser, Director of Fresh Foods, Fuller Market Basket Inc.

Oregon

Grocery Store Pilot Project
Web page at: www. doh.wa.gov/fish

UC Berkeley Health Research for Action
Perspectives August 2008

Fish Contamination:
Environment and Health at Risk

What is WA doing to reduce contaminants?

Washington's Persistent BioaccumulativeToxins (PBT) Rule (Chapter 173-333 WAC)

- A unique program among states
- Goal is to reduce and phase-out PBTs
  - Rule contains an initial list of 74 PBTs and 2 metals of concern and a schedule for revising the list
- Directs Ecology, in consultation with Dept. of Health, to develop Chemical Action Plans (CAPs) for PBTs that:
  - Identify, characterize, and evaluate the uses of PBTs, and
  - Recommend actions to protect human health and the environment
- PBTs evaluated to date:
  - Mercury (2003)
  - Polybrominated diphenyl ethers (PBDE) flame retardants (2006)
  - Lead (2008)
  - Polycyclic aromatic hydrocarbons (PAHs) – 2009-2010
  - Perfluorooctane sulfonates (PFOS) - > 2010

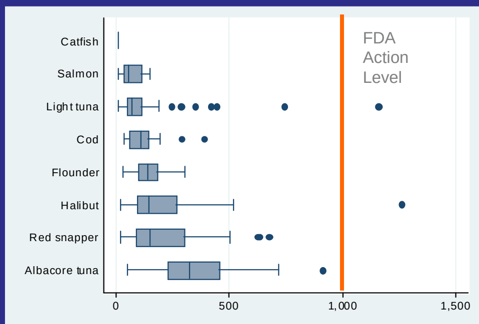
Demographics

75 survey respondents

Women
- 49 (65%) surveyed were women.
- Age range 19-87 years.
- White 85%, Asian 6%, Pacific Islander 3%, Black African 2%.
- 26 women (60%) noticed the materials.
- Of those 26 women, 11 (55%) had children at home.
- Age range 28-54.

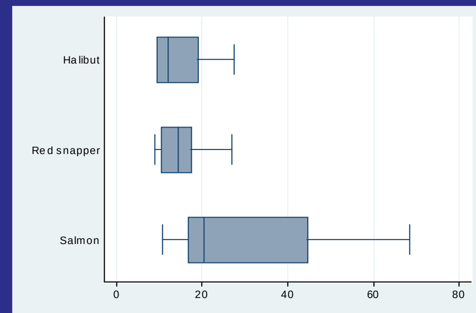
Men
- 26 (34%) were men.
- Age range: 26-66 yrs.
- White 98% , Alaskan American Indian 2%
- 16 men (61%) noticed the materials.
- Of those 16 men, 6 (38%) had children at home.
- Age range: 26-46

Mercury Concentrations



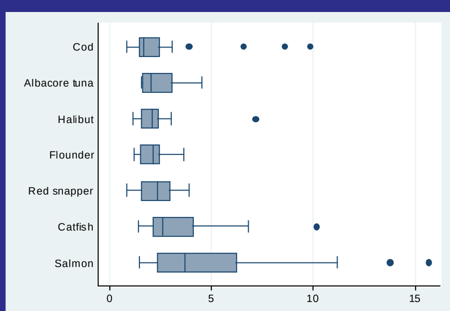
Total Mercury (ppb)

PCB Concentrations



Total PCBs (ppb)

PBDE Concentrations



Total PBDEs (ppb)

Cut-offs values for the green, yellow, and red columns

For mercury:

Recommendation	Hg Concentration (ppb)	Category
Do not eat	> 1000	Red
One meal per month	646 – 1000	Red
2 meals per month	316 – 645	Yellow
1 meal per week	156 - 315	Yellow
2 meals per week	76 – 155	Green
Unlimited	< 75	Green

For PCBs:

Recommendation	PCB Concentration (ppb)	Category
Do not eat	> 340	Red
One meal per month	126 – 340	Red
2 meals per month	61 – 125	Yellow
1 meal per week	31 – 60	Yellow
2 meals per week	16 – 30	Green
Unlimited (	< 15	Green

Update
PBDEs:

PBDE Cap (2006) Resulted in a law (RCW70.76) passed in 2007 banning products containing penta and octa.

Deca in electronics and residential furniture is banned in Washington State beginning in 2011 based on the agencies identifying safer alternatives per the law.

Ecology and DOH report (January 2009)
Alternatives to Deca-BDE in Televisions and Computers and Residential Upholstered Furniture
http://www.ecy.wa.gov/biblio/0907041.html .

Lead :

Lead wheel weights are banned starting in 2011. Ecology plans to propose legislation in 2011 to require assessments for lead-based paint in pre-1960 rental homes and apartments.

Who are we trying to protect?

- Women who are or may become pregnant, nursing mothers, and young children
- High-end consumers
  - Native American tribes
  - Asian and Pacific Islander communities
  - Recreational anglers
  - Communities that utilize a specific fishing area.
- General population – people who are concerned about toxins in fish.

Questions and Answers

Q. What type feedback on the wallet card did you receive?

A. People really like it and we get a lot of requests for it. Women, Infants and Children (WIC) clinics and supermarkets are also distributing the cards.

Q. Did you encounter any barriers working with supermarkets because the card can point out less sustainable fish? Did any stores not want to carry the cards?

A. We didn't experience any difficulties working with stores.

Q. Did you encounter any pushback from industry or anyone else?

A. Farmed salmon has an asterisk because of the debates surrounding aquaculture. We discussed differences in wild-caught versus farmed fish, but we want people to eat fresh fish, so we included it.

Q. The states should also consider the impact on fish stocks. Also, it appears that posting the information where consumers buy fish seems to be more effective for state fish resources.

A. We also trained the staff at the supermarkets so they could engage in conversations about fish consumption with those buying the fish.

Q. Did you have any interactions with health professionals? If so, did you receive any information on if they do consumption screenings with patients?

A. These results are part of the Behavioral Risk Factor Surveillance System (BRFSS). Please contact me if you would like more information.

n-3 Fatty Acid Intake and Longitudinal Mercury Exposure from Fish Consumption within the Japanese and Korean Communities

Ami Tsuchiya, University of Washington, Institute for Risk Analysis and Risk Communication

Biosketch

Ms. Ami Tsuchiya has been a research scientist at the University of Washington's Institute for Risk Analysis and Risk Communication since 2006 and received her M.S. in Environmental Toxicology and her M.P.H. in Epidemiology and Public Health Nutrition from University of Washington. She has worked with the Washington State Department of Health assessing contaminant exposure, nutritional status, and fish consumption patterns among populations of concern. In addition, she is a Registered Dietitian and has worked as a nutritionist with local public health departments and various clinics. Her current research focus is on the integration of nutrition and toxicology.

Abstract

Public health guidance pertaining to fish consumption requires that we be cognizant of the health concerns associated with consuming contaminated fish, as well as the nutritional benefits obtained from fish. Accordingly, there is a need for improved understanding of contamination within various fish species consumed by populations of concern and the extent of exposure to these contaminants while accounting for the benefits of fish consumption when establishing guidance.

As part of the Arsenic Mercury Intake Biometric Study involving the Japanese and Korean communities, we obtained fish and nutrient intake data, determined mercury fish tissue concentrations for species consumed, analyzed for hair-mercury levels, and examined the intake of 2 n-3 long-chain fatty acids: eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). In total, 214 participants (106 Japanese and 108 Koreans) were enrolled into this longitudinal study, which spanned more than 1 year.

The study results showed that more than 50 fish species are consumed, with 8 species representing approximately 3 out of every 4 fish consumed by the Japanese and 10 species representing approximately 4 out of every 5 fish consumed by the Koreans. The fish species responsible for highest mercury intake did not change over time; less than 10 species accounted for most of the mercury body burden in each population. Fish intake for both communities was close to the 95th percentile for the U.S. general population. Hair-mercury levels were also above the national average. Although total finfish consumption rates between the two populations are nearly identical, mercury intakes between the two are significantly different. Consumption patterns suggest that within both populations, there may be a percentage of individuals not obtaining their daily dietary requirement of DHA or DHA+EPA. Japanese with hair-mercury levels >1.2ppm (mean=2.2ppm) consumed ≈150% more fish than those ≤1.2ppm (mean=0.7ppm). However, as many participants consumed substantial amounts of fish (40-60 g/d) while having hair-mercury levels ≤ 1.2 ppm, the nutritional benefits offered from fish consumption should be obtainable without exceeding the RfD.

The observed differences in fish-species consumption behavior and mercury intake levels between the two populations suggest that Asian populations should not be grouped as a whole, but treated independently. Fish consumption guidelines based on contaminant concentrations alone can have the unintended consequence of causing a portion of the population to have an insufficient intake of required nutrients or to have overexposure to contaminants. Public health goals will be better served if nutritional elements and contaminant concerns are quantitatively incorporated into fish consumption guidelines.

* NOTE: This work was supported by the U.S. Environmental Protection Agency (U.S. EPA), Region 10 [Clean Water Act, 104 (b)(3): 66-463]; Pacific Northwest Center for Human Health and Ocean Sciences [National Institute of Environmental Health Sciences (NIEHS)/National Institutes of Health (NIH) grant P50 ES012762, and National Science Foundation (NSF) grant OCE-0434087 and OCE-0910624] and the Washington State Department of Health.

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N-3 Fatty Acid Intake and Longitudinal Mercury Exposure From Fish Consumption within the Japanese and Korean Communities

Ami Tsuchiya
University of Washington

Washington State Department of Health
2009 National Forum Contaminants in Fish: November 2 2009

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Washington State Department of Health
&
University of Washington
PNW Center for Human Health and Ocean Studies
&
Institute for Risk Analysis and Risk Communication

Collaborators:
Thomas A. Hinners, Finn Krogstad, Joan Hardy,
Jim W. White, Elaine M. Faustman,
Thomas M. Burbacher
PI: Koenraad Mariën

Washington State Department of Health

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Fish consumption guidance is based on exposure to contaminants

Contaminants → Adverse Health Effects

- MeHg, Dioxin, Polychlorinated biphenyls (PCBs), Polybrominated diphenyl ethers (PBDEs), Dichloro-Diphenyl-Trichloroethane (DDT), etc.
- Health effects of MeHg include neurodevelopmental impacts
  - First noted in Minamata & Iraqi incidents in 1970s
- US EPA's RfD for MeHg: 0.1µg /kg/d (2001)

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Fish also contains nutrients

Nutrients → Essential to Optimal Health

- Omega-3 fatty acids:
  - Docosahexaenoic acid (DHA) & Eicosapentaenoic acid (EPA)
- Fish is the major source of DHA and EPA in our diet
- Fish consumption is related with ↓CVD
- DHA and EPA intake is associated with ↑neurodevelopment
- Recommended intake:
  - DHA: 100-300 mg/day (Akabas 2006)
  - DHA+EPA: 400-500 mg/day for women (or 2 meals of fatty fish /week) (AHA)

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Why study Asians in the U.S.?

- Asians consume large amounts of seafood
  - US EPA's estimate for US general population = 0.3 g/kg/day
  - Asians in Seattle area =1.9 g/kg/day (n=202) (Sechena et al, 2004)
- Previous studies have indicated Asians have elevated Hg level (Mahaffey et al 2009, Knobeloch et al 2005)
- In Washington State: 300,000+ (~6%)
  - 36,000 Japanese (0.6% of total pop)
  - 47,000 Koreans (0.8% of total pop) (APIAHF 2000)

Photo credit: Microsoft Clipart

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Arsenic Mercury Intake Biometric Study

Principal Investigator: Koenraad Mariën

Washington State Department of Health

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Project Overview

- To determine exposure to mercury and arsenic
- To assess dietary patterns
- To collect biological samples (blood, hair, urine, toenails) for mercury and arsenic analysis
- To assess exposure overtime
- To collect fish and shellfish samples for metal analysis
- Study Populations:
  Japanese and Korean women of childbearing age living in Seattle area, Washington, US.

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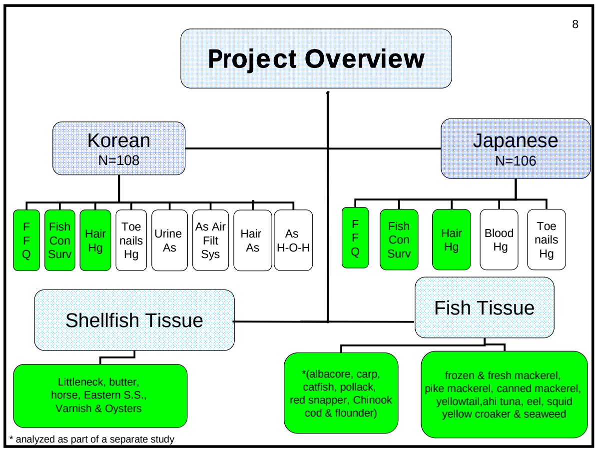

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Questionnaires

- Structured interviews
- Fish Consumption Surveys:
  - Fish eaten (with pictures)
  - Frequency of consumption for each fish species eaten
  - Usual portion size for each fish species (with models)

Photo credit: K. Marien

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Fish Models

Photo credit: A. Tsuchiya

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Mercury Analysis

- Hair Analysis:
  - By the US EPA lab, Nevada
  - Hg measurement:
    combustion, amalgamation and atomic absorption spectrophotometry *(US EPA Method 7473)*
  - Detection limit: 0.01 ng

Photo credit: A.Scherer

- Fish Tissue Analysis:
  - By a local lab, cold-vapor atomic absorption method *(US EPA Method 7471A)*
  - Commonly consumed fish among the community were purchased from stores in Puget Sound area (Shoreline to Olympia) over 4 weeks
  - Detection limit: 0.01 µg/g

Photo credit: Microsoft Clipart

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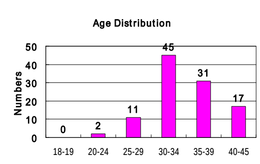
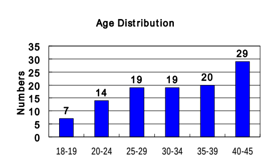
Study Population (n=214)

- 106 Japanese
- 97 % (n=103) preferred to be interviewed in Japanese
- 25 % were pregnant
- Average wt: 55.4 kg



- 108 Korean
- 66 % (n=71) preferred to be interviewed in Korean
- 5 % were pregnant
- Average wt: 59.4 kg



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Finfish intakes were similar

	Finfish			Shellfish			Finfish & Shellfish combined		
	Mean	50^{th}%	95^{th} %	Mean	50^{th}%	95^{th} %	Mean	50^{th}%	95^{th} %
Japanese (n=106)	60	43	159	14	9	59	73	55	188
Korean (n=108)	59	49	147	23	13	84	82	64	230

g/person/day

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Japanese & Korean fish intake is at 95^{th}

	Finfish & Shellfish combined		
	Mean	50^{th}%	95^{th} %
Japanese (n=106)	73	55	188
Korean (n=108)	82	64	230
US General (CSFII[1])	14	NA	72
US General (NHANES[2])	1.8*	NA	87

g/person/day

1:Jacobs 1997, 2: Mahaffey 2004 , *geometric mean

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Average Japanese Hg intake is close to 95^{th}

		n	Mean	Percentiles 50^{th}	75^{th}	90^{th}	95^{th}
Estimated Hg Intake (ug/kg/d)	Japanese	106	0.14	0.09	0.18	0.25	0.37
	Korean	108	0.07	0.05	0.09	0.15	0.19
	US General (NHANES 1999-2000[1])	1,727	0.02*	NA	0.0	0.04	0.13

1:Mahaffey 2004, *geometric mean

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Average Korean Hg intake is 90^{th}-95^{th} percentile

		n	Mean	Percentiles 50^{th}	75^{th}	90^{th}	95^{th}
Estimated Hg Intake (ug/kg/d)	Japanese	106	0.14	0.09	0.18	0.25	0.37
	Korean	108	0.07	0.05	0.09	0.15	0.19
	US General (NHANES 1999-2000[1])	1,727	0.02*	NA	0.0	0.04	0.13

1:Mahaffey 2004, *geometric mean

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Average Japanese hair Hg is 90^{th}-95^{th} percentile

		n	Mean	Percentiles 50^{th}	75^{th}	90^{th}	95^{th}
Hair Hg (ppm)	Japanese	106	1.57	1.37	1.96	2.68	3.52
	Korean	108	0.75	0.67	1.02	1.29	1.52
	US General (NHANES 1999-2000*)	1,727	0.47	0.19	0.42	1.11	1.73

*McDowell 2004

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Korean hair Hg is 75^{th}-90^{th} percentile

		n	Mean	Percentiles 50^{th}	75^{th}	90^{th}	95^{th}
Hair Hg (ppm)	Japanese	106	1.57	1.37	1.96	2.68	3.52
	Korean	108	0.75	0.67	1.02	1.29	1.52
	US General (NHANES 1999-2000*)	1,727	0.47	0.19	0.42	1.11	1.73

*McDowell 2004

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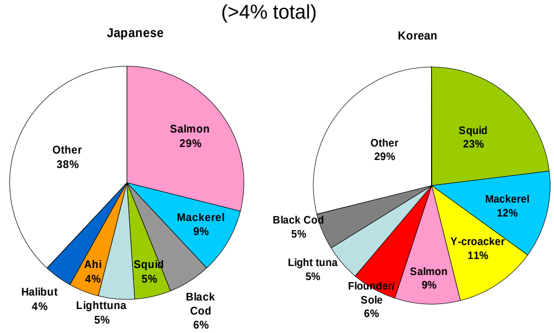
Many different fish species were consumed

Species Providing Greatest % to Total Intake in weight (>4% total)



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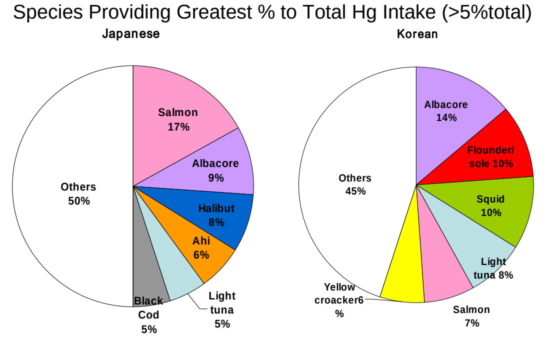
Sources of Hg exposures are very different

Species Providing Greatest % to Total Hg Intake (>5%total)



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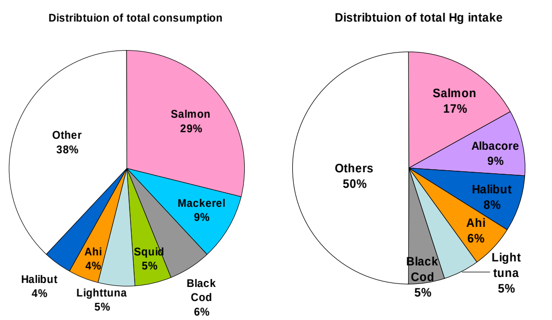
Fish intake of Japanese: weight vs. Hg

Species Providing the Greatest % to Total intake & Hg Intake



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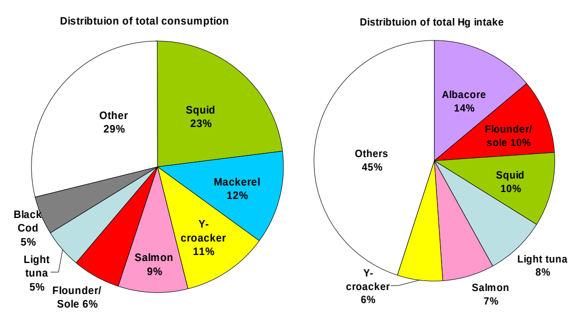
Fish intake of Korean: weight vs. Hg

Species Providing the Greatest % to Total intake & Hg Intake



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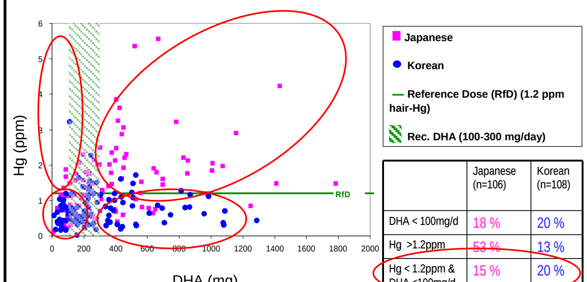
Estimated DHA intake & Hg exposure



	Japanese (n=106)	Korean (n=108)
DHA < 100mg/d	18 %	20 %
Hg >1.2ppm	53 %	13 %
Hg < 1.2ppm & DHA <100mg/d	15 %	20 %
Hg >1.2ppm & DHA >300mg/d	38 %	8 %
Hg >1.2ppm & DHA < 100mg/d	3 %	0

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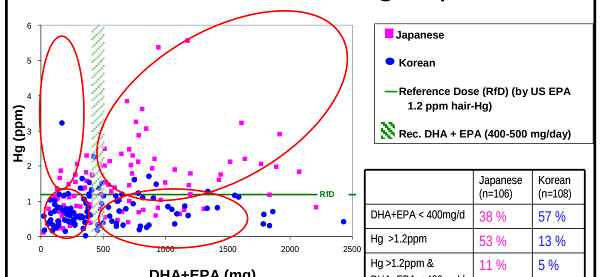
DHA+EPA intake & Hg exposure



	Japanese (n=106)	Korean (n=108)
DHA+EPA < 400mg/d	38 %	57 %
Hg >1.2ppm	53 %	13 %
Hg >1.2ppm & DHA+EPA < 400mg/d	11 %	5 %
Hg >1.2ppm & DHA+EPA >500mg/d	40 %	8 %
Hg < 1.2ppm & DHA+EPA <400mg/d	26 %	54 %

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Longitudinal Aspects

Length of study : 14 months

Average time between visits: 4 ¾ months

Fish Consumption Guidance

	1st Visit	2nd Visit	3rd Visit
Japanese	n=108	n=90	n=85
Korean	n=106	n=63	---
FCS Recall Periods	open-ended	2 weeks	2 weeks

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Total fish intake for each visit by Hg exposure

		1st Visit			2nd Visit			3rd Visit		
		total	≤1.2ppm	>1.2ppm	total	≤1.2ppm	>1.2ppm	total	≤1.2ppm	>1.2ppm
Japanese	N	85	36	49	85	40	45	85	41	44
	Mean Fish Intake (g/day)	63.5	46.0	76.4	33.7	26.6	38.2	31.3	23.0	39.1
Korean	N	63	54	9	63	51	12	-	-	-
	Mean Fish Intake (g/day)	71.7	72.6	66.2	29.1	25.3	45.3	-	-	-

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Results Summary

- Fish intake and Hg exposure levels were above the 95th percentile levels to national levels
- Nearly identical amounts of finfish intakes
  - ~ 60 g/person/day
  - Consumed different types of fish
- Different Hg exposure levels
  - 55% of Japanese vs.13% of Korean exceed US EPA's RfD for mercury
- Large % do not obtain recommended DHA or DHA+EPA levels
  - ~20% did not consume daily rec DHA, larger for DHA+EPA

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Recommendations

- Asian populations should not be grouped as a whole, but treated independently by cultural heritage
- The goal of fish consumption guidance should ensure that optimal health is achieved
  - Not just minimize exposure to the contaminant
  - Nutritional elements and contaminant concerns need to be quantitatively incorporated (into fish consumption guidelines)

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Acknowledgements

Minamata Memorial

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Debi Knox & Lakewood WIC Clinic Staff

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AmTest: Kathy Fugiel
Fred Hutchinson: Judi Stanley

Washington State Department of Health:
Koenraad Mariën
Office of Env.Health Assessment Staff

University of Washington:
Elaine Faustman
Thomas Burbacher
IRARC staff (Finn, Alison, Bill et al)

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- Longitudinal Mercury Monitoring Within the Japanese And Korean Communities (U.S.); Implications for Exposure Determination and Public Health Protection
  - Tsuchiya A, Hinners TA, Krogstad F, White JW, Burbacher TM, Faustman EM, Mariën K. (Environ Health Perspect. Epub 2009 July 31.)

Questions and Answers

Q. Did you observe or record any generational differences in the results?

A. We did not include generation (i.e., if the participants were born here or in Asia), but from the language preference, we would speculate that most of the Japanese were first generation and the Korean participants were approximately 50% first generation residents.

Q. We observed similar results in New York City, where the fish selections in Chinese immigrants were totally different and the selections differed even further by the respective region the participants were immigrating from as well. Did you take into consideration income, since the fish selections within populations might be further divided by cost of preferred fish?

A. We did not ask about income because it might have altered the answers of the subjects.

Q. The average fish intake is 60 g/day, yet many of the participants did not meet daily DHA requirements. Any ideas why? Also, did you look at red blood cell fatty acid content?

A. We did not do any red blood cell fatty acids testing. Regarding the DHA requirements, the assumption was that the consumed fish in these populations were generally fish with lower DHA levels.

Q. What are the behavioral determinants driving individual fish consumptions for each population and how might it drive communication and outreach strategies?

A. We have observed that when fish is heavily incorporated into the diet, it's very difficult to take it out of the diet.

Q. Has the program looked at dioxin-like PCBs?

A. We briefly reviewed TEQs. At first, our lab's aroclor limits were set too high, but we did look at 15 aroclor equivalents in the second half. Additional research into dioxin-like PCBs is a future goal.

Q. Reaching consumers at the point of sale is really important. Are there any plans to extend work with specialty markets or other point of sale locations? Also, are there any plans to translate the guides into other languages besides Spanish?

A. Yes, but our plans are contingent on funds. The results suggest we need to do so.

Section II-C
Sampling and Analysis Issues

Moderator:

Robert Duff, Washington State Department of Ecology

Mr. Robert Duff received a B.S. in Zoology from the University of Massachusetts at Amherst in 1986. His interests moved from cancer research to toxicology and, in 1993, he received an M.S. from the Department of Environmental Health at the University of Washington in Seattle. Mr. Duff's thesis was in the field of exposure assessment, investigating the dermal uptake of contaminants from soil. Following his thesis work, Mr. Duff was employed by the State of New Hampshire in the Bureau of Health Risk Assessment, with duties involving risk assessment, community education, grant writing, and development of regulatory standards. After moving back to Washington in 1996, he did similar work as a toxicologist for the Washington State Department of Health, eventually becoming Director of the department's Office of Environmental Health Assessments, where he led a team of risk assessors, toxicologists, epidemiologists, and health educators toward the goal of reducing human exposure to environmental contaminants. Mr. Duff currently manages the Environmental Assessment Program at the Washington State Department of Ecology. The Environmental Assessment Program provides critical monitoring and the analytical capacity to measure toxics, nutrients, and bacterial contamination in both marine and freshwater aquatic environments. Assessments of these data provided by program staff are the foundation for agency decision making to protect and enhance human health and the environment in Washington State.

Presentations

Results of the EPA Pilot Study of Pharmaceuticals and Personal Care Products in Fish Tissue

John Wathen, Office of Science and Technology, Office of Water, U.S. EPA

Review of EPA's National Lake Fish Tissue Study Final Report

Leanne Stahl, Office of Science and Technology, Office of Water, U.S. EPA

National Survey of Mercury in Fish, Bed Sediment, and Water from Streams

Barbara Scudder, U.S. Geological Survey

Regional Distribution of Environmental Contaminants in Alaskan Fishes

Robert Gerlach, Alaska Department of Environmental Conservation

Hair Mercury Biomonitoring Results from Alaska and Hawaii—Demonstrating the Value of Local Fish Consumption Advice

Lori Verbrugge, Alaska Division of Public Health; Barbara Brooks, Hawaii Department of Health

Mercury and PCBs in Asian Market Fish: A Response to Results from Mercury Biomonitoring in New York City

Wendy McKelvey, New York City Department of Health and Mental Hygiene

Tissue Analysis for Mercury and PCBs from a New York City Commercial Seafood Market

Moses Chang, U.S. EPA, Region 2

Mercury in the North Pacific Ocean: Implications for Fisheries

Elsie Sunderland, Harvard University

A Comparison of Non-Lethal Techniques for the Measurement of Mercury in Fish Tissue

Kristofer Rolfhus, University of Wisconsin-La Crosse

Results of the EPA Pilot Study of Pharmaceuticals and Personal Care Products in Fish Tissue

John B. Wathen, U.S. Environmental Protection Agency, Office of Science and Technology, Standards and Health Protection Division, Fish, Shellfish, Beaches and Outreach Branch

Biosketch

Mr. John B. Wathen is the Assistant Chief of the Fish, Shellfish, Beaches and Outreach Branch in the Standards and Health Protection Division of the Office of Science and Technology in EPA's Office of Water. Mr. Wathen received his B.A. in Geology from Northeastern University and his M.S. in Earth Sciences from the University of New Hampshire. He worked as a consulting hydrogeologist for 15 years, conducting landfill siting and closure investigations, industrial site remediation, and water source protection studies, primarily in northern New England. In 2000, he entered the public sector as Director of the Southern Maine Regional Office of the Maine Department of Environmental Protection and joined EPA in 2005. He provides management support to the BEACH Act monitoring and advisory program, with current emphasis on predictive modeling for beach advisories and recreational pathogen criteria development, and fish tissue research on contaminants of emerging concern and their potential ecological and human health implications. Mr. Wathen is a Maine Certified Geologist and a Certified Ground Water Professional.

Abstract

This talk presents results on the occurrence and concentration of 5 and 7 out of 24 pharmaceuticals compounds determined in the study, five were detected in fish fillet tissue and seven were detected in fish liver samples. These samples were collected from five locations and a reference site in disparate locations in the United States. Two synthetic musk compounds out of 10 personal care product compounds were also quantified in the low parts-per-million (ppm) range. Samples were collected from effluent-dominated streams receiving discharge from wastewater treatment plants employing a range of treatment levels. The U.S Environmental Protection Agency is expanding the geographic coverage of fish tissue sampling for pharmaceutical and personal care product analysis to 150 urban river locations as part of the National Rivers and Streams Assessment.

Results of the EPA Pilot Study of Pharmaceuticals and Personal Care Products in Fish Tissue

a.k.a

Occurrence of pharmaceuticals and personal care products (PPCPs) in fish: Results of a national pilot study in the U.S.

Alejandro J. Ramirez, Richard A. Brain, Sascha Usenko, Mohammad A. Mottaleb, John G. O'Donnell, Leanne L. Stahl, John B. Wathen, Blaine D. Snyder, Jennifer L. Pitt, Pilar Perez-Hurtado, Laura L. Dobbins, Bryan W. Brooks, C. Kevin Chambliss*

ETC Paper in Press

EPA PPCP Fish Pilot Study

Obtaining data on pharmaceuticals as contaminants of emerging concern is a priority for EPA.

- Recent research indicates that pharmaceuticals occur widely in surface water, sediment, and municipal effluent.
- Limited data are available on accumulation of pharmaceuticals in fish.
- Designed to be biologically active, affect specific receptors.

Personal Care Products are a separate but related issue

- Different properties, not designed to a be biologically active
- Produced and discharged in very large quantities

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EPA PPCP Fish Pilot Study

In 2006, OST initiated the EPA Pilot Study of PPCPs in Fish Tissue to investigate PPCP occurrence in fish tissue.

Several collaborators contributed to this project, including:

- Baylor University Center for Reservoir and Aquatic Systems
- EPA Great Lakes National Program Office
- Metropolitan Water Reclamation District of Greater Chicago
- New Mexico Environment Department

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Study Design

The targeted study design involved the following components:

- Sampling fish from five effluent-dominated streams and one reference site in various parts of the country
- Collecting six composites containing three or four adult fish of the same resident species in the vicinity of WWTP discharges
- Freezing and shipping whole fish to an analytical laboratory at Baylor University
- Sample preparation include the preparation of both fillet and liver tissue samples
- Analyzing fillet and liver tissue samples from each fish composite for 24 pharmaceutical compounds
- Analyzing fillet tissue samples (only) for 12 personal care products

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Site Selection Criteria

EPA identified five priority sites using the following selection criteria:

- Effluent-dominated stream segments near WWTP discharges
- WWTP discharges subject to different levels of treatment
- Urban/suburban areas with high population densities
- Geographic areas with a larger percentage of elderly residents
- Availability of sufficient numbers and sizes of fish

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Sampling Sites

State	River, Location	Date	Species	No. of Fish
AZ	Salt River, Phoenix	Nov. 2006	Common carp	18
FL	Little Econlockhatchee River, Orlando	Oct. 2006	Bowfin	17
IL	North Shore Channel, Chicago	Sep. 2006	Largemouth bass	24
NM	East Fork Gila River (*Reference Site*)	Nov. 2006	Sonora sucker	24
PA	Taylor Run, West Chester	Aug. 2006	White sucker	24
TX	Trinity River, Dallas	Oct. 2006	Smallmouth buffalo	18

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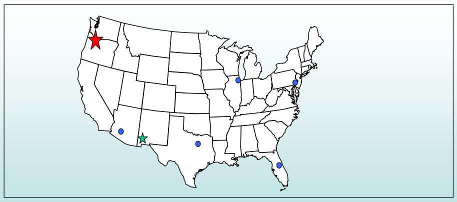
Sampling Sites



Portland! *Not a sampling site*

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Target Chemicals

EPA analyzed fillet and liver tissue samples for 24 pharmaceutical compounds and 12 personal care products.

Pharmaceuticals

- 3 analgesics
- 1 anti-acid reflux
- 6 antibiotics
- 1 anticoagulant
- 3 antidepressants
- 1 anti-fungal agent
- 1 antihistamine
- 4 anti-hypertension
- 1 antilipemic
- 1 anti-seizure
- 1 antispasmodic
- 1 stimulant

Personal Care Products

- 1 antimicrobial compound
- 5 fragrances/musks
- 1 insect repellant
- 3 surfactants
- 2 UV filtering compounds

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Analytical Methods

Baylor employed different methods for the two classes of compounds

Pharmaceuticals

- Pharmaceutical analyses were performed using HPLC-MS/MS (Ramirez et al.,2007)
- Tissue and Liver Samples analyzed

Personal Care Products

- Personal Care Products analyses employed GC-MS/MS (Mottaleb et al., 2008)
- Fillet tissue only

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Pharmaceutical Chemicals Not Detected in Fillet and Liver Tissue

Chemical	Use	Chemical	Use
Acetaminophen	Analgesic	Metoprolol	Anti-hypertension
Atenolol	Anti-hypertension	Miconazole	Anti-fungal
Caffeine	Stimulant	Propranolol	Anti-hypertension
Cimetidine	Anti-acid reflux	Sulfamethoxazole	Antibiotic
Codeine	Analgesic	Thiabendazole	Anti-fungal
Erythromycin	Antibiotic	Warfarin	Anticoagulant
Ibuprofen	Analgesic	Tylosin	Antibiotic
Lincomycin	Antibiotic	1,7-dimethylxanthine	Antispasmodic
Trimethoprim	Antibiotic		

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Pharmaceuticals detected

Antidepressants: Fluoxetine, Norfluoxetine, Sertraline

Antihistamine: Diphenhydramine

Anti-Hypertension: Diltiazem

Antilipemic: Gemfibrozil

Anti-seizure: Carbamazepine

Difficult analyses- issues with matrix spike and matrix spike duplicate over-recovery.

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Pharmaceuticals detected

In fillet tissue, mean/max

Central Nervous System compounds:

	Chicago	Phoenix	W. Chester
Norfluoxetine	3.2/3.2	4.0 /4.8	3.9/5.0
Sertraline	nd	5.0/6.5	11/19
Carbamazepine	2.3/3.1	nd	nd

Units: ng/g ww (ppb)

Note: Means are of detections only

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Pharmaceuticals detected

In fillet tissue, mean/max

Other pharmaceutical compounds:

	Chicago	Phoenix	W. Chester
Diphenhydramine	1.4/1.7	1.2/1.4	1.7/2.5
Diltiazem	0.13/0.2	nd	0.15/0.2

ng/g ww (ppb)

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Pharmaceuticals detected

In liver tissue, mean/ max

Central Nervous System compounds:

	Chicago	Phoenix	W. Chester
Fluoxetine	19/23	nd	70/80
Norfluoxetine	73/130	33/44	38/48
Sertraline	84/149	71/105	381/545
Carbamazepine	6/8	nd	nd

ng/g ww (ppb)

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Pharmaceuticals detected

In liver tissue, mean/ max

Central Nervous System compounds:

	Dallas	Orlando	MDL
Fluoxetine	nd	nd	**12.41**
Norfluoxetine	37/48	57/78	**15.31**
Sertraline	27/28	--/21	**17.29**
Carbamazepine	nd	nd	**1.86**

ng/g ww (ppb)

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Pharmaceuticals detected

In liver tissue, mean/max

Other pharmaceutical compounds:

ng/g ww (ppb)	Chicago	Phoenix	W. Chester
Diphenhydramine	7/10	7/11.1	10/11
Diltiazem	0.7/0.9	0.3/0.4	0.7/0.8
Gemfibrozil	nd	70/90	27.1/27.3
		Dallas	
Diphenhydramine		0.5/0.9	

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Personal Care Products

- Determined only in **fillet** tissue
- Major lipid interference in GC/MS method
- Galaxolide detected in all samples at all locations (*except* Orlando (5/6))
- Tonalide detected in all samples at all locations (*except* Orlando (1/6))

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Personal Care Products

Concentration in fillet tissue (mean/max)

Location	Galaxolide	Tonalide
Chicago	1,300/1,800	160/230
Dallas	800/1,800	70/150
Orlando	100/300	--/21
Phoenix	1,800/2,100	240/290
West Cester	1,800/2,000	60/70

ng/g ww (ppb)

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Personal Care Products

Compounds NOT detected in fish tissue

Compound	MDL (ng/g)
4-methylbenzylidene-camphor (4MBC)	120.5
Benzophenone	16.4
Celestolide	17.7
m-Toluamide	5.1
Musk Ketone	321.2
Musk Xylene	397.1
Nonylphenol	9.7
Octocrylene	36
Octylphenol	8.2
Triclosan	37.8

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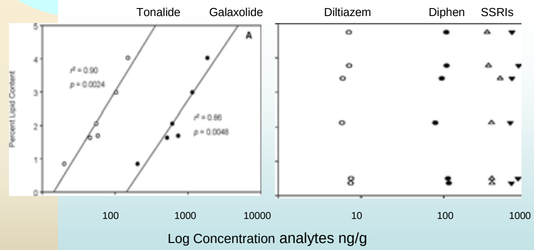
Lipids and polar/nonpolar compounds



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Type of treatment at Study Facilities

Facility	%Effluent	Type Treatment
Phoenix Az	100	Advanced Treatment I, Nutrient removal
Orlando FL	64	Advanced Treatment II, Nutrient removal
Chicago	100	Advanced Treatment I, Nutrient removal
West Chester PA	36-86	Advanced Treatment I, Nutrient removal
Dallas	100	Advanced Treatment II, Nutrient removal

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Conclusions

☞Pharmaceuticals and personal care products are imparted to fish tissue from wastewater- compound/class specific

☞Level of treatment matters

☞Extent of occurrence is unknown

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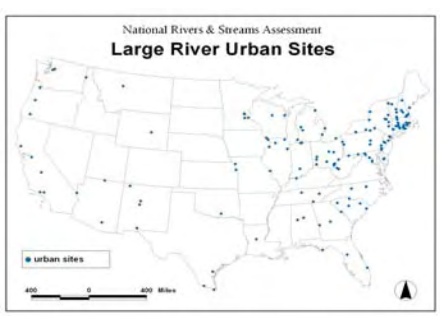
What's next…



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National Rivers and Streams Assessment

☞Pharmaceuticals, limited personal care products, and perfluorinated compounds (PFOS/PFOA, etc.) determined in fish from 154 urban sites out of 900 sites sampled

☞Sampling being conducted 2008-2009

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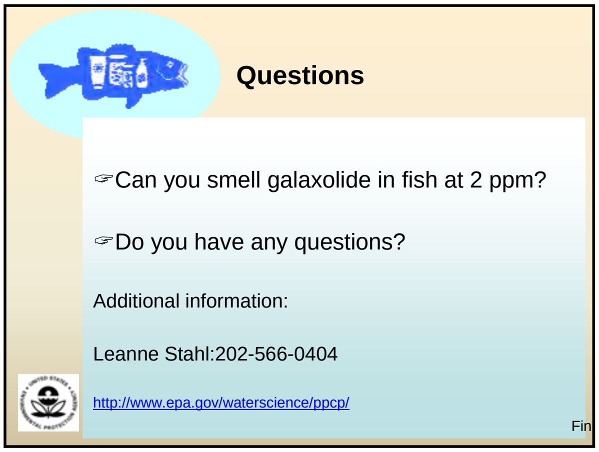

Questions
☞Can you smell galaxolide in fish at 2 ppm?
☞Do you have any questions?
Additional information:
Leanne Stahl:202-566-0404
http://www.epa.gov/waterscience/ppcp/
Fin

Questions and Answers

Q. *What is the holding time for the fish? We have imported fish and if anyone is interested these fish.*

A. Frozen fish tissues can last a long time when they've been prepped, but the holding time varies by compound.

Q. *How did you determine the sampling areas and compounds? Did you look at hydrophobic compounds?*

A. We looked at PPCP samples from U.S. Geological Survey (USGS) in sediment when determining sampling areas, and we measured for compounds in which there was interest.

Q. *PPCPs are an area of outreach since situations arise, such as in hospices, where a pills are poured into the toilet. Studies have shown that galaxolide can be absorbed through inhalation and current diphenhydrine levels could result in 1–2 mg dosings. What does this mean for allergic or sensitive populations?*

A. Levels may be problematic with certain cultures with large consumption rates of liver; however, the understanding of PPCPs requires more studies and may also have effects on aquatic life.

Q. *Hormone-based components are causing the feminization of the fish outside of Chicago, and there is a huge change in the behavior of fish. Is it possible for PPCPs to similarly affect humans?*

A. The PPCPs in this study are not hormonal, but are capable of affecting behavior through endocrine disruption.

Comment: We have an USGS outreach program at smartrx.com at hopes to educate people on the correct ways to dispose of medications.

Review of the National Lake Fish Tissue Study Final Report

Leanne Stahl, U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington, DC

Biosketch

Ms. Leanne Stahl is an environmental scientist in EPA's OST within Office of Water. Since 1999, she has served as the project manager of the National Study of Chemical Residues in Lake Fish Tissue, moving the project from its planning phase through full implementation and final reporting. She has recently managed the OST's Pilot Study of Pharmaceuticals and Personal Care Products in Fish Tissue and leads OST's participation in EPA's National Rivers and Streams Assessment. Leanne moved to EPA from the National Oceanic and Atmospheric Administration in 1990 and has worked in a variety of water programs over the past 19 years. Prior to joining federal service, she served as the fisheries specialist for a marine research team at the University of Washington in Seattle.

Abstract

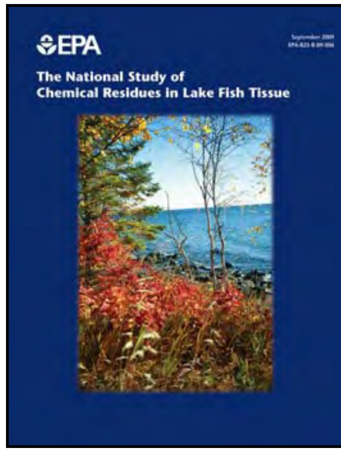
The U.S. Environmental Protection Agency's (EPA's) Office of Water has released the final report for the National Study of Chemical Residues in Lake Fish Tissue, a statistically-based national survey of contaminants in fish from lakes and reservoirs in the lower 48 states. For 4 years, EPA worked with 47 states, three Tribes, and two other federal agencies to collect fish from 500 lakes and reservoirs selected randomly from the estimated 147,000 target population of lakes and reservoirs in the lower 48 states. Analysis of fish samples included 268 persistent, bioaccumulative, and toxic (PBT) chemicals, most notably mercury, polychlorinated biphenyls (PCBs), and dioxins and furans. Results show that mercury and PCBs were detected in every fish sample from all 500 lakes and reservoirs. Mercury concentrations in fish fillet samples exceeded EPA's recommended tissue-based water quality criterion of 0.3 ppm at 49% (for over 36,000 lakes of the sampled population of 76,559 lakes). Fillet tissue concentrations exceeded the 0.12 ppb screening value for total PCBs at 17% of the sampled population of lakes, which represents about 13,000 lakes.

Review of EPA's National Lake Fish Tissue Study Final Report

2009 National Fish Forum

November 2, 2009

Leanne Stahl
Program Manager
Office of Water/
Office of Science & Technology



It's Done and It's Available! (soon)

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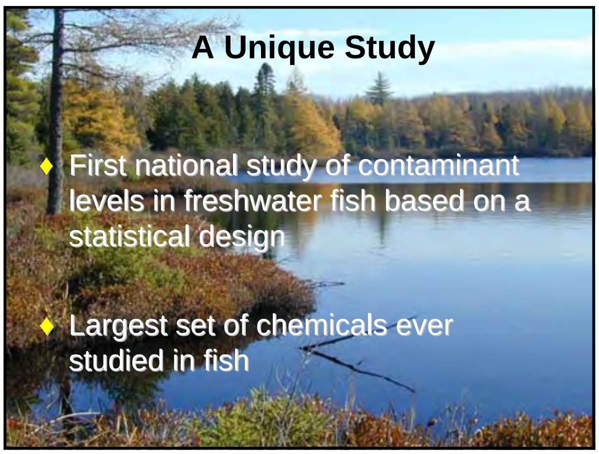
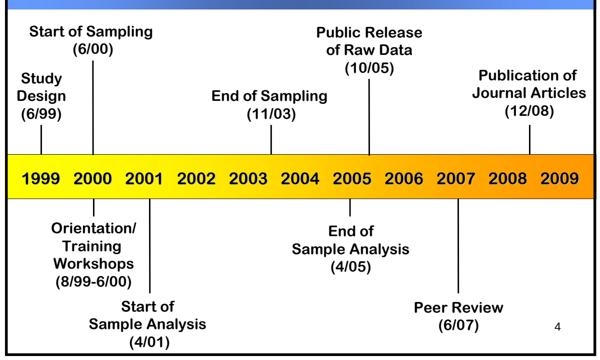


Key Milestones



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Objective

- *The objective of the National Lake Fish Tissue Study was to estimate the national distribution of the mean levels of selected persistent, bioaccumulative, and toxic chemical residues in fish tissue from lakes and reservoirs in the conterminous United States.*
- Study results
  - Provided the first national estimates of median concentrations of PBT chemicals in fish tissue.
  - Defined a national baseline for assessing progress of pollution control activities.

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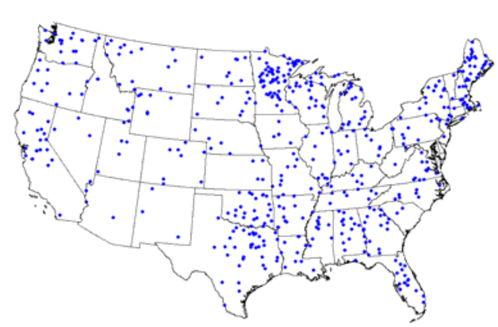
500 Sampling Locations



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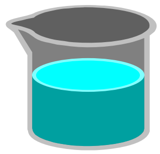
Study Design

- Six size categories of lakes ranging from 1 hectare to > 5000 hectares with varying probabilities for each size category
- Two fish composites per site (predators and bottom dwellers) with 5 adult fish per composite
- Analysis of fish tissue for 268 chemicals
  - 2 metals (Hg and As [5 forms])
  - 17 dioxins/furans
  - 159 PCB congener measurements
  - 46 pesticides
  - 40 semi-volatile organics (e.g., PAHs)



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Final Report Summary

- The National Lake Fish Tissue Study Final Report is a 242-page document containing:
  - Executive Summary
  - 4 Chapters of study information
  - 9 Appendices of data summaries
- The report presents 2 primary products from statistical analysis of the data:
  - Cumulative density functions (or CDFs)
  - Percentile tables for each target chemical

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Critical Reporting Information

- Predator and bottom-dwelling species did not occur together at every sampling site.
  - The target lake was sampled if either composite type occurred.
  - 486 predator composites and 395 bottom-dweller composites were collected from the 500 sampling sites.
- Results from each composite type comprise nationally representative samples, but differences in occurrence define different sampled populations.
  - Predator results can be extrapolated to 76,559 lakes.
  - Bottom-dweller results can be extrapolated to 46,190 lakes.
- Developing national estimates of tissue concentrations required use of sample weights due to the unequal probability design.

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Reporting the Results

- Analytical results are presented in three tiers:
  - Non-detected chemicals
  - Rarely-detected chemicals
  - Commonly-detected chemicals
- Five chemicals are highlighted as commonly detected:
  - Mercury
  - Total PCBs
  - Total Dioxins and Furans
  - Total DDT
  - Total Chlordane

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Chemical Detections

CHEMICAL	PREDATORS	BOTTOM DWELLERS
Mercury	100%	100%
PCBs	100%	100%
Dioxins/furans	81%	99%
Total DDT	78%	98%
Chlordane	20%	50%

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2008 Fish Advisories

CHEMICAL	NO. OF ADVISORIES	LAKE ACRES UNDER ADVISORY	PERCENT OF TOTAL U.S. LAKE ACRES
Mercury	3,361	16,808,032	42 %
PCBs	1,025	6,049,506	15 %
Dioxins	123	35,400	<1 %
DDT	76	876,520	2 %
Chlordane	67	842,913	2 %

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Percentile Tables

Tissue Concentration Estimates for Predators (Fillets)

Chemical	Number of Samples	Number of Detects	Maximum Concentration	Units	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile
PCB 84	486	449	2320	ppt	< MDL	< MDL	0.97	3.02	10.01	31.61	85.04
PCB 85 + PCB 116 + PCB 117	486	485	7980	ppt	2.84	3.81	8.76	17.97	64.98	179.65	300.95
PCB 86 + PCB 87 + PCB 97 + PCB 108 + PCB 119 + PCB 125	486	476	18900	ppt	1.96	6.86	14.89	37.03	126.15	418.07	660.55
PCB 88 + PCB 91	486	469	4770	ppt	< MDL	0.77	1.72	4.33	14.31	73.43	113.10
PCB 89	486	121	22.3	ppt	< MDL	< MDL	< MDL	< MDL	< MDL	0.76	1.26
PCB 90 + PCB 101 + PCB 113	486	484	36500	ppt	10.30	15.72	38.92	80.10	262.84	884.10	1420.95
PCB 92	486	481	8620	ppt	1.83	2.94	6.99	15.23	54.77	187.79	303.98

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Tissue Concentrations

Chemicals	Predators (ppb)		Bottom Dwellers (ppb)	
	Median	Maximum	Median	Maximum
Mercury	285	6605	69	596
PCBs	2	705	14	1266
Dioxins/furans	6×10^{-6}	8×10^{-3}	4×10^{-4}	2.4×10^{-2}
DDT	1.5	1481	13	1761
Chlordane	<MDL	100	2	378

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Screening Value Exceedances

CHEMICAL	HUMAN HEALTH SCREENING VALUE	PERCENT OF LAKES EXCEEDED	NUMBER OF LAKES EXCEEDED
Mercury	0.3 ppm	49 %	36,422
PCBs	12 ppb	17 %	12,886
Dioxins/Furans	0.15 ppt	8 %	5,856
DDT	69 ppb	2 %	1,329
Chlordane	67 ppb	<1 %	235

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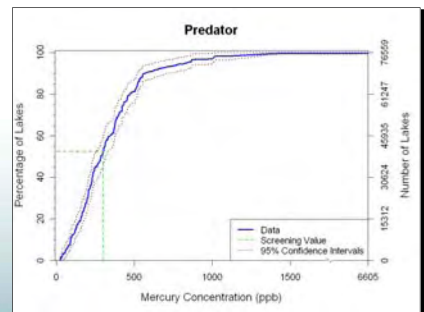
Mercury CDF



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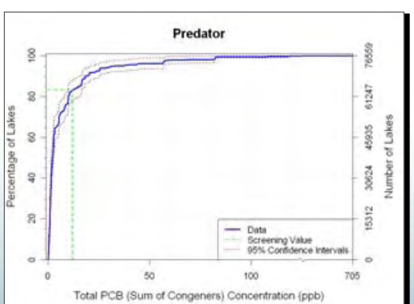
Total PCB CDF



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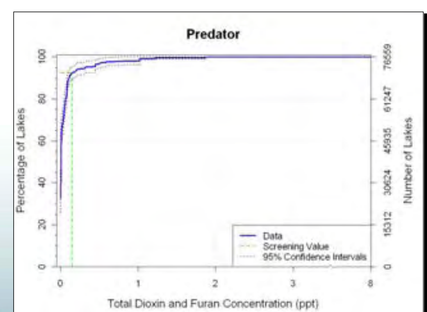
Total Dioxin and Furan CDF



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Published Journal Articles

Olsen, A.R., B.D. Snyder, L.L. Stahl, and J.L. Pitt. 2009. Survey design for lakes and reservoirs in the United States to assess contaminants in fish tissue. *Environmental Monitoring and Assessment* 150:91-100.

Stahl, L.L., B.D. Snyder, A.R. Olsen, and J.L. Pitt. 2009. Contaminants in fish tissue from U.S. lakes and reservoirs: a national probabilistic study. *Environmental Monitoring and Assessment* 150:3-19.

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What's Coming on the National Lake Fish Tissue Study Web Site

- Soon to be available online
  - Report Release Fact Sheet
  - Final Report Executive Summary
  - Final Report (full 242-page document)
  - Journal Articles
  - Instructions for ordering data CDs

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Our Final Thanks

Alabama Department of Environmental Management
Arizona Game and Fish Department
Arkansas Department of Environmental Quality
California Department of Fish and Game
Colorado Division of Wildlife
Connecticut Department of Environmental Protection
Crater Lake National Park
Florida Fish and Wildlife Conservation Commission
Georgia Department of Natural Resources
Idaho Department of Environmental Quality
Illinois Environmental Protection Agency
Illinois Department of Natural Resources
Indiana Department of Environmental Management
Iowa Department of Natural Resources
Kansas Department of Health and Environment
Kentucky Department of Environmental Protection
Louisiana Department of Environmental Quality
Maine Department of Environmental Protection
Maryland Department of the Environment
Maryland Department of Natural Resources
Massachusetts Department of Environmental Protection
Michigan Department of Environmental Quality
Minnesota Chippewa Tribe
Minnesota Department of Natural Resources
Mississippi Department of Environmental Quality
Missouri Department of Conservation
Missouri Department of Natural Resources
Montana Department of Fish, Wildlife and Parks
Nebraska Department of Environmental Quality
Nevada Division of Wildlife
New Hampshire Department of Environmental Services
New Jersey Department of Environmental Protection
New Mexico Environment Department
New York Department of Environmental Conservation
North Carolina Department of Environment
North Dakota Department of Health
Ohio Department of Natural Resources
Oklahoma Conservation Commission
Oklahoma Department of Environmental Quality
Oregon Department of Environmental Quality
Pennsylvania Department of Environmental Protection
Pictured Rocks National Lakeshore
Pyramid Lake Paiute Tribe
Rhode Island Department of Environmental Management
South Carolina Department of Health and Environmental Control
South Dakota Game, Fish, and Parks
Tennessee Valley Authority
Tennessee Wildlife Resources Agency
Texas Commission on Environmental Quality
Utah Department of Environmental Quality
Vermont Department of Environmental Conservation
Virginia Department of Environmental Quality
Washington Department of Ecology
West Virginia Department of Environmental Protection
Wind River Environmental Quality Commission
Wisconsin Department of Natural Resources
Wyoming Game and Fish Department
Yellowstone National Park

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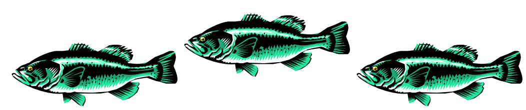
What's Next?

- Final technical report for the PPCP Fish Pilot Study.
- Report on PBDE results from the National Lake Fish Tissue Study.
- Analysis of CECs for the National Rivers and Streams Assessment (NRSA) Urban River Study (Please visit our poster this evening).



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Questions and Answers

Q. Did the program sample different fish in every state

A. We were very opportunistic, but there was a list of fish for each area.

Q. What types of mercury were analyzed?

A. Total mercury was analyzed with the presumption that almost all mercury in fish is methylmercury.

Q. Did you normalize for size and did you make an attempt to analyze the same fish species?

A. Half of the samples were largemouth bass. Regarding the size of the fish used in the study, the smallest individual obtained from a sampling site could not be any less than 75% of the largest size.

Q. Are there plans to study estuarine species?

A. Traditionally, we have looked at freshwater species and are not sure the first report will include estuarine and marine species. I believe Great Lakes initiative has looked at estuarine species.

National Survey of Mercury in Fish, Bed Sediment, and Water from Streams

Barbara C. Scudder, U.S. Geological Survey (USGS), Middleton, WI
Lia C. Chasar, USGS, Tallahassee, FL
Dennis A. Wentz, USGS, Portland, OR
Nancy J. Bauch, USGS, Lakewood, CO
Mark E. Brigham, USGS, Mounds View, MN
Patrick W. Moran, USGS, Tacoma, WA
David P. Krabbenhoft, USGS, Middleton, WI

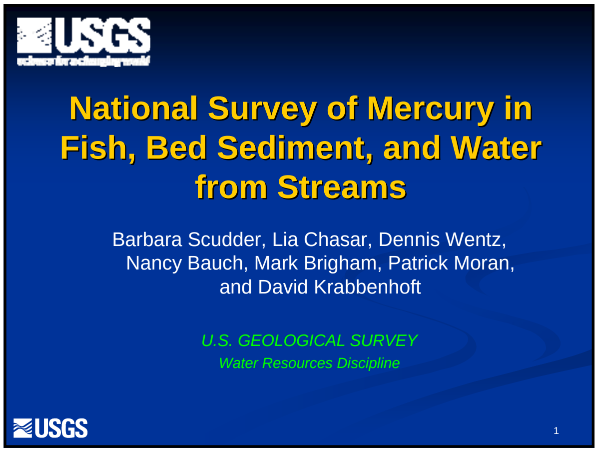
Biosketch

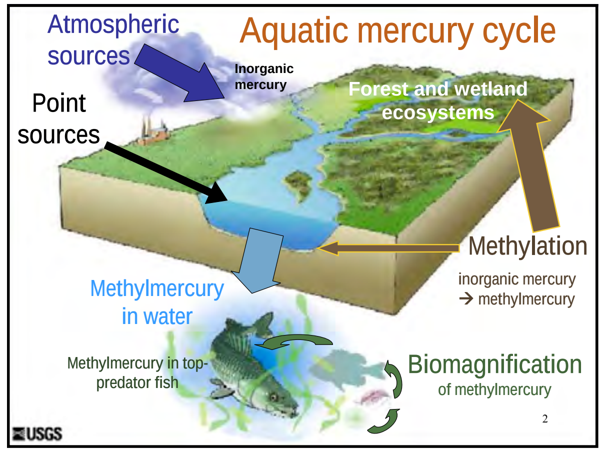
Ms. Barbara C. Scudder is a hydrologist with the U.S. Geological Survey, where she has worked since 1981. Ms. Scudder's expertise is in the effects of water quality on stream biota, with emphasis on trace elements, bioaccumulation, and toxicity; she also studies community ecology of benthic algae, invertebrates, and fish. Ms. Scudder received a B.A. in Aquatic Biology in 1979 from the University of California, Santa Barbara, and an M.S. in Marine Science in 1984 from California State University, Hayward (Moss Landing Marine Laboratories). Since 1991, she has been the lead study unit biologist for the Western Lake Michigan Drainages study unit of the National Water Quality Assessment Program, where she has been involved in multi-disciplinary research efforts on water quality using aquatic biota.

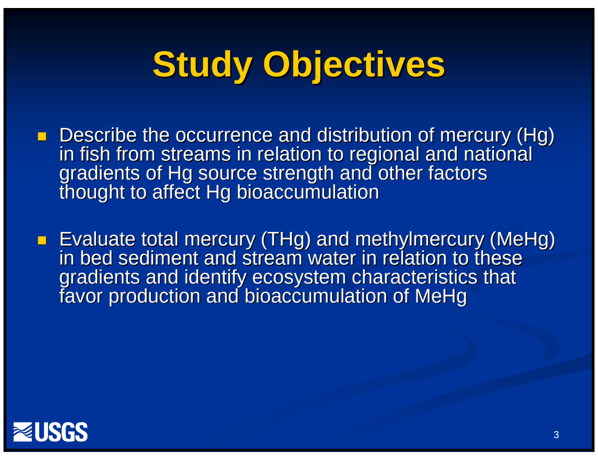
Abstract

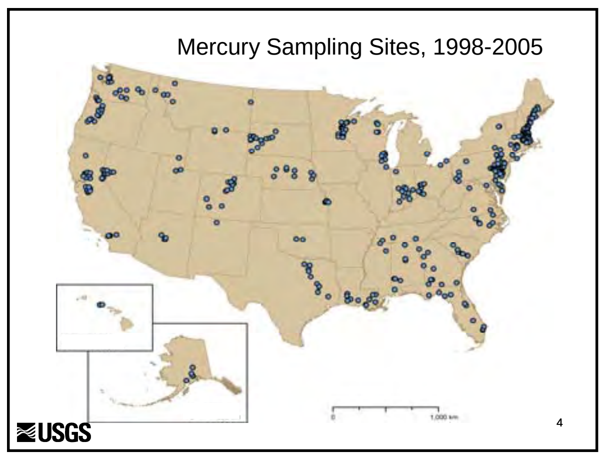
The main source of mercury (Hg) to natural waters in the United States is inorganic Hg that is emitted into the atmosphere and deposited with precipitation or dry particles. However, atmospheric deposition alone does not explain high Hg levels in fish from our nation's streams. Hg was examined in top-predator fish, bed sediment, and water from streams that spanned regional and national gradients of Hg source strength and other factors thought to influence methylmercury (MeHg) bioaccumulation. Sampled settings include stream basins that were agricultural, urbanized, undeveloped (i.e., forested, grassland, shrubland, and wetland land cover), and mined (for gold and Hg). Each site was sampled one time during seasonal low flow. Predator fish were targeted for collection, and composited samples of fish (primarily skin-off fillets) were analyzed for total Hg (THg) because most of the Hg found in fish tissue (95%–99%) is MeHg. Samples of bed sediment and stream water were analyzed for THg, MeHg, and characteristics thought to affect Hg methylation (e.g., loss-on-ignition [LOI], which is a measure of organic matter content; acid-volatile sulfide in bed sediment) and pH, dissolved organic carbon (DOC), and dissolved sulfate in water. Fish Hg concentrations at 27% of sampled sites exceeded the U.S. Environmental Protection Agency's human-health criterion of 0.3 µg/g wet weight. Exceedances were geographically widespread, although the study design targeted specific sites and fish species and sizes, so results do not represent a true nationwide percentage of exceedances. The highest THg concentrations in fish were from blackwater coastal-plain streams draining forests or wetlands in the eastern and southeastern United States and from streams draining gold- or Hg-mined basins in the western United States (1.80 and 1.95 µg of THg/g wet weight, respectively). For unmined basins, length-normalized Hg concentrations in largemouth bass were significantly higher in fish from predominantly undeveloped or mixed land-use basins compared to urban basins. Hg concentrations in largemouth bass from unmined basins correlated positively with basin percentages of evergreen forest and also woody wetlands, especially with increasing proximity of these two land-cover types to the sampling site; this underscores the greater likelihood for Hg bioaccumulation to occur in these types of settings. Increasing concentrations of MeHg in unfiltered stream water and of bed-sediment MeHg normalized by LOI and decreasing pH and dissolved sulfate were also important in explaining increasing Hg concentrations in largemouth bass. MeHg concentrations

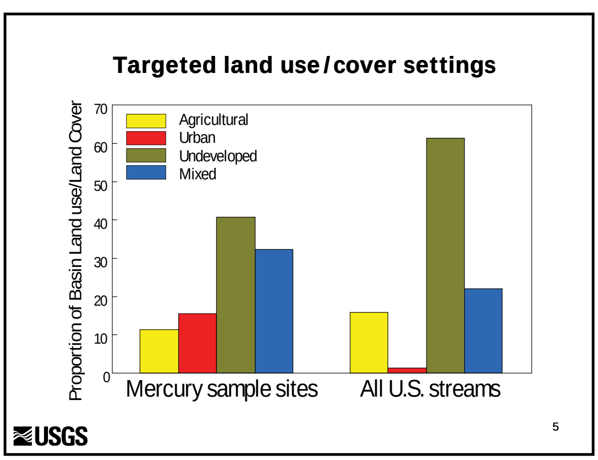
in bed sediment correlated positively with THg, LOI, and acid-volatile sulfide. MeHg concentrations in water correlated positively with DOC, ultraviolet absorbance, and THg in water; the percentage of MeHg in bed sediment; and the percentage of wetlands in the basin.

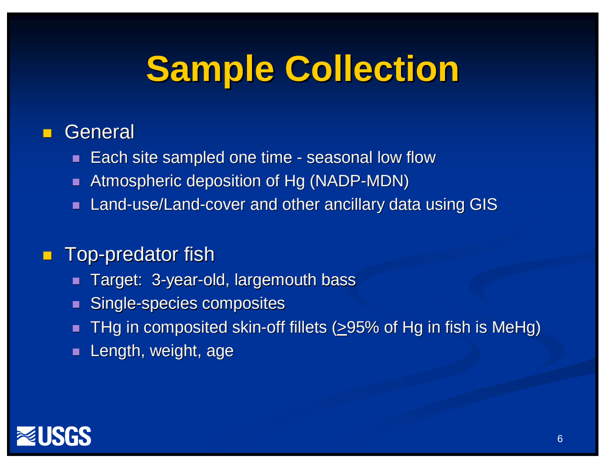

USGS
National Survey of Mercury in Fish, Bed Sediment, and Water from Streams
Barbara Scudder, Lia Chasar, Dennis Wentz, Nancy Bauch, Mark Brigham, Patrick Moran, and David Krabbenhoft
U.S. GEOLOGICAL SURVEY
Water Resources Discipline
USGS
1


Aquatic mercury cycle
Atmospheric sources
Inorganic mercury
Point sources
Forest and wetland ecosystems
Methylation
inorganic mercury → methylmercury
Methylmercury in water
Methylmercury in top-predator fish
Biomagnification of methylmercury
USGS
2


Study Objectives
Describe the occurrence and distribution of mercury (Hg) in fish from streams in relation to regional and national gradients of Hg source strength and other factors thought to affect Hg bioaccumulation
Evaluate total mercury (THg) and methylmercury (MeHg) in bed sediment and stream water in relation to these gradients and identify ecosystem characteristics that favor production and bioaccumulation of MeHg
USGS
3


Mercury Sampling Sites, 1998-2005
USGS
4


Targeted land use / cover settings
Proportion of Basin Land use/Land Cover
0
10
20
30
40
50
60
70
Agricultural
Urban
Undeveloped
Mixed
Mercury sample sites
All U.S. streams
USGS
5


Sample Collection
General
Each site sampled one time - seasonal low flow
Atmospheric deposition of Hg (NADP-MDN)
Land-use/Land-cover and other ancillary data using GIS
Top-predator fish
Target: 3-year-old, largemouth bass
Single-species composites
THg in composited skin-off fillets (≥95% of Hg in fish is MeHg)
Length, weight, age
USGS
6

Sample Collection - continued

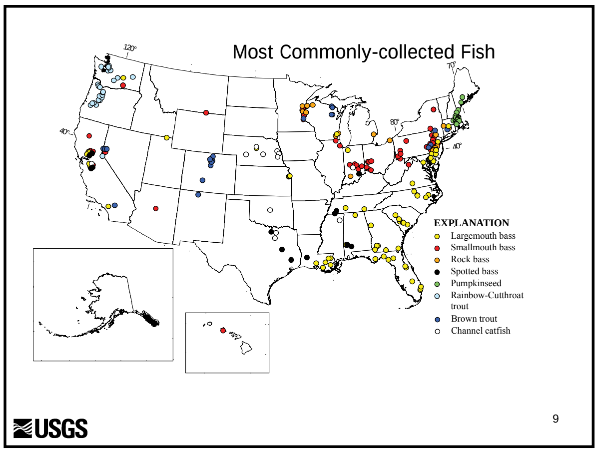
- Streambed sediment
  - Single composite sample, bulk (unsieved) – surface, depositional
  - MeHg and THg
  - Acid volatile sulfide
  - Loss on ignition (a measure of organic carbon)
  - Particle size
- Surface-water
  - Single grab sample – center of stream flow
  - Unfiltered, filtered and particulate (unfiltered in 1998)
  - MeHg, THg
  - Dissolved organic carbon (DOC), sulfate, pH, temperature, flow

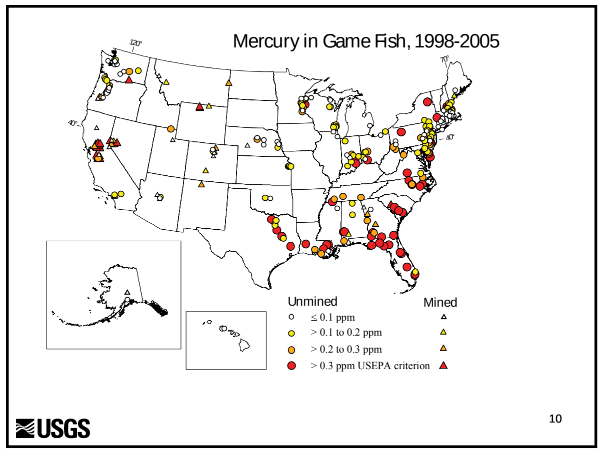
USGS 7

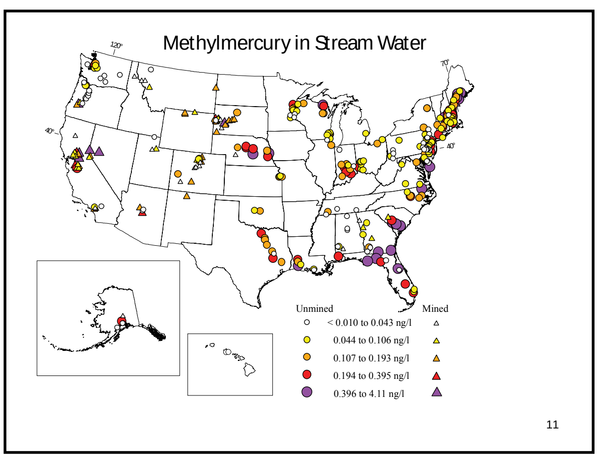
Results

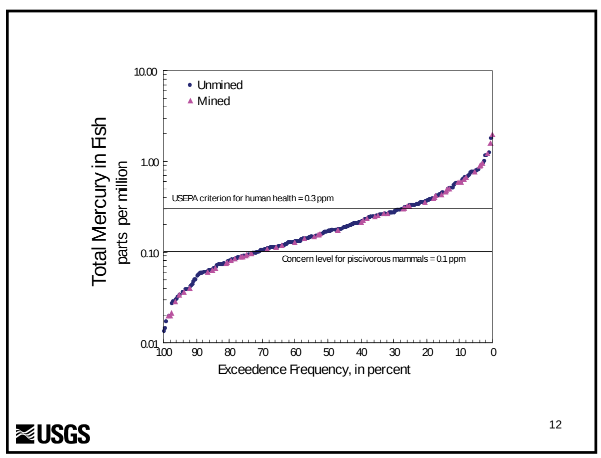
- Spatial distribution of Hg bioaccumulation
- Comparison to benchmarks
- Comparison among fish, sediment, water
- Factors related to Hg bioaccumulation in fish

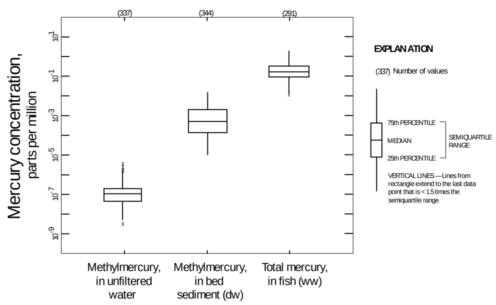
USGS 8



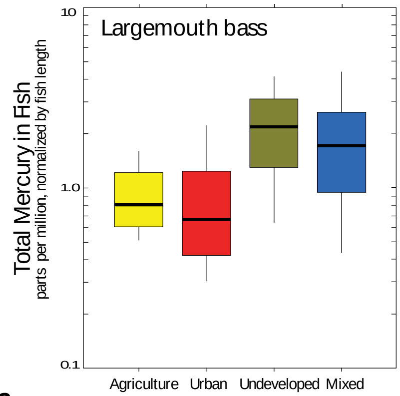








13



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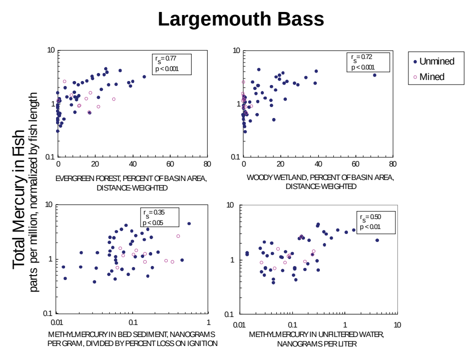
Higher length-normalized Hg concentrations in largemouth bass from unmined basins were primarily related to:

- Increasing amounts of evergreen forest and woody wetland
- Increasing MeHg in stream water
- Increasing MeHg in bed sediment when normalized by loss-on-ignition (a measure of organic carbon in sediment)
- Decreasing pH
- Dissolved sulfate in stream water

15



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Summary

- This comprehensive national-scale study of streams will allow managers to better anticipate mercury levels in fish, bed sediment, and water
- Fish from 27 percent of sampled sites exceeded the USEPA methylmercury criterion for the protection of people who consume average amounts of fish
- The highest fish mercury levels were from southeastern and eastern coastal streams draining largely undeveloped forested and wetland basins, as well as from western streams draining gold- or mercury-mined basins
- Mercury in fish is related to methylmercury in stream water, which is related to the amount of mercury input to a stream basin, organic carbon, and the susceptibility of the stream basin to form methylmercury
- Undeveloped basins, such as evergreen forests and wooded wetlands, are more susceptible than urban or agricultural basins to mercury inputs due to characteristics favoring formation and transport of methylmercury to streams

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For more information:

Contact info: Barb Scudder (bscudder@usgs.gov)

INTERPRETIVE REPORT:

http://pubs.usgs.gov/sir/2009/5109 (Scudder and others, 2009)

DATA REPORT:

http://pubs.usgs.gov/ds/307 (Bauch and others, 2009)

www.usgs.gov/mercury/

18

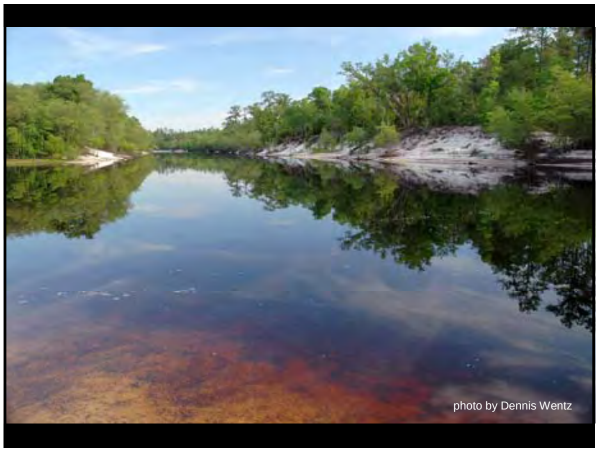


photo by Dennis Wentz

Questions and Answers

Q. *Can you elaborate on the lack of relationship observed between atmospheric levels of mercury and concentrations in fish? In our studies, we have observed that when local sources ceased, there were decreases in fish concentrations.*

A. We used National Atmospheric Deposition Program (NADP) data, which would have been taken at the same time as our study, to obtain the atmospheric levels, and only rockfish had a correlation. A study by Ripel indicated that the characteristics of individual stream basins and the structure of the food webs can be very important, which may explain our results.

Q. *Did you measure for selenium? Latest studies suggest that the highest levels of selenium are associated with lowest mercury levels.*

A. No.

Q. *Do you have information on the physical characteristics of streams, and if so, were there any analyses on types of streams?*

A. No. There were a broad range of streams and drainage areas, and some are regulated and some not.

Q. *How did you select the mercury sampling areas for the survey?*

A. We selected areas where there was a National Water-Quality Assessment Program (NAWQA) basin.

Q. *Can you isolate the sources in areas where mercury levels in fish are high?*

A. We tried to avoid point sources. The elevated areas may be related to different species of fish.

Regional Distribution of Environmental Contamination in Alaskan Fishes

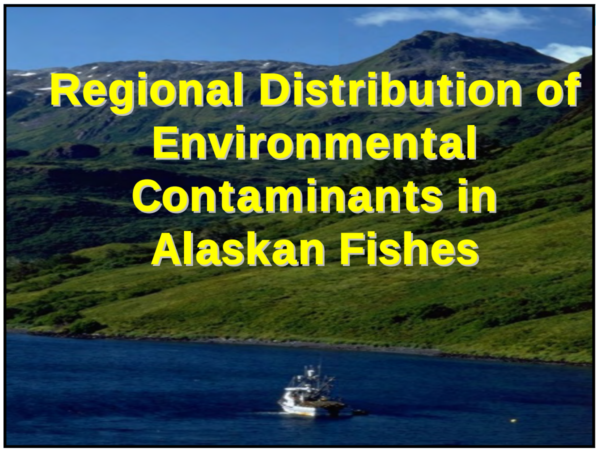
Robert F. Gerlach, VMD, Alaska Department of Environmental Conservation

Biosketch

Dr. Robert F. Gerlach works for the Alaska Department of Environmental Conservation as the Alaska State Veterinarian. He is responsible for animal health regulations, animal disease surveillance, and managing the State's Fish Monitoring Program and is the State's Fish Advisory Program Coordinator. Dr. Gerlach attended Pennsylvania State University and received his V.M.D. from the University of Pennsylvania in 1982. From 1984 to 1987, he was the attending veterinarian and a post-doctoral fellow at the Lovelace Respiratory Research Institute in Albuquerque, NM. In 1987, Dr. Gerlach moved to Alaska and worked in private practice until being hired in 2001 to manage the State's Fish Monitoring Program. Working with state and federal partners in addition to commercial, recreational, and subsistence fisherman, over 5,000 fish have been collected and analyzed for environmental contaminants. The data generated by the program is used by Department of Health and Social Services to develop fish consumption advice for Alaska residents.

Abstract

The presence of environmental contaminants in fish has been a major concern and has raised questions regarding the benefits of consuming fish as part of a healthy diet. In Alaska, there are few industrial sources for these contaminants, and long-range transport via atmospheric patterns and ocean currents are considered the primary routes through which these contaminants enter Alaska's ecosystems. The Alaska Department of Environmental Conservation is collecting fish from across the state to analyze for heavy metals and organic contaminants, and the resulting data are used with results from the state's Division of Public Health biomonitoring program to develop public health advice for fish consumption in Alaska. Polychlorinated biphenyls (PCBs), dioxins, pesticides, and polybrominated diphenylethers (PBDEs) were detected, but concentrations are very low compared with other areas of the world. Mercury concentrations vary among species, and regional differences were noted. These data were compared with data collected in studies performed by the National Oceanic and Atmospheric Administration, and the regional and temporal differences are discussed.



Population 640,000
586,400 square miles (375,296,000 acres)
3 million lakes 12,000 rivers 33,000 miles of coastline
Spanning 3 different seas: Arctic Ocean, Pacific Ocean, Bering Sea

Fish Monitoring Program:

Determine if Alaska's seafood and freshwater fishes have been negatively impacted by environmental contaminants and monitor data trends

- General Survey of Alaskan Fishes:
  - Commercial , Subsistence, Recreational species
  - Opportunistic sampling-
    - Samples collected at commercial, recreational and subsistence fish harvest sites
  - Sampling Plan developed for Halibut with guidance from the IPHC biometricians

Fish Collection Procedures

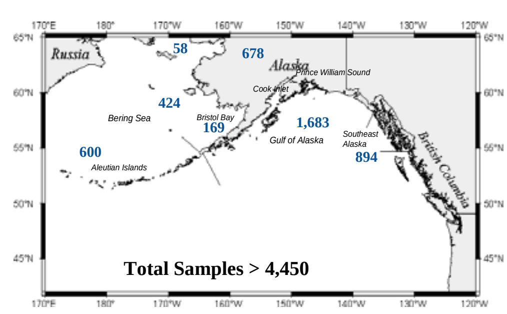
- Basic technique:
- -Whole fish are collected (trawls, seine nets, hook and line)
- -Fish are killed and placed in a food grade plastic bag (fish sleeve)
- -Fish are placed on ice and shipped immediately; or frozen and shipped later
- Modified technique for Halibut:
- -Halibut are caught on longline
- -Length measurements are used to calculate weight, otoliths are removed for aging
- -3 to 5 pound section of fillet will be removed from directly behind the gill plate and processed as skinless fillet
- Dockside or Creel Survey:
- -Portion of the fillet is collected in a food grade plastic bag
- - Analyzed for total mercury and trace metals

Target Analytes

- **Heavy Metals:**
  - Mercury: Total Mercury, Methyl-Mercury
  - Arsenic, Cadmium, Chromium, Nickel, Lead, Selenium
- **Organochlorine Compounds:**
  - PCBs
  - Dioxins and Furans
  - Pesticides
- **Emerging Contaminants:**
  - Brominated Fire Retardants (PBDE)

*** Analysis is performed on a skinless fillet

Areas Where Fish Were Collected in the DEC Fish Monitoring Program

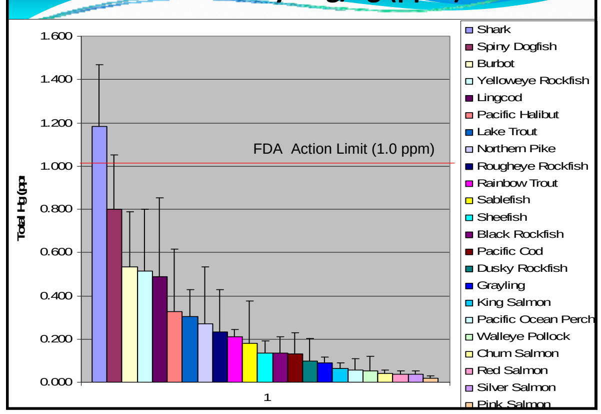


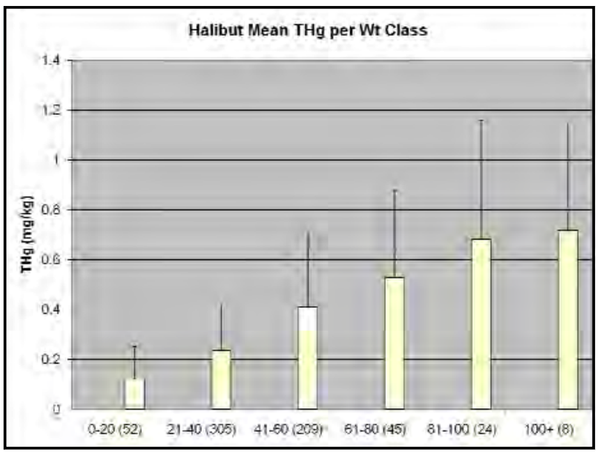
Number of Fish Samples per Region

Fish Tissue Monitoring Program	
Halibut	1,431
Pacific Cod	135
Pollock	185
Lingcod	136
Sablefish	230
Black Rockfish	71
Rougheye Rockfish	38
Pacific Ocean Perch	78
Chinook Salmon	140
Coho salmon	253
Sockeye Salmon	230
Chum Salmon	257
Pink Salmon	172
Northern Pike	483
Grayling	33
Dolly Varden	16
Sheefish	8
Burbot	21
Rainbow Trout	34
Lake Trout	16

Dockside Creel Survey	
Halibut	198
Pacific Cod	4
Lingcod	114
Sablefish	6
Black Rockfish	53
Rockfish- Silvergray	4
Rockfish-Dusky	55
Rockfish-Quillback	6
Rockfish-Yelloweye	53
Shark	86
Shark-Spiny Dogfish	49

Mean Total Mercury: mg/kg (ppm)





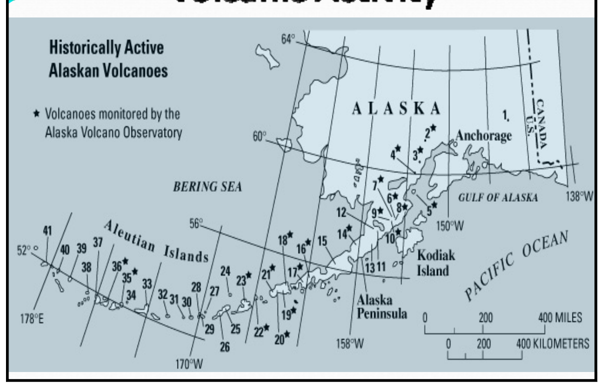
Sources of Environmental Contaminants

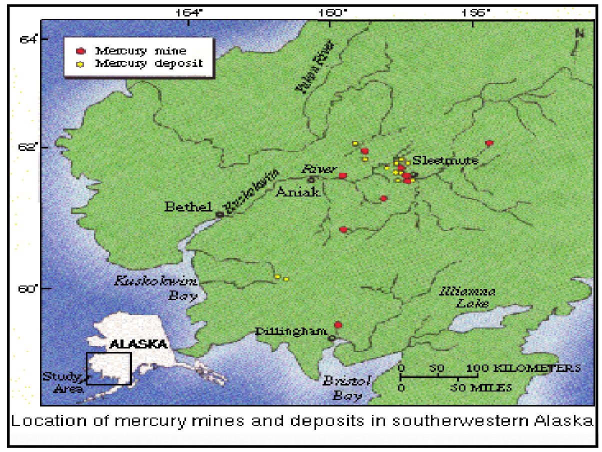
- Local
  - Natural Geologic sources, forest fires
  - Industrial production
  - Military Sites
  - Resource Extraction- mines, oil exploration
- Long Range Transport
  - Atmospheric
  - Ocean Currents
  - Animal migration
  - Commercial transport

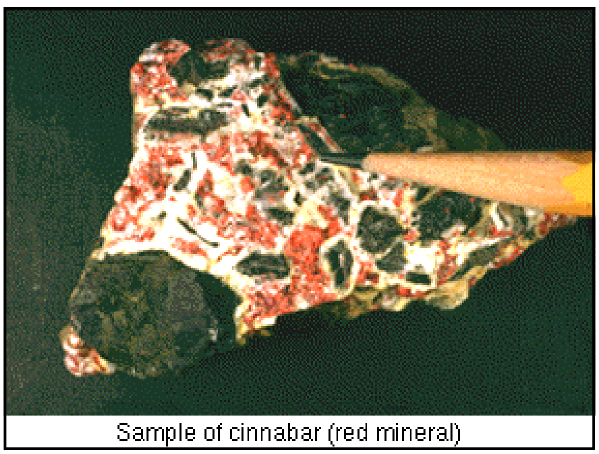
Long Range Transport vs Local Sources

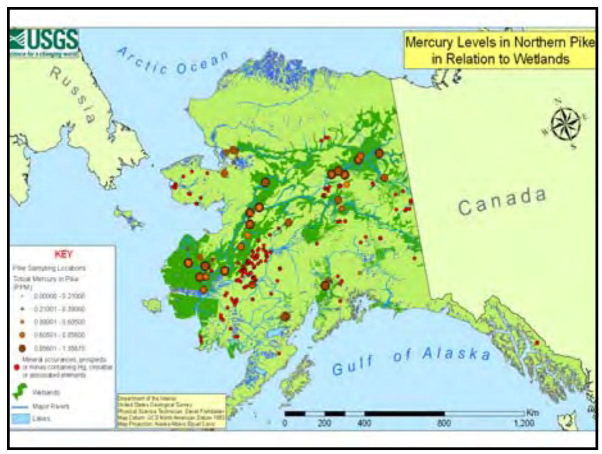
- Survey Work by USFWS – current and historic data
- Western Airborne Contaminants Study – National Parks Service
- Research Work by University of Fairbanks
- Historic Fisheries surveys NOAA

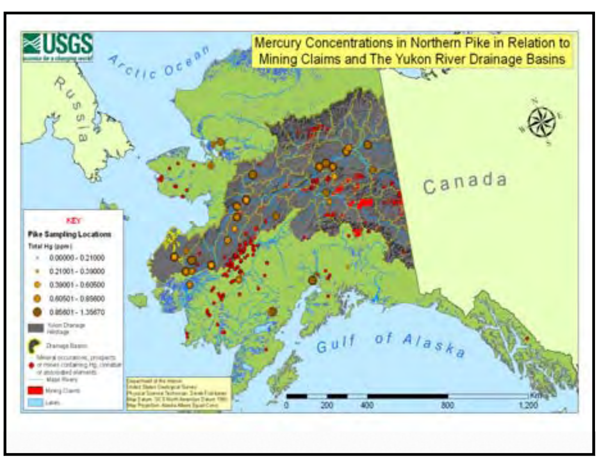
Volcanic Activity

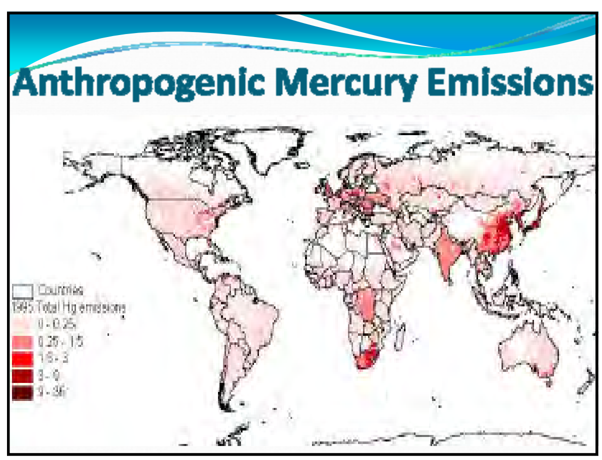



Mercury mine
Mercury deposit
Yukon River
Sleetmute
Kuskokwim River
Aniak
Bethel
Kuskokwim Bay
Iliamna Lake
Dillingham
ALASKA
Study Area
Bristol Bay
0 50 100 KILOMETERS
0 50 MILES
Location of mercury mines and deposits in southerwestern Alaska

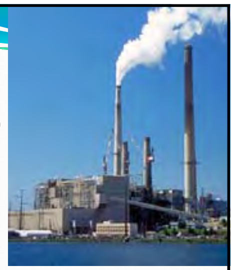

Sample of cinnabar (red mineral)


USGS
Mercury Levels in Northern Pike in Relation to Wetlands
Arctic Ocean
Russia
Canada
Gulf of Alaska
KEY


USGS
Mercury Concentrations in Northern Pike in Relation to Mining Claims and The Yukon River Drainage Basins
Arctic Ocean
Russia
Canada
Gulf of Alaska
KEY


Anthropogenic Mercury Emissions
Countries
1995 Total Hg emissions

Atmospheric Mercury (Hg)



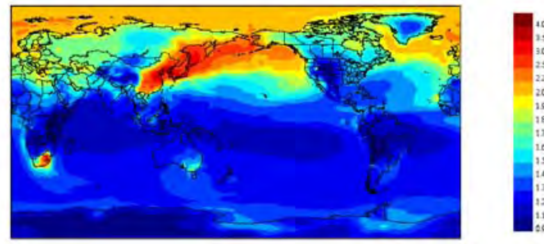
Sources : Anthropogenic (80%)
Natural (20%)

Forms of Mercury and Residence Time

Gaseous Elemental Hg (Hg^o): ~ 1 year
Reactive Gaseous Hg (RGM): minutes-weeks
Particulate Hg (Hg_p): minutes-weeks

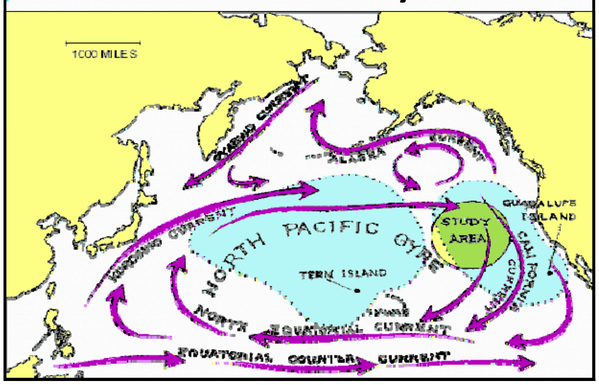
Global transport modelling

Average elemental mercury surface concentrations for July 2001 (ng/m3)



GRAHM (Global/Regional Atmospheric Heavy Metals Model) simulation – Ashu Dastoor, Meteorological Service of Canada,Environment Canada

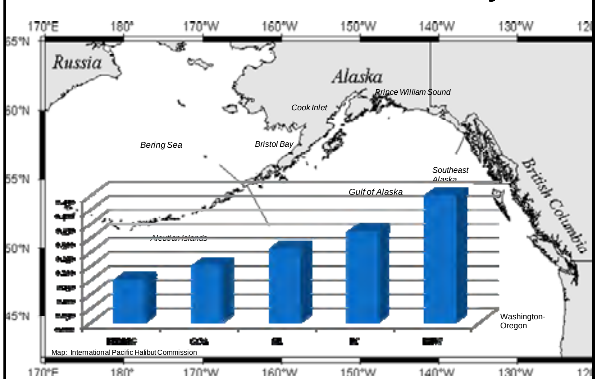
North Pacific Gyre



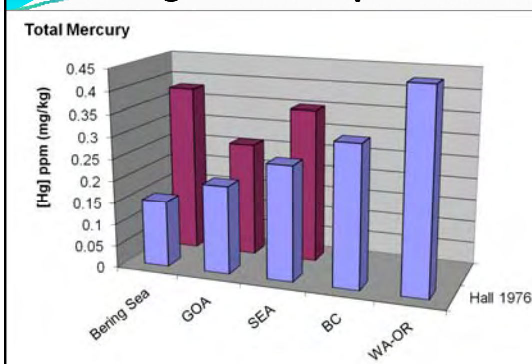
Mercury concentration in fish tissue

- NOAA study (Hall, et.al. 1976)
  - Total Mercury Concentration
  - Skinless Fillet
  - Regional comparison:
    - Bering Sea
    - Gulf of Alaska
    - South East Alaska
    - British Columbia
    - Washington-Oregon

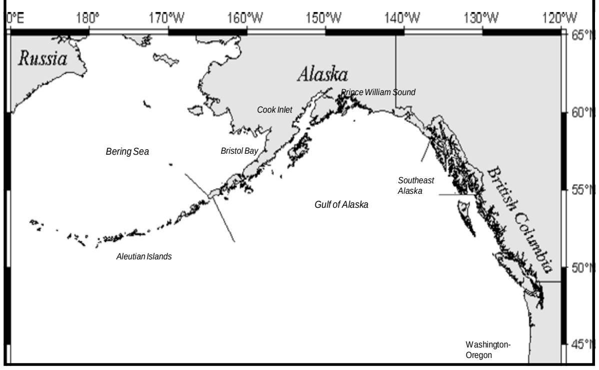
NOAA 1976 Hall et. al. Study



Regional Comparison



Areas Where Fish Were Collected in the DEC Fish Monitoring Program vs. NOAA 1976 Hall et. al. Study

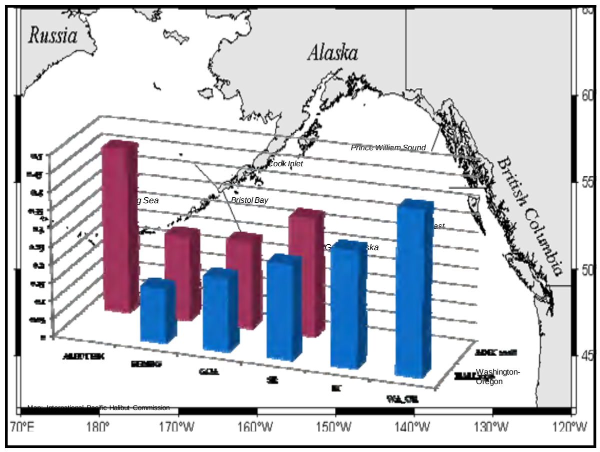


Comparison FMP to NOAA Study
(Hall, et. al. 1976)

	Number fish			Weight (kg)	
	Hall	FMP		Hall	FMP
Aleutian	0	336		0	17.7
Bering Sea	152	189		24.8	18.8
GOA	761	612		32.6	19.1
SE	70	284		30.7	18.9
Total samples	983	1,421			

Comparison FMP to NOAA Study
(Hall,et. al. 1976)

Total-Hg (ppm)	Mean			Minimum		Maximum	
	Hall	FMP	%	Hall	FMP	Hall	FMP
Aleutian		0.455			0.073		1.947
Bering Sea	0.150	0.234	56%	0.020	0.037	1.000	0.926
GOA	0.200	0.240	20%	0.010	0.013	1.280	1.578
SE	0.260	0.327	26%	0.040	0.040	1.300	1.512



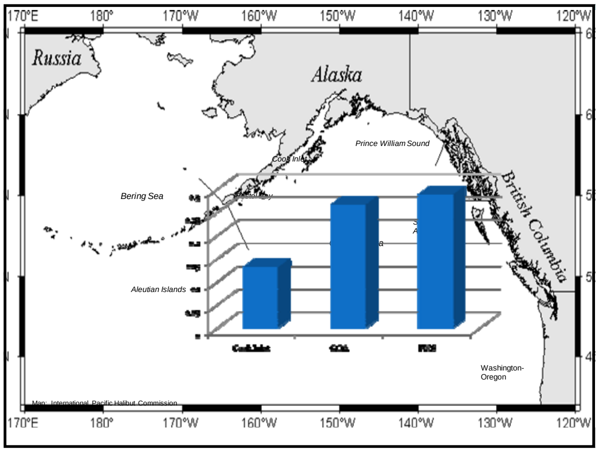
Comparison FMP to NOAA Study
(Hall,et. al. 1976)

Percentage of samples exceeding [Total Mercury] of 0.5 ppm

	Hall	FMP
Aleutian		32.2
Bering	4.6	12.6
GOA	5.0	10.8
SE	12.8	19.7

Regional Differences in Gulf of Alaska

Hg (ppm)		Mean			Minimum		Maximum	
	#	Hall	FMP	%	Hall	FMP	Hall	FMP
GOA	612	0.200	0.240	20%	0.010	0.013	1.280	1.578


170°E
180°
170°W
160°W
150°W
140°W
130°W
120°W
Russia
Alaska
Prince William Sound
Cook Inlet
Bering Sea
British Columbia
Aleutian Islands
Washington-
Oregon
Map: International Pacific Halibut Commission

Hair Mercury Biomonitoring Results from Alaska and Hawaii—Demonstrating the Value of Local Fish Consumption Advice

Lori Verbrugge, Ph.D., Alaska Division of Public Health
Barbara Brooks, Ph.D., Hawaii Department of Health

Biosketch

Dr. Lori Verbrugge (Ph.D.) is the Environmental Public Health Program Manager for the Alaska Division of Public Health. She has worked to assess the human health implications of contaminants in Alaska's environment since 1997. Dr. Verbrugge helped coordinate the development of analytical chemistry capacity and programs for the Alaska Public Health Laboratory and currently works in the Section of Epidemiology to provide expert toxicological support and policy advice to the Division. Dr. Verbrugge oversees various environmental health programs, including human biomonitoring, blood lead surveillance, subsistence food safety, environmental health research, and an Agency for Toxic Substances and Disease Registry cooperative agreement to assess the public health implications of contaminants sites in Alaska. Dr. Verbrugge received her Ph.D. in Environmental Toxicology from Michigan State University, where she researched the toxicological effects of PCBs and dioxins on fish-eating birds. She also holds an M.S. in Fisheries and Wildlife from Michigan State University and a B.S. in Environmental Toxicology from the University of California, Davis.

Dr. Barbara Brooks (Ph.D.) is the State Toxicologist with the Hazard Evaluation and Emergency Response Office, Hawaii Department of Health (HDOH). In her 13 years with HDOH, she has prepared numerous health risk assessments on health effects from exposure to hazardous substances. One of her primary responsibilities is the analysis of the health risk from consuming contaminated fish. Dr. Brooks coordinated a study of the mercury levels in commonly consumed pelagic fish and helped develop a Hawaii-specific fish advisory targeting pregnant women and children. Her current focus with HDOH is to enhance the environmental public health tracking of diseases related to environmental exposures. She is currently supervising two integral projects related to environmental public health tracking, including surveillance using the State's Pesticide and Heavy Metal Poisoning database and human biomonitoring for arsenic and mercury in hair. She recently completed an investigation with the Agency for Toxic Substances and Disease Registry to measure arsenic exposure in residents living on former sugarcane land on the Island of Hawaii.

Abstract

Subsistence, with fish as a major component, is a fundamental cornerstone of Alaska Native cultures, providing spiritual, nutritional, medicinal, cultural, and economic well-being. In Alaska, providing appropriate fish consumption advice requires consideration not only of contaminant risks, but also of the health and cultural benefits of fish consumption, the risks associated with alternative replacement foods, and food security issues.

In Hawaii, fish is a traditional staple protein food for Native Hawaiians and an integral part of island culture. Fish is also a favorite among other Pacific Islander and Asian peoples living in Hawaii. Fish consumption is promoted by the Hawaii State Department of Health (HDOH) because of its health benefits. However, many of the popular types of fish (e.g., ahi) consumed in Hawaii contain levels of mercury that may be harmful to the developing brain.

To reduce uncertainty related to mercury exposure estimates, the Alaska Division of Public Health has conducted an ongoing Statewide Hair Mercury Biomonitoring Program since 2002. Through June 30, 2009, 751 Alaskan women of childbearing age (WCBA) have been tested, with a median hair mercury

concentration (or level) of 0.47 parts per million (range, 0.01-7.82 ppm). Only four WCBA had hair mercury levels at or above 5 ppm, which is the ADPH cut-off for individual follow-up activities.

In October 2008, the HDOH and the University of Hawaii began measuring mercury in hair in volunteers attending the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). From October 2008 to April 2009, 189 WCBA and 103 children (0 to 5 years of age) were tested. The average hair mercury level in WCBA was 1.46 ppm, and the median was 1.14 ppm (0.01–10.35 ppm). In children, the average hair mercury level was 0.92 ppm, and the median was 0.42 ppm (0.03–7.03 ppm). Four WCBA and two children had levels exceeding 5 ppm.

The median hair mercury level in WCBA from Hawaii was more than two times higher than Alaskan WCBA, demonstrating great inter-location variability in mercury exposure based on the type of fish consumed. Our results demonstrate both the utility of human biomonitoring to characterize actual contaminant exposures and the importance of providing local fish consumption advice based on local fish and human exposure data.

Hair Mercury Biomonitoring Results from Alaska and Hawaii

Demonstrating the Value of Local Fish Consumption Advice

Barbara Brooks, Ph.D. - Hawaii Department of Health
Lori Verbrugge, Ph.D. - Alaska Division of Public Health

Data ADPH Uses to Develop Fish Consumption Advice

- Mercury levels in Alaska fish
- Human biomonitoring data
- Fish consumption rates in Alaska
- Nutrition-related disease rates and trends in Alaska

Drawbacks of Restricted Consumption of Traditional Foods

- Health risks associated with alternative foods
  - ↑ saturated fat: cardiovascular disease
  - ↑carbohydrates: diabetes
- Loss of nutritional and health benefits
- Overall negative health impact of dietary and lifestyle changes
- High cost of replacement foods
- Social, economic and health consequences from the breakdown of subsistence

What is Human Biomonitoring?

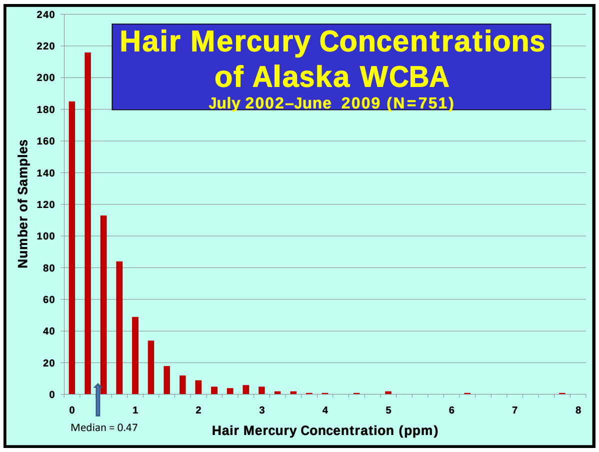
- Measure level of an environmental chemical (or its metabolite) in the human body
  - lab measurements of blood, urine, serum, saliva, or tissue samples
- Directly measure level of exposure
  - Reduced uncertainty of risk assessment

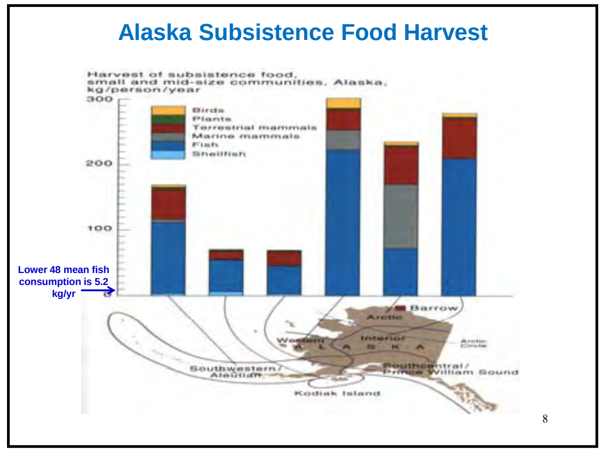
Hair Mercury Biomonitoring - Why?

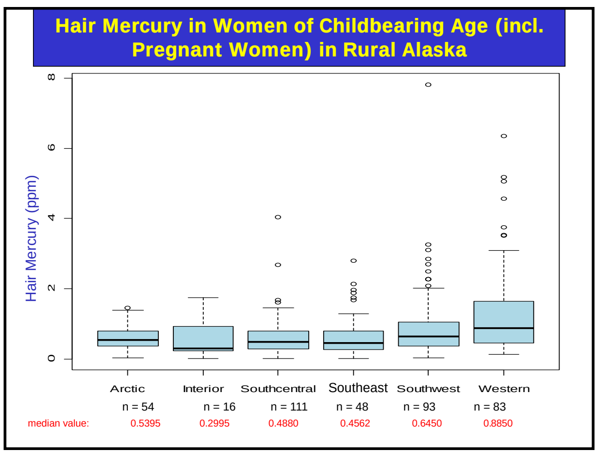
- Estimate of exposure needed to predict health effects of contaminants
- Measuring actual exposure is much more accurate than modeling or risk assessment
- Hair a long-term methylmercury dose integrator
- Relationship of mercury in blood and hair well-characterized
- Hair is simple to collect, handle and ship

Alaska's Statewide Maternal Hair Mercury Biomonitoring Program

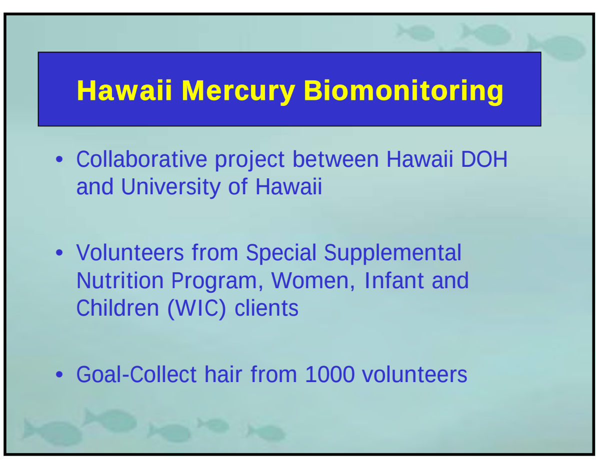
- Program initiated in July 2002
- Available to all women of childbearing age in Alaska
- Sample collected through Health Care provider
- Analyzed for free by Alaska Public Health Laboratory

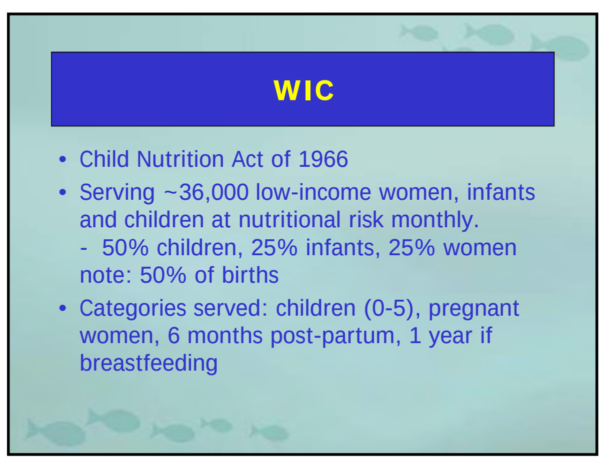

Hair Mercury Concentrations of Alaska WCBA
July 2002–June 2009 (N=751)
Number of Samples
0
20
40
60
80
100
120
140
160
180
200
220
240
0 1 2 3 4 5 6 7 8
Median = 0.47
Hair Mercury Concentration (ppm)


Alaska Subsistence Food Harvest
Harvest of subsistence food, small and mid-size communities, Alaska, kg/person/year
300
200
100
0
Birds
Plants
Terrestrial mammals
Marine mammals
Fish
Shellfish
Lower 48 mean fish consumption is 5.2 kg/yr
Barrow
Arctic
Western
Interior
Southwestern/Aleutian
Southcentral/Prince William Sound
Kodiak Island
8


Hair Mercury in Women of Childbearing Age (incl. Pregnant Women) in Rural Alaska
Hair Mercury (ppm)
0
2
4
6
8
Arctic
Interior
Southcentral
Southeast
Southwest
Western
n = 54
n = 16
n = 111
n = 48
n = 93
n = 83
median value:
0.5395
0.2995
0.4880
0.4562
0.6450
0.8850

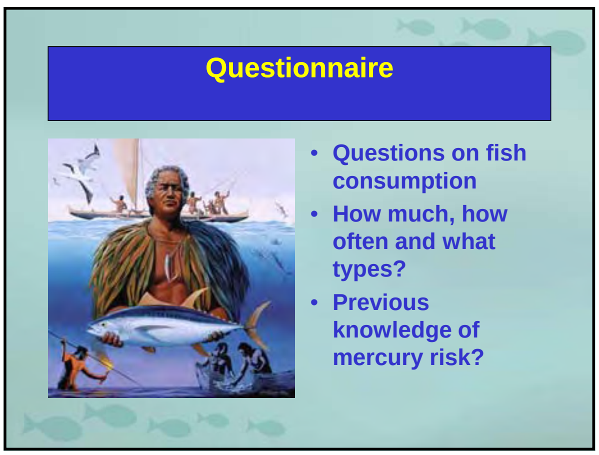

Mercury in Northern Pike in National Wildlife Refuges in Alaska
• USFWS Special Project, Alaska Region
• Collaborative effort with Alaska DHSS
– Hair mercury biomonitoring
– Fish consumption surveys
– Pike consumption guidance
• Determine mercury levels in northern pike meat from traditional and well-used subsistence fishing sites

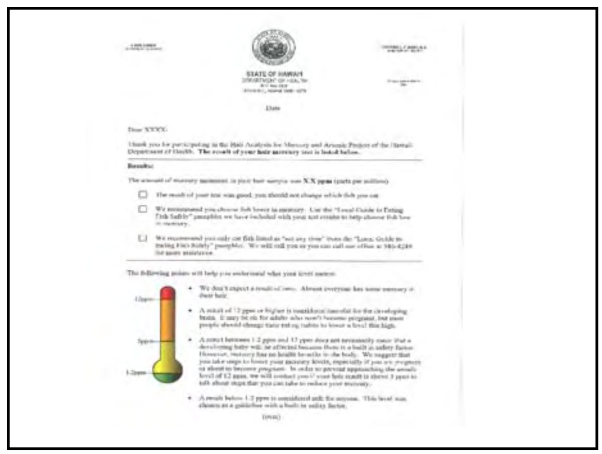

Hawaii Mercury Biomonitoring
• Collaborative project between Hawaii DOH and University of Hawaii
• Volunteers from Special Supplemental Nutrition Program, Women, Infant and Children (WIC) clients
• Goal-Collect hair from 1000 volunteers

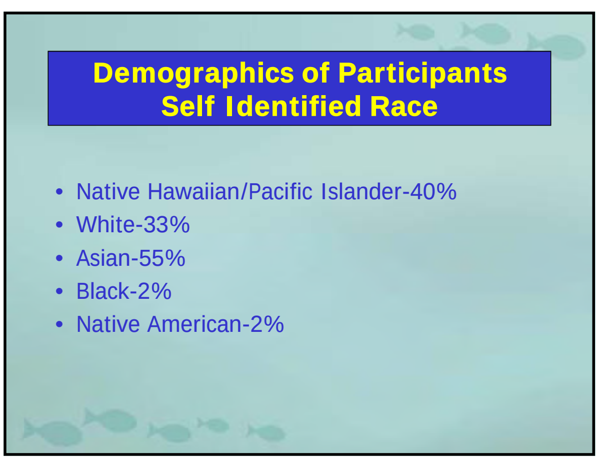

WIC
• Child Nutrition Act of 1966
• Serving ~36,000 low-income women, infants and children at nutritional risk monthly.
- 50% children, 25% infants, 25% women
note: 50% of births
• Categories served: children (0-5), pregnant women, 6 months post-partum, 1 year if breastfeeding

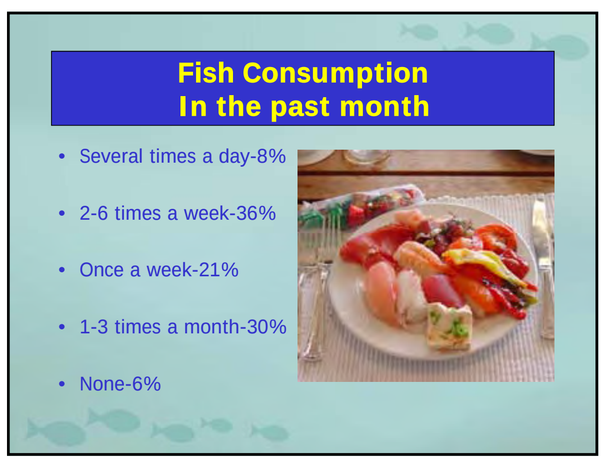

Free
Mercury Testing
Eating Fish Safely
What happens when you agree to be tested for mercury
OCT 10 2008

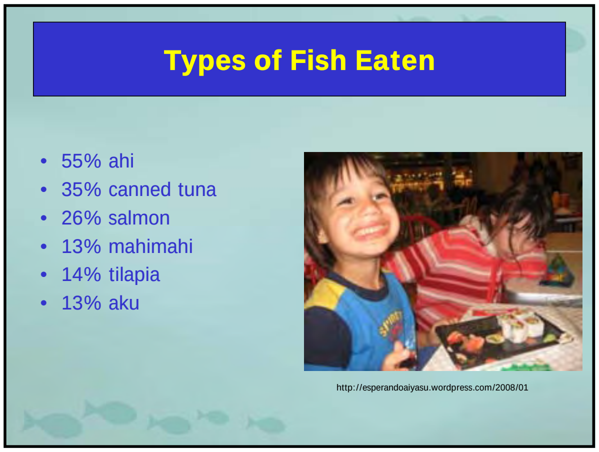

How much hair do we need

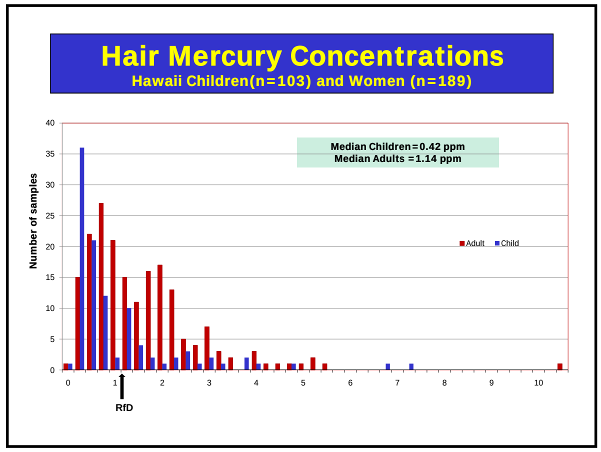

Questionnaire
• Questions on fish consumption
• How much, how often and what types?
• Previous knowledge of mercury risk?

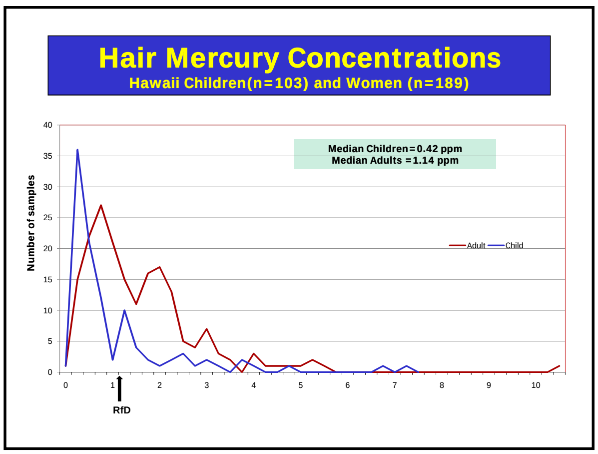



Demographics of Participants
Self Identified Race
• Native Hawaiian/Pacific Islander-40%
• White-33%
• Asian-55%
• Black-2%
• Native American-2%


Fish Consumption
In the past month
• Several times a day-8%
• 2-6 times a week-36%
• Once a week-21%
• 1-3 times a month-30%
• None-6%


Types of Fish Eaten
• 55% ahi
• 35% canned tuna
• 26% salmon
• 13% mahimahi
• 14% tilapia
• 13% aku
http://esperandoaiyasu.wordpress.com/2008/01


Hair Mercury Concentrations
Hawaii Children(n=103) and Women (n=189)
Median Children=0.42 ppm
Median Adults =1.14 ppm
Number of samples
Adult
Child
RfD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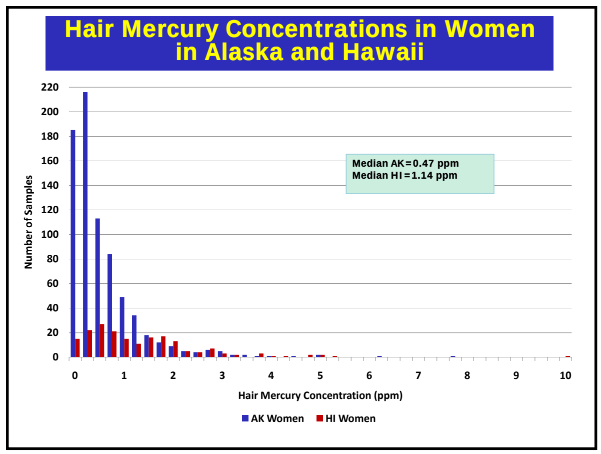
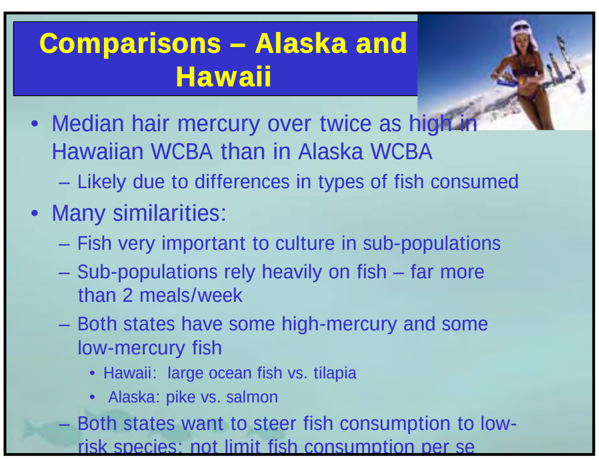
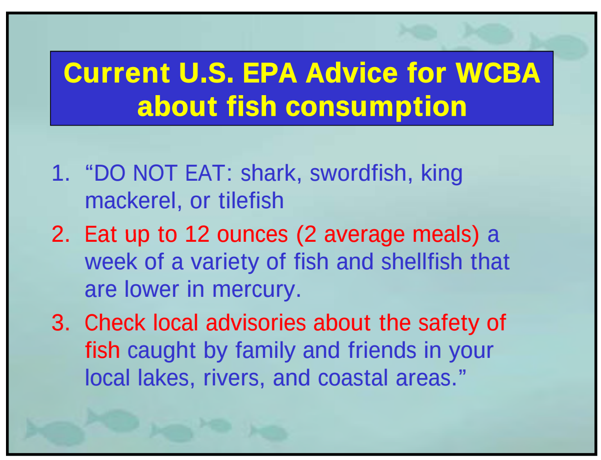
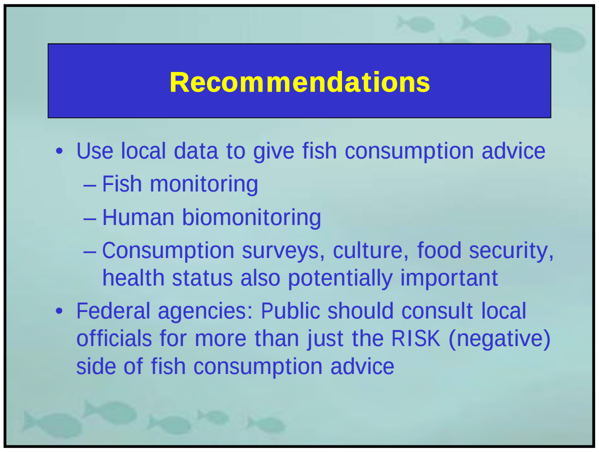

Hair Mercury Concentrations in Women in Alaska and Hawaii
Median AK=0.47 ppm
Median HI=1.14 ppm
Number of Samples
Hair Mercury Concentration (ppm)
AK Women
HI Women


Comparisons – Alaska and Hawaii
• Median hair mercury over twice as high in Hawaiian WCBA than in Alaska WCBA
– Likely due to differences in types of fish consumed
• Many similarities:
– Fish very important to culture in sub-populations
– Sub-populations rely heavily on fish – far more than 2 meals/week
– Both states have some high-mercury and some low-mercury fish
• Hawaii: large ocean fish vs. tilapia
• Alaska: pike vs. salmon
– Both states want to steer fish consumption to low-risk species; not limit fish consumption per se


Current U.S. EPA Advice for WCBA about fish consumption
1. "DO NOT EAT: shark, swordfish, king mackerel, or tilefish
2. Eat up to 12 ounces (2 average meals) a week of a variety of fish and shellfish that are lower in mercury.
3. Check local advisories about the safety of fish caught by family and friends in your local lakes, rivers, and coastal areas."


Recommendations
• Use local data to give fish consumption advice
– Fish monitoring
– Human biomonitoring
– Consumption surveys, culture, food security, health status also potentially important
• Federal agencies: Public should consult local officials for more than just the RISK (negative) side of fish consumption advice

Questions and Answers

Q. I have seen some research indicating that there are high uncertainties in direct measurements of mercury in hair. Did you see high uncertainties as well?

A. Our public lab has a QA/QC and proficiency testing program, and we run every sample in duplicate. If there is variability, we run triplicate. We see very tight numbers. There are two different methods for analyzing mercury. The labs that use DMA-80 have less uncertainty than those that use absorption. We use DMA-80 and we use QA/QC and have tight numbers.

We use the Milestone method (absorption) and have very tight numbers. We have a very good QC program.

Q. Where do you think the mercury is coming from?

A. We did not look for sources.

Q. Do you have data on the varying ethnicities in your study? Do you think you might have differences in Alaska?

A. I do not have that data.

Q. What is the proportion of fish consumption to mercury levels since you encourage consumption every day?

A. We had a grad student look at this, but the numbers weren't tight. People that had really high consumption of raw fish and/or mammal blubber consumers had the highest mercury levels.

Q. The Hawaiian WIC gives out canned tuna and salmon. Did the study ask women which fish they receive? Also, the study indicates that one out of every 2 low-income women is exceeding the RfD. Can you comment on this?

A. We don't ask about the canned fish they receive, just what types of fish they regularly eat. Many people in Hawaii exceed the RfD, because tuna has very high mercury levels.

Q. Do you have data on the women that don't eat fish? Is there a correlation?

A. Women that don't eat fish had very low concentrations of mercury.

Mercury and PCBs in Asian Market Fish: A Response to Results from Mercury Biomonitoring in New York City

Wendy McKelvey, New York City Department of Health and Mental Hygiene

Biosketch

Dr. Wendy McKelvey (Ph.D.) currently directs the epidemiology unit for the Bureau of Environmental Surveillance and Policy in the New York City Department of Health and Mental Hygiene. She is also the lead epidemiologist for New York City's CDC-funded Environmental Public Health Tracking Program. Before joining the New York City Health Department in 2004, Dr. McKelvey was the senior epidemiologist at Silent Spring Institute, where she conducted research on environmental causes of breast cancer. She received her M.S. and Ph.D. in Epidemiology from the University of California, Los Angeles, and did a post-doctoral fellowship in environmental exposure assessment in the Division of Environmental Sciences and Engineering, University of North Carolina, Chapel Hill. She has also taught epidemiology as an associate adjunct professor in the Urban Public Health Program at Hunter College in New York City.

Abstract

Fish and shellfish contain high-quality protein and other essential nutrients, but they may also accumulate contaminants, including mercury and polychlorinated biphenyls (PCBs). In 2004, the New York City Department of Health and Mental Hygiene (NYC DOHMH) conducted a Health and Nutrition Examination Survey that measured blood mercury concentrations in a representative sample of 1,811 adult New Yorkers. Asians—and the foreign-born Chinese, in particular—had the highest levels, and fish consumption was the strongest predictor of mercury exposure.

In response, the NYC DOHMH measured total mercury and the sum of 101 PCB congeners in 282 specimens of 19 species or seafood products from fish markets in Chinese neighborhoods. Species were selected based on their volume in the market, and absence or insufficiency of national data on mercury levels, or potential for PCB contamination. PCBs were considered because they are also contaminants of concern. All measurements were made on a wet weight basis on whole fillets (with skin) or products (drained of liquid).

Mean mercury levels ranged from below the limit of detection (4 ng/g) in tilapia to 229 ng/g in tilefish. The highest mercury level—which was above the U.S. Food and Drug Administration action level—was measured in a tilefish specimen (1,150 ng/g). The mercury levels measured in tilefish appeared to be a function of specimen size. Mean PCB levels ranged from 2 ng/g in red snapper to 100 ng/g in buffalo carp. The highest PCB levels were measured in a buffalo carp (470 ng/g) and in a yellow croaker (495 ng/g) specimen. Within-species variability in PCB concentration was relatively high; species-specific differences accounted for only 6.8% of total variability, in contrast with 39.2% for mercury.

Mercury and PCB levels in the majority of fish purchased in Chinese markets fell in the low to moderate range, although similar to previous studies, tilefish stands out as a higher mercury fish. Higher exposures in communities that consume fish frequently may be due to frequent consumption of moderately contaminated fish. Lowering exposure levels in these communities requires providing guidance on how to select fish meals in combinations.

Mercury and PCBs in Asian Market Fish: A Response to Results from Mercury Biomonitoring in New York City

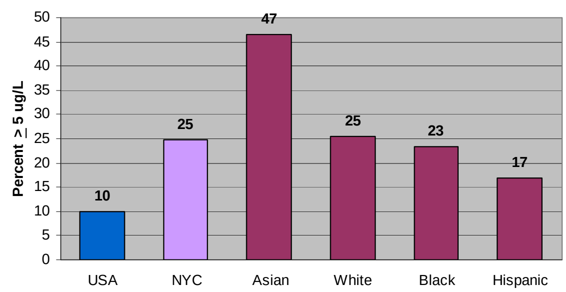
Wendy McKelvey, Ph.D.

New York City Department of Health and Mental Hygiene

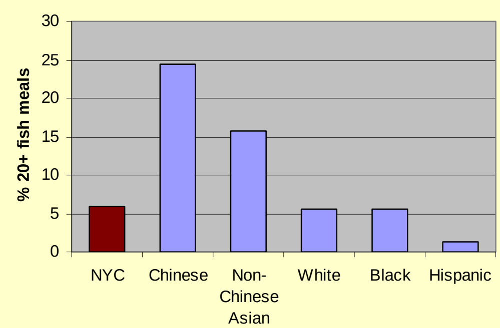
NYC Health and Nutrition Examination Survey

- Modeled after CDC's National HANES
- Population-based sampling of non-institutionalized NYC residents aged 20+ years
- June – December, 2004
- Combination of interview and physical exam (blood samples from 1811 participants)

One in four NYC adults has elevated blood mercury (NYC HANES, 2004)



Percent of New Yorkers Eating Fish or Shellfish 20+ Times in Past Month

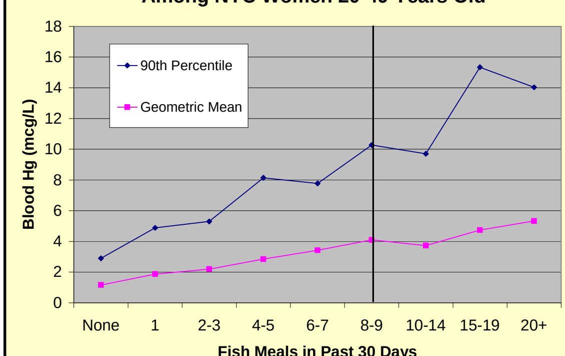


Blood Mercury Concentrations (µg/L) in NYC Adults

	No.	Geometric Mean	95th Percentile
NYC Total	1811	2.7	11.0
Race/Ethnicity			
White	529	2.8	10.9
Black	390	2.6	9.3
Asian	231	4.1	19.2
Hispanic	630	2.3	8.5
Foreign-born Chinese	93	7.3	22.5

Source: NYC HANES 2004

Blood Mercury Levels By Fish Meals in Past 30 Days Among NYC Women 20-49 Years Old



"Eat Fish, Choose Wisely" Brochure

www.nyc.gov/html/doh/html/epi/mercury.shtml

New York City Responds…

- More data needed on mercury in fish species consumed by the Chinese.
- Our Agency supported a contaminants in fish study to measure mercury and PCB's in 20 species popular among the Chinese.

Study Objectives

- Estimate mercury and PCB levels in market fish consumed by Chinese and Asian New Yorkers.
- To improve fish consumption advisories for Chinese and other Asian ethnic groups in NYC.
- To improve the consumer information base for reducing mercury and PCB exposure through fish consumption.

Criteria for Selecting Target Species

- Availability (based on volume) in stores in the three target neighborhoods.
- Inadequate data on mercury content.
- Fish is on our "recommended" list, but with potential for PCB contamination.
- Change in import patterns.

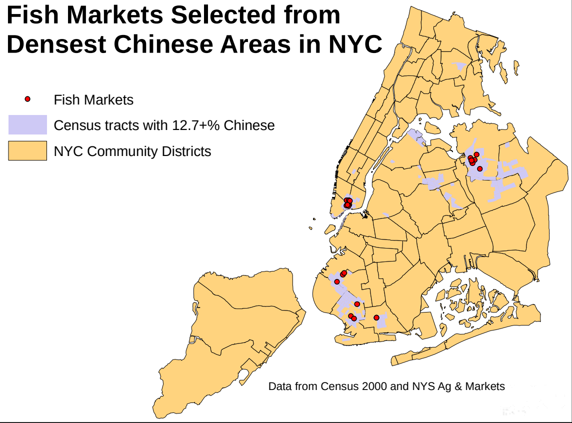
Species selected and purchased for mercury and PCB testing

- Bighead Carp
- Buffalo Carp
- Black Sea Bass
- Blue Crab
- Cutlass/Beltfish
- Flounder/Sole
- Golden Pompano
- Hybrid Striped Bass
- Porgy
- Red Snapper
- Sleeper
- Spanish Mackerel
- Blackfish/Tautog
- Tilapia
- Tilefish
- Unagi Eel
- White Pompano
- Yellow Croaker
- Canned Eel
- Canned Dace

Study Design & Protocol

- Identified fish markets in NYC.
- Selected markets from those located in the top 10% Chinese populated census tracts.
- Markets were selected according to the relative Chinese population size in Queens, Manhattan and Brooklyn.
- Sample size of 15 for each target species: 4, 5 and 6 specimens from markets in Manhattan, Brooklyn and Queens, respectively.
- Samples collected Aug – Sep, 2007

Fish Markets Selected from Densest Chinese Areas in NYC



Laboratory Methods

- Total mercury (n=282) – CVAA EPA method 245.6 (LOD = 4 ppb)
- Total 101 PCB congeners (n=196) – parallel dual-column GC-ECD (IDL: 0-0.017 ppb) – based on EPA method 8082
- PCB method also measures organochlorine pesticides: DDE, HCB and Mirex
- QA/QC
  - Method & reagent blanks
  - Blind duplicates and laboratory replicates
  - Standardized or certified reference materials
  - Surrogate standard (PCBs)

New York City Market Fish Sampling Target Species


Hybrid Striped Bass (14”; $4.05/lb)


Black Sea Bass (13”; $4.60/lb)


Blackfish (16”; $9.60/lb)


Sleeper (11”; $7.90/lb)

New York City Market Fish Sampling Target Species


Beltfish (33”; $2.60/lb)


Yellow Croaker (11”; $4.55/lb)


Buffalo Carp (22”; $3.15/lb))


Bighead Carp (25”; $2.85/lb)

New York City Market Fish Sampling Target Species


White Pompano (9.5”; $3.85/lb)


Golden Pompano (11.5”; $2.95)


Spanish Mackerel (17”; $2.55/lb)


Porgy (11”; $2.40/lb)

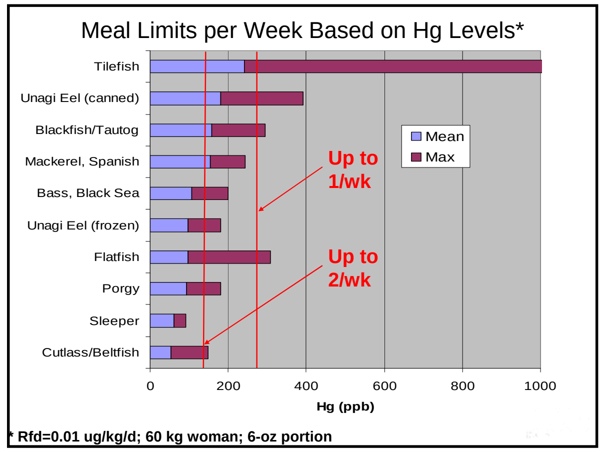
New York City Market Fish Sampling Target Species

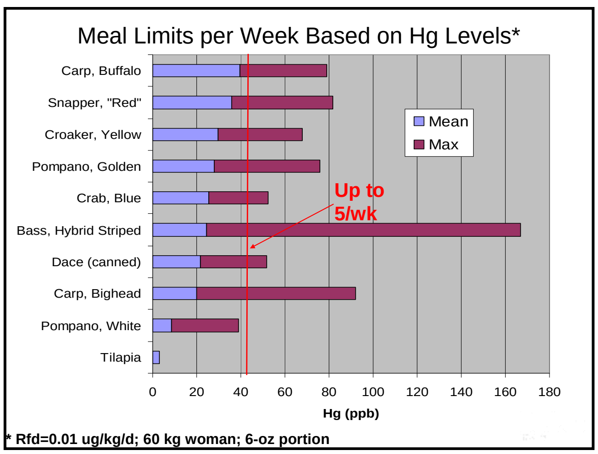

Tilapia (12”; $1.90/lb)

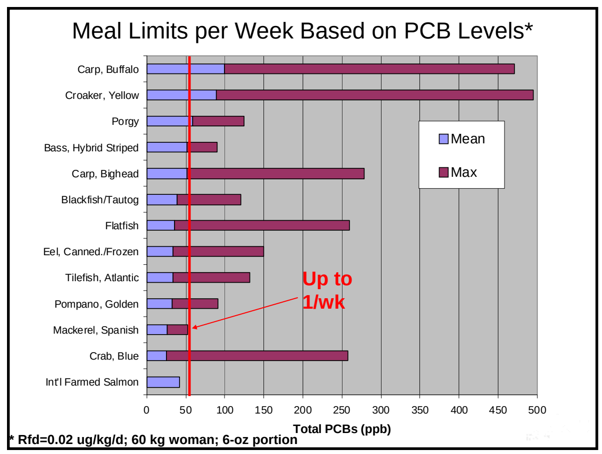

Red Snapper (15”; $4.40/lb)

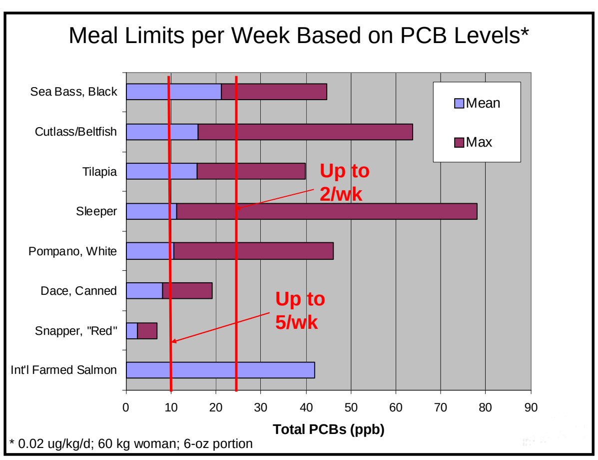

Rex Sole (Flatfish: 16”; $3.45/lb)


Tilefish (22.5”; $4.85/lb)









		Meal Limits Based on Average Hg Levels		
		5/week	2/week	1/week
Meals Lmits Based on Avg. PCBs	5/wk	Dace, canned Snapper, red		
	2/wk	Pompano, white Tilapia	Bass, black sea Sleeper Cutlass	
	1/wk	Pompano, golden Crab, blue Carp, bighead Bass, hybrid striped	Eel, frozen Flatfish	Blackfish Mackerel, Spanish Tilefish Eel, canned
	Do not eat	Croaker, yellow Carp, buffalo	Porgy	

Proposed Bins Based on Mercury Levels (Tagging High PCB Levels)

Up to 5/week	Up to 2/week	Up to 1/wk	Do not eat
Carp, Bighead Carp, Buffalo Crab, Blue Croaker, Yellow Dace (Mud Carp) Pompano, Golden or White Tilapia	Bass, Hybrid Striped Bass, Black Sea Cutlass Flounder Porgy Sleeper Snapper, Red Sole	Blackfish Eel Mackerel, Spanish	Tilefish

* These fish may contain high levels of PCBs

Conclusion

- Higher Hg levels in Chinese New Yorkers probably due to eating more (lower Hg) fish and lower bodyweight.
- No evidence that specimens from Chinese markets are higher in Hg.
- High within-species variability in PCB levels.
- OC pesticide levels were low.
- Hg and PCB levels not strongly correlated, which complicates combining the data in risk messages.
- Communicating meal allowances for combinations of species is a challenge.

PCB Risk Communication - Discussion Questions

- Should we communicate species-specific PCB risks, based on the data we collected?
  - Did we collect enough data?
  - Does high intra-species variation warrant species-specific messages?
  - Does it matter that we do not have PCB data on all species?
- Should we combine data from various studies?
- Is the EPA 0.02 µg/kg/d reference dose an appropriate choice for advice directed to pregnant women and young children?

An Inter-Agency Collaboration

- **NYC DOHMH**
  - **Study design, conduct and presentation of results**
  - **Outreach to NYC Chinese community.**
- **US EPA Region 2**
  - **Chinese fish market expertise**
  - **Testing of fish from Fulton Fish Market**
- **NYS Agriculture & Markets**
  - **Data on fish markets**
  - **Testing of high mercury fish**
- **CUNY-Hunter College**
  - **Field work and specimen processing**
- **SUNY-Albany**
  - **Mercury and PCB analyses**

Questions and Answers

Q. Where are the buffalo carp and bighead carp tested in your study coming from?

A. Possibly the Mississippi basin drainage.

Tissue Analysis for Mercury and PCBs from a New York City Commercial Seafood Market

Moses Chang, Ph.D., U.S. Environmental Protection Agency, Region 2

Biosketch

Dr. Moses Chang (Ph.D.) received his B.S. in Fishery Science from National Taiwan Ocean University. Dr. Chang earned his M.A. and Ph.D. in Biology from the City College and the City University of New York, respectively. His initial research interests were in the area of fishery, marine science, marine ecology, and ichthyology. Dr. Chang's career in Region 2 of EPA began in 1987, and his major responsibilities include the implementation of the Clean Water Act Sections 301(h), 403(c), and 316 Programs in Region 2. These programs are related to ocean or thermal discharge impact assessment, water quality evaluation, biological assessment including bioaccumulation monitoring development and analysis. In addition, Dr. Chang serves as EPA Region 2's representative on EPA's Intake Structure Workgroup and Coral Reef Biocriteria Workgroup. Furthermore, as the Region's Aquatic Biologist, he is responsible for biological evaluation and assessment and has played a major role in the region's decision-making processes related to biological opinion, including issues on marine aquaculture, coral reef, biological monitoring, fish bioaccumulation, essential fish habitats, and invasive, threatened, and endangered species. Dr. Chang has taught environmental science–related courses as a visiting professor in the Fishery and Environmental Science Department of the National Taiwan Ocean University and the National Kaohsiung Marine University in Taiwan since 2000 and 2005, respectively. He has been an associate professor in the School of Earth and Environmental Science of the Queens College of the City University of New York since 2007.

Abstract

The New York City Commercial Market (CM) Seafood Study was undertaken by the U.S. Environmental Protection Agency (EPA; the New York Regional Office in collaboration with the Office of Research and Development) to measure mercury concentrations in composite samples of seafood species that are most commonly consumed by residents of the New York City metropolitan area.[1] The goal of this study is to provide objective information and descriptive statistics on the levels of mercury found in commonly consumed seafood species to support the New York City Department of Health and Mental Hygiene's (NYCDOHMH) public health message on seafood consumption, "Eat Fish, Choose Wisely."

This study was conducted in response to a Health and Nutritional Examination Survey (HANES) conducted by the NYCDOHMH, which included measurements of blood mercury concentration in a probability sample of 1811 New Yorkers selected to represent the age, gender, and ethnic composition of the adult population (McKelvey, 2007). The geometric mean (approximately equal to the median) concentration was elevated three-fold compared to national estimates. Asians registered unusually high blood mercury, with Chinese New Yorkers registering a geometric mean almost three times that of the overall sample value. An estimated 72% of Chinese New Yorkers had blood mercury attaining the New York State reportable level of 5 µg/L or above. Citywide, the HANES estimated that 1.4 million adults in New York City have blood mercury at or above the reportable level**.**

Samples of 33 commonly consumed species were obtained from the New Fulton Fish Market (Bronx, N.Y.), the largest commercial seafood market in the nation. Samples from the targeted species list were purchased from vendors operating in the market. For each species selected, multiple specimens from the

[1] McKelvey, W., R.C. Gwynn, N. Jeffery, D. Kass, L.E. Thorpe, R.K. Garg, C.D. Palmer, and P.J. Parsons. 2007. A biomonitoring study of lead, cadmium, and mercury in the blood of New York City Adults. *Environmental Health Perspectives 115*(10):1435–1441.

same vendor were combined to form a composite sample. Samples were analyzed for total mercury (Hg) concentrations. A small subsample was also analyzed for PCBs. This report presents statistics summarizing the measured mercury concentrations and places the measured concentrations within a public health context.

Samples were analyzed by accepted market name for each species, which is the name by which consumers typically purchase the seafood. Only three species (tuna, swordfish, and mahi-mahi) had an overall mean mercury concentration exceeding the most-stringent advisory (State of Maine - 0.2 ppm) identified in the report (note, however, that only a single mahi-mahi composite sample was analyzed). Shellfish, particularly bivalves (e.g., clams) and shrimp, had the lowest mercury concentrations. Blue crabs and hardshells had higher mercury concentrations than softshells, and wild-caught striped bass had higher mercury concentrations than farm-raised, hybrid striped bass. For most of the species analyzed, mercury concentrations did not vary by waterbody of origin. Because mercury bioaccumulates in fish tissue, older fish and fish higher in the food chain tend to have higher mercury concentrations, and this trend held true for many market names (species) in the CM samples. When mercury concentrations were correlated with total fish weight and length (as a proxy for age), length was a better predictor of mercury concentration.

The observed data were compared to four, health-based action levels:

- 0.2 mg/kg: Maine Action Level
- 0.3 mg/kg: EPA Screening Level
- 0.5 mg/kg: Florida/EU/Canada Action Level
- 1 mg/kg: U.S. Food and Drug Administration (FDA) Action Level

None of the measured mercury concentrations in the individual composite samples had concentrations that were higher than the FDA action level; however, tuna and swordfish had composite samples that exceeded the Maine Action level, the EPA Screening Level, and the Florida/EU/Canada Action Level, and their mean values exceeded the Maine Action level and the EPA Screening Level.

The data collected in this study were used to estimate recommended limits on the number of fish servings per week for adult women for each species sampled. This calculation was performed assuming a body weight of 65 to 67 kg and a serving size of 8 oz fresh weight (or 6 oz cooked weight), and employing the EPA Reference Dose (RfD) for methyl mercury of 0.1 ug/kg/day. Using the observed mean mercury concentrations, the results indicated that tuna, swordfish, and mahi-mahi should not be eaten weekly and should be eaten only a few times a month by adult women. Spanish mackerel, halibut, bluefish, Chilean sea bass, pollock, and monkfish can all be eaten weekly without exceeding recommended limits. Individuals who eat up to seven meals a week of fish or shellfish should select a diet of squid, mussels, rainbow trout, clams, salmon, scallops, and shrimp, which all permit seven or more servings per week under the conservative concentration assumption (i.e., mean composite concentration plus two standard deviations).

To place the measurements within the broader context of seafood mercury concentrations from across the United States, the CM species mean composite concentrations were compared to mean concentrations in FDA monitoring data collected from 1995 through 2004. This comparison showed that the CM mean concentrations tended to be lower than FDA mean concentrations, particularly for swordfish. However, it should also be noted that the mercury concentration in swordfish was based on a small sample size. Accordingly, recommendations on swordfish consumption in this report should be viewed with an appropriate degree of caution. The CM tuna mercury mean concentrations agreed to within 5% with the more recent FDA monitoring data.

A limited subsample (N = 50) was also analyzed for PCBs. The PCB analysis was constrained by the limited resources of the EPA Region 2 laboratory, which conducted all the mercury and PCB analyses for this study. Unlike the case for mercury, the limited PCB analysis was opportunistic rather than public health driven because the NYCDOHMH HANES did not obtain biomonitoring data for PCBs.

Additionally, the FDA has reported a steady decline in PCBs levels in its Market Basket Surveys (personal communication with Dr. Michael Bolger, U.S. FDA). Consequently, PCB analysis was limited to 50 samples across five species (e.g., salmon, crab, tuna, catfish and mackerel), thus precluding a detailed statistical analysis.

This study also made use of recent advances in DNA sequencing technology. "DNA barcoding" has emerged as a useful taxonomic tool that can help overcome some of the issues associated with morphology-based identifications. Barcoding uses a short genetic sequence from a standard part of the genome in an attempt to accurately assign a specimen to a given taxon, ideally, a species. Such an assignment can be made by examining a genomic region that exhibits a high degree of sequence conservation within a species, but appreciable divergence compared to other species. DNA sequencing of a portion of the cytochrome C oxidase subunit 1 (cox1) gene was performed by EPA's Office of Research and Development laboratory in Cincinnati.

Generally, three individual fish of the same species were collected from a vendor to make up a composite sample for mercury analysis. In cases where the three were whole fish, the project plan called for only one of the three to have their DNA sequenced. In the case of fillets, however, all three samples were sequenced. Employing this plan yielded a list of 288 samples for DNA analysis. Results were successfully obtained and reported for 284 of the 288 samples. DNA samples were initially sequenced and "DNA identified" blindly, and the results submitted to EPA Region 2 for comparison to market names of the fish. Overall, there was concordance between the DNA-based results and the market names; however, in cases where there appeared to be a significant difference, DNA reanalysis of samples was done to confirm or refute the earlier results. In total, 27 samples were reanalyzed. In five of these cases, the "DNA ID" was changed after reanalysis and the final result agreed with the morphologically derived result.

Tissue Analysis for Mercury and PCBs from a New York City Commercial Seafood Market

Moses C. Chang Ph.D.
Aquatic Biologist
U.S. EPA R2

2009 National Forum on Contaminants in Fish
Portland, Oregon, November 2–5

Why NYC Commercial Seafood Market Study?

- New York City Health and Nutrition Examination Survey - "**NYC HANES**"
- General Population Getting Seafood from the largest NYC Seafood Wholesale Source

Goals of EPA Fish Tissue Study

- Determine the Hg concentration in a sample of the 20 most commonly consumed seafood species consumed by New Yorkers
- Determine the PCBs concentration in a sample of the 5 species which are potentially high with PCBs
- Provide an empirical tool to support NYCDOHMH's public health message "Eat Fish, Choose Wisely"

EPA Hg Fish Tissue Study (Sampling)

- **Fulton Fish Market (NYC)**
  - Largest wholesale market in the US
  - 22* most commonly consumed species of fin and shell fish
  - Composite of 3 specimens per sample for most species
  - Target sample size (N = 10 - 15)
  - Super samples for small species (e.g., shrimp, clams, crabs)

* Additional species collected but constrained by small (<4) sample size

New Fulton Fish Market since 2005
(Fulton Fish Market since 1807)

- http://www.newfultonfishmarket.com/

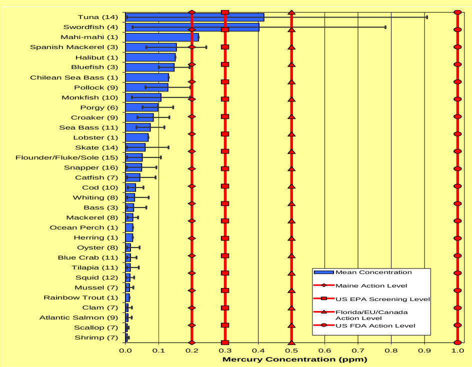
EPA Fish Tissue Study (Analysis)

- Hg and subset of 5 species analyzed for PCBs
- Hg and PCBs performed by EPA R2's Edison Lab
- Composite of 3 specimens per sample, more for super samples
- Edible tissue
  - soft shell crab – whole specimen
  - blue claw crab – muscle tissue only
- DNA sequencing on representative specimen from all samples

DNA Sequencing Technology

- Genetic Sequence from a genome
- DNA Barcoding
- Cytochrome C Oxidase subunit 1 (cox1)
- Accurately assign a specimen to a given species
- Performed by EPA's ORD Lab in Cincinnati

Hg Results



Risk Communication

- Propose arraying species into bins as per NYCDOHMH pamphlet (for pregnant and breastfeeding women and children)
- Estimated Allowed Serving - ounces per week allowed based on tissue concentration and allowable intake as per the RfD for HgCH3

Table 14. Estimated Allowed Servings per Week for an Adult Female Based on Mercury Concentrations by Market Name[a]

Market Name of Species	Mean Mercury (mg/kg)	Mean Mercury Plus Two Standard Deviations (mg/kg)	Allowed Servings per Week using Mean Mercury	Allowed Servings per Week using Mean Mercury Plus Two Standard Deviations
Tuna *	0.42	0.91	0	0
Swordfish *	0.40	0.78	0	0
Mahi-mahi *	0.22	N/A	0	N/A
Spanish Mackerel	0.15	0.24	1	0
Halibut	0.15	N/A	1	N/A
Bluefish	0.15	0.19	1	1
Chilean Sea Bass	0.13	N/A	1	N/A
Pollock	0.13	0.20	1	1
Monkfish	0.11	0.19	1	1

[a] Estimates were predicted using the following exposure assumptions: Serving size = 8 ounces of fish fresh weight, Adult female weight = 65 kg, RfD for methyl mercury = 1×10^{-4} mg/kg/day (U.S. EPA IRIS database), and the person consumes only the one type of fish or shellfish.
* These concentrations yield estimates indicating less than one serving a week can be eaten by an adult female; however, they correspond to two servings per month for tuna and swordfish and four servings per month for mahi-mahi, assuming 30 days in a month.

Estimated Allowed Serving – By adult women: None or Less than weekly – tuna, swordfish, mahi-mahi

Thunnus albacares - Yellowfin Tuna

Estimated Allowed Serving – By adult women: None or Less than weekly – tuna, swordfish, mahi-mahi

Xiphias gladius - Swordfish

Estimated Allowed Serving – By adult women: None or Less than weekly – tuna, swordfish, mahi-mahi

Coryphaena hippurus - Mahi-Mahi

Table 14. Estimated Allowed Servings per Week for an Adult Female Based on Mercury Concentrations by Market Name [a]

Market Name of Species	Mean Mercury (mg/kg)	Mean Mercury Plus Two Standard Deviations (mg/kg)	Allowed Servings per Week using Mean Mercury	Allowed Servings per Week using Mean Mercury Plus Two Standard Deviations
Porgy	0.098	0.14	2	1
Croaker	0.084	0.13	2	1
Sea Bass	0.075	0.12	2	1
Lobster	0.069	N/A	2-3	N/A
Skate	0.060	0.13	3	1
Flounder / Fluke / Sole	0.051	0.11	3-4	1
Snapper	0.049	0.093	4	2
Catfish	0.044	0.091	4	2
Cod	0.031	0.054	6	3
Whiting	0.028	0.070	7	2
Bass	0.025	0.063	8	3

Estimated Allowed Serving – By adult women: Weekly – Spanish mackerel, halibut, Chilean sea bass, pollock, monkfish

Dissostichus eleginoides - Chilean Sea Bass

Estimated Allowed Serving – By adult women: Weekly – Spanish mackerel, halibut, Chilean sea bass, pollock, monkfish

Lophius americanus - Monkfish

Table 14. Estimated Allowed Servings per Week for an Adult Female Based on Mercury Concentrations by Market Name [a]

Market Name of Species	Mean Mercury (mg/kg)	Mean Mercury Plus Two Standard Deviations (mg/kg)	Allowed Servings per Week using Mean Mercury	Allowed Servings per Week using Mean Mercury Plus Two Standard Deviations
Ocean Perch	0.022	N/A	8-9	N/A
Herring	0.022	N/A	9	N/A
Oyster	0.015	0.043	13	4
Blue Crab	0.015	0.033	13	5-6
Tilapia	0.014	0.040	13-14	5
Squid	0.014	0.026	14	7
Mussel	0.012	0.024	16	8
Rainbow Trout	0.012	N/A	16-17	N/A
Clam	0.0081	0.020	24-25	10
Atlantic Salmon	0.0081	0.019	24-25	10
Scallop	0.0055	0.0099	36-37	20
Shrimp	0.0054	0.010	36-38	19

[a] Estimates were predicted using the following exposure assumptions: Serving size = 8 ounces of fish fresh weight, Adult female weight = 65 kg, RfD for methyl mercury = 1×10^{-4} mg/kg/day (U.S. EPA IRIS database), and the person consumes only the one type of fish or shellfish.

* These concentrations yield estimates indicating less than one serving a week can be eaten by an adult female; however, they correspond to two servings per month for tuna and swordfish and four servings per month for mahi-mahi, assuming 30 days in a month.

Estimated Allowed Serving – By adult

Women: Daily - squid, mussels, rainbow trout, clams, Tilapia, Atlantic salmon, scallops, shrimp

Salmo salar - Atlantic Salmon

Estimated Allowed Serving – By adult

Women: Daily - squid, mussels, rainbow trout, clams, Tilapia, Atlantic salmon, scallops, shrimp

Oreochromis niloticus niloticus - Tilapia

Estimated Allowed Serving – By adult

Women: Daily - squid, mussels, rainbow trout, clams, Tilapia, Atlantic salmon, scallops, shrimp

Oncorhynchus mykiss - Rainbow Trout

Estimated Allowed Serving – By adult

Women: Daily - squid, mussels, rainbow trout, clams, Tilapia, Atlantic salmon, scallops, shrimp

penaeus vannamei - White Shrimp

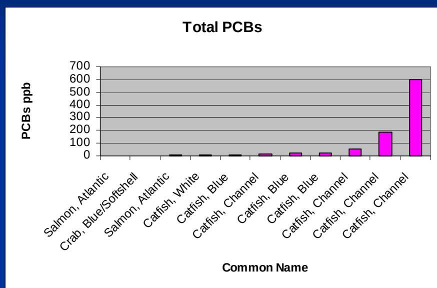
PCBs results

- Limited PCBs Analysis (N=50)
- 5 Species (salmon, crab, tuna, catfish, and mackerel)
- Large portion of non detects preclude a statistical analysis
- PCBs were detected in all 8 catfish, 1 blue crab and 2 Atlantic salmon

PCBs results

Count of result value	Detect_flag		
Common Name	N	Y	Grand Total
Catfish, Blue		3	3
Catfish, Channel		4	4
Catfish, White		1	1
Crab, Blue/Hardshell	6		6
Crab, Blue/Softshell	3	1	4
Mackerel, Atlantic	7		7
Mackerel, Spanish	3		3
Salmon, Atlantic	8	2	10
Scallop, Sea	1		1
Swordfish	1		1
Tuna, Bigeye	7		7
Tuna, Yellowfin	3		3
Grand Total	**39**	**11**	**50**

PCBs results



Biokinetic Model for Methylmercury

- Based on the 1-compartment model proposed by Clarkson et al. (1988), the steady state concentration of mercury in blood (µg/L), in an adult woman (bw=60 kg) who ingests methylmercury in the diet daily, will be approximately 0.95 x daily dose (µg Hg/day).
- Assumptions are:
- Absorption fraction (AF)=0.95
- Blood fraction of absorbed dose (BF)= 0.05
- Blood volume (BV) = 4.2L (0.07 x bw)
- Elimination rate coefficient (ke) = 0.014 d^-1
- Dosing interval (DI)= 1 d
- Dose (D) = X ug
- Css = (D x AF x BF)/(ke*BV*DI)
- Clarkson et al. 1988. In Biological Monitoring of Metals. Clarkson et al (eds). Plenum Press: NY. ISBN 0-306-42809-1

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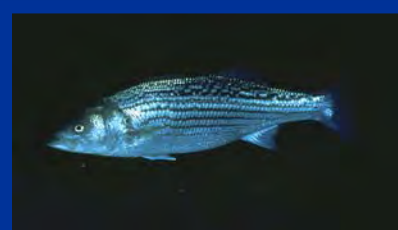
- Cheryl Itkin, EPA ORD DC
- Mike Borst, EPA R2 Edison
- John Bourbon, EPA R2 Edison
- Beverly Comfort, EPA RTP
- Carolyn Esposito, EPA Edison
- John Martinson, EPA ORD CI
- Wendy McKelvey, NYC DOHMH

Questions?

- *Morone saxatilis* Striped bass



For a copy of the final report, e-mail: Chang.Moses@epa.gov

Mercury in the North Pacific Ocean: Implications for Fisheries

Elsie M. Sunderland, Harvard University School of Engineering and Applied Sciences, Cambridge, MA
David P. Krabbenhoft, United States Geological Survey, Middleton, WI
John Moreau, School of Earth Sciences, University of Melbourne, Melbourne, Australia
Sarah Strode, Department of Atmospheric Sciences, University of Washington, Seattle, WA
William Landing, Department of Oceanography, Florida State University, Tallahassee, FL

Biosketch

Dr. Elsie Sunderland (Ph.D.) is a research associate in the Harvard School of Engineering and Applied Sciences and the Harvard School of Public Health. Her work focuses on developing and applying environmental models to better quantify interactions between the atmosphere and terrestrial/aquatic ecosystems and understanding how these interactions affect human exposure and economic endpoints used in regulatory decision making. From 2003–2008, Dr. Sunderland worked for EPA's Office of Research and Development in Washington, DC. While at EPA, Dr. Sunderland worked with the Council for Regulatory Environmental Modeling, a cross-agency body that promotes consistency and consensus in the Agency's use of models to support regulatory decisions. Dr. Sunderland is one of the principal authors of the Agency's guidelines for environmental modeling. Her research focuses on characterizing relationships between anthropogenic mercury, changes in ambient environmental concentrations at a variety of scales, and human exposure. EPA recognized Dr. Sunderland's research by awarding her a gold medal in 2005 and a Level I Scientific and Technological Achievement Award in 2008. Dr. Sunderland received her Ph.D. in Environmental Toxicology from the School of Resource and Environmental Management at Simon Fraser University, Canada, and her B.Sc. from McGill University, Canada.

Abstract

Fish harvested from the Pacific Ocean are a major contributor to human methylmercury (MeHg) exposure. Limited oceanic mercury (Hg) data, particularly MeHg, has confounded our understanding of linkages between sources, methylation sites, and concentrations in marine food webs. Here, we present methylated (MeHg and dimethylmercury [Me_2Hg]) and total Hg concentrations from 16 hydrographic stations in the eastern North Pacific Ocean. We use these data with information from previous cruises and coupled atmospheric–oceanic modeling results to better understand controls on Hg concentrations, distribution, and bioavailability. Total Hg concentrations (an average of 1.14 ± 0.38 pM) are elevated relative to previous cruises. Modeling results agree with observed increases and suggest that current atmospheric Hg deposition rates and basin-wide Hg concentrations will double, relative to circa 1995, by 2050. Methylated Hg accounts for up to 29% of the total Hg in subsurface waters (an average of 260 ± 114 fM). We observed lower ambient methylated Hg concentrations in the euphotic zone and in older, deeper water masses, which likely result from the decay of MeHg and Me_2Hg when net production is not occurring. We found a significant, positive linear relationship between methylated Hg concentrations and the rates of organic carbon remineralization ($r^2 = 0.66$, $p < 0.001$). These results provide evidence for the importance of particulate organic carbon (POC) transport and remineralization on the production and distribution of methylated Hg species in marine waters. Specifically, settling POC is a source of inorganic Hg(II) in microbially active subsurface waters and can provide a substrate for microbial activity facilitating water column methylation.

MERCURY IN THE NORTH PACIFIC OCEAN: IMPLICATIONS FOR FISHERIES

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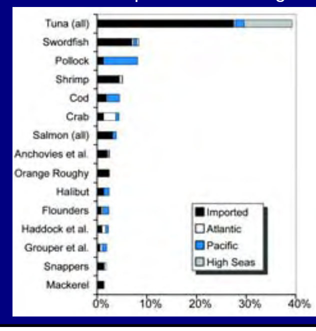
John Moreau, University of Melbourne, AU
Sarah Strode, University of Washington, USA
William Landing, Florida State University, USA

Oceanic Hg sources and cycling remains poorly defined yet >90% of population-wide Hg exposure in the US is from consumption of estuarine & marine fish (Sunderland, 2007)

Fraction of Population-Wide Hg Intake (%)



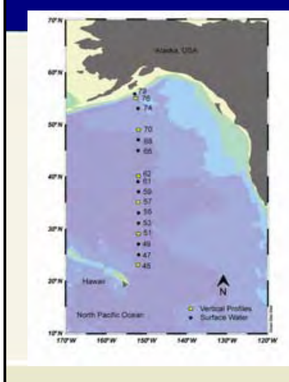
U.S. Population-Wide Hg Intake

~200 kg MeHg per year consumed in fish and shellfish

	% MeHg Intake
Fresh & Farmed	14.9%
Nearshore Marine	7.9%
North Atlantic >55N	6.5%
Atlantic	14.7%
North Pacific >30N	29.5%
Pacific/Indian <30N	25.4%
Mediterranean	1.0%
Antarctic	0.1%
Total	100.0%

Data Sources: Sunderland, 2007, NMFS 2000-2006, UNFAO 2000-2006

P16N Cruise Track (March 10-30, 2006)



Research Questions

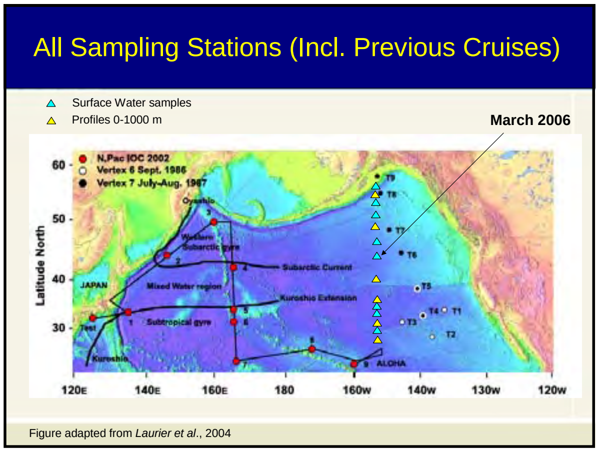
- Are mercury concentrations in ocean waters tracking trends in atmospheric mercury deposition?
- How long will it take for the North Pacific to respond to changing atmospheric Hg emissions?
- What are the likely effects of future changes in anthropogenic emissions and climate on Hg accumulation and bioavailability?
- What are the likely tredns in marine fish MeHg levels?

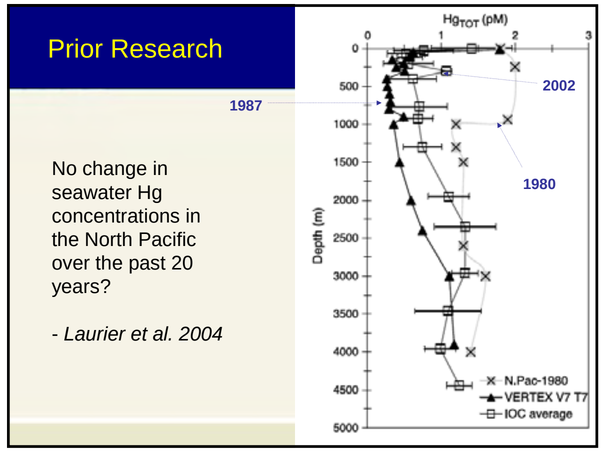
Modeling Tools Applied

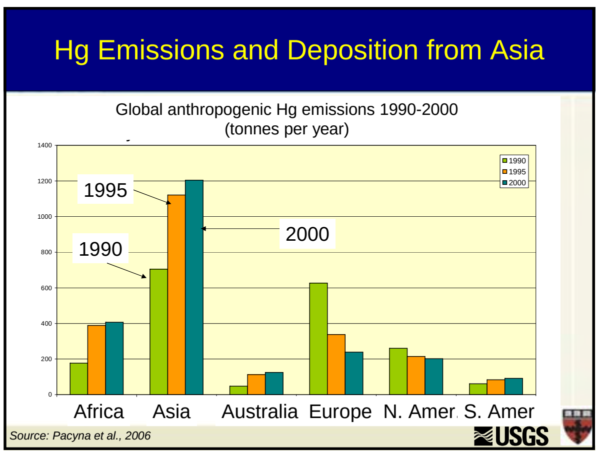
GEOS-Chem Global Atmospheric Chemistry Model (Selin et al., 2007, *JGR-Atm.*)
- Including a Surface Ocean Slab Model (Strode et al., 2007, *GBC*)
- Tagged tracer results (*Strode et al*., 2008, *JGR-Atm.*)

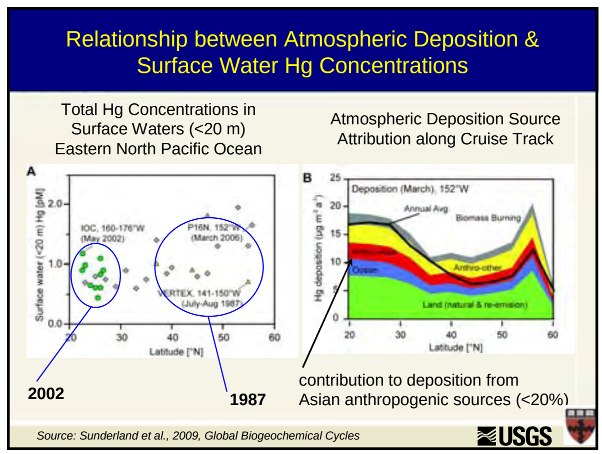
Intermediate & Deep Ocean Model
- *Sunderland & Mason* (2007, *GBC*)

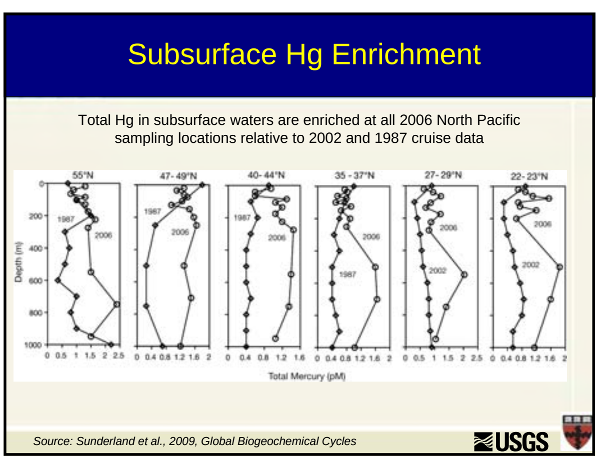
Comparison to other N. Pac. cruise data
- NPAC 1980
- VERTEX 1987
- IOC 2002

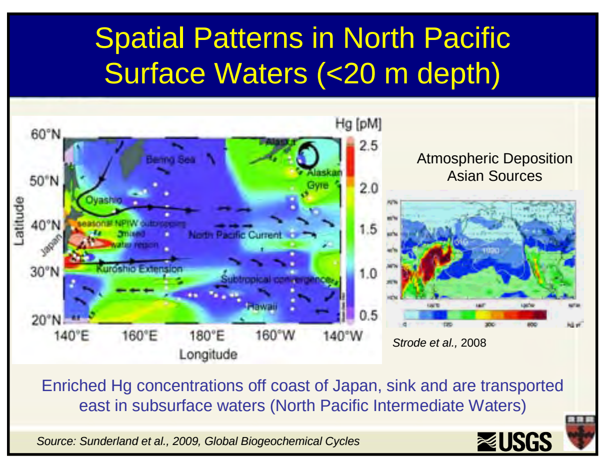

All Sampling Stations (Incl. Previous Cruises)
Surface Water samples
Profiles 0-1000 m
March 2006
N.Pac IOC 2002
Vertex 6 Sept. 1986
Vertex 7 July-Aug. 1987
Latitude North
Oyashio
Western Subarctic gyre
Subarctic Current
JAPAN
Mixed Water region
Kuroshio Extension
Subtropical gyre
Kuroshio
ALOHA
120E
140E
160E
180
160w
140w
130w
120w
Figure adapted from Laurier et al., 2004

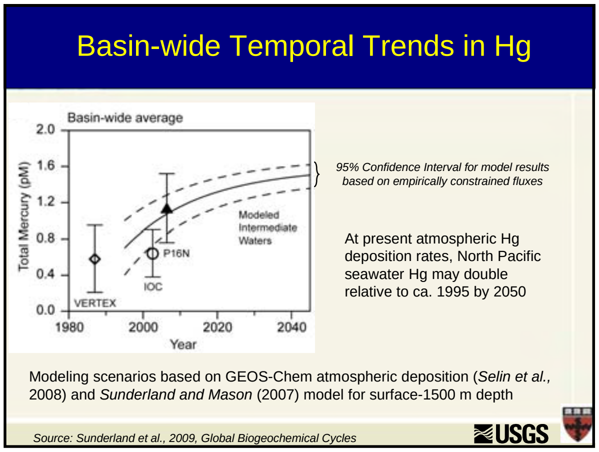

Prior Research
No change in seawater Hg concentrations in the North Pacific over the past 20 years?
- Laurier et al. 2004
1987
2002
1980
Depth (m)
N.Pac-1980
VERTEX V7 T7
IOC average

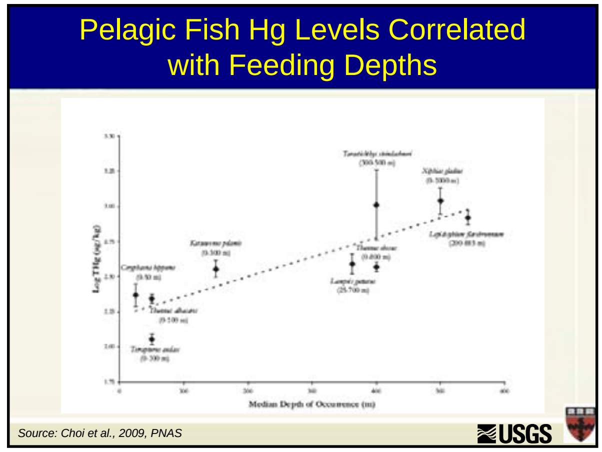

Hg Emissions and Deposition from Asia
Global anthropogenic Hg emissions 1990-2000
(tonnes per year)
1995
1990
2000
Africa
Asia
Australia
Europe
N. Amer.
S. Amer
Source: Pacyna et al., 2006
USGS

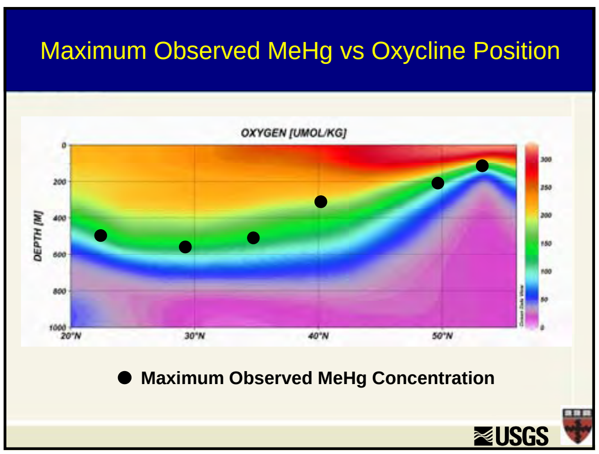

Relationship between Atmospheric Deposition & Surface Water Hg Concentrations
Total Hg Concentrations in Surface Waters (<20 m)
Eastern North Pacific Ocean
Atmospheric Deposition Source Attribution along Cruise Track
2002
1987
contribution to deposition from Asian anthropogenic sources (<20%)
Source: Sunderland et al., 2009, Global Biogeochemical Cycles
USGS

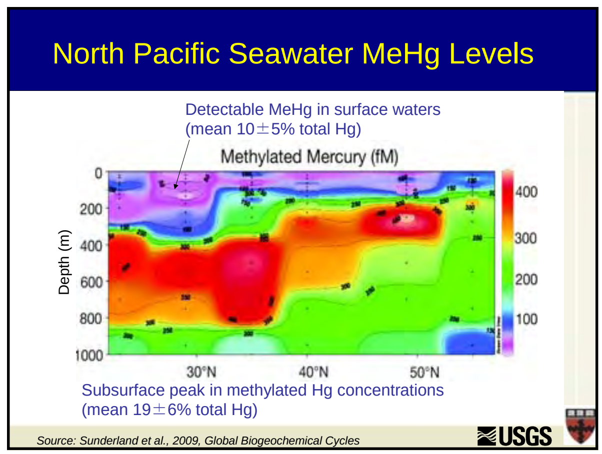

Subsurface Hg Enrichment
Total Hg in subsurface waters are enriched at all 2006 North Pacific sampling locations relative to 2002 and 1987 cruise data
Total Mercury (pM)
Source: Sunderland et al., 2009, Global Biogeochemical Cycles
USGS

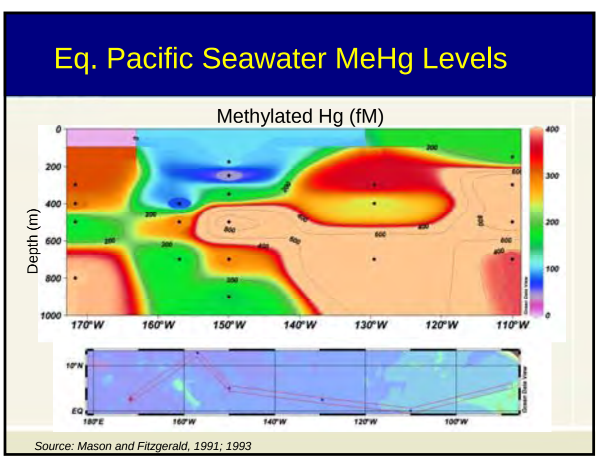

Spatial Patterns in North Pacific Surface Waters (<20 m depth)
Hg [pM]
Latitude
Longitude
Bering Sea
Alaskan Gyre
Oyashio
North Pacific Current
Kuroshio Extension
Subtropical convergence
Hawaii
Atmospheric Deposition Asian Sources
Strode et al., 2008
Enriched Hg concentrations off coast of Japan, sink and are transported east in subsurface waters (North Pacific Intermediate Waters)
Source: Sunderland et al., 2009, Global Biogeochemical Cycles
USGS

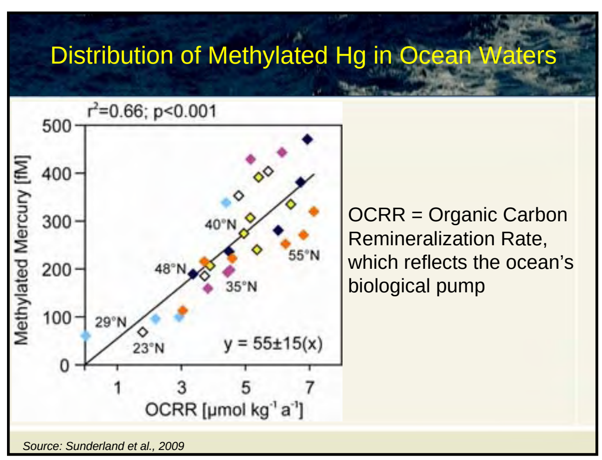

Basin-wide Temporal Trends in Hg
Basin-wide average
Total Mercury (pM)
2.0
1.6
1.2
0.8
0.4
0.0
VERTEX
P16N
IOC
Modeled Intermediate Waters
1980
2000
2020
2040
Year
95% Confidence Interval for model results based on empirically constrained fluxes
At present atmospheric Hg deposition rates, North Pacific seawater Hg may double relative to ca. 1995 by 2050
Modeling scenarios based on GEOS-Chem atmospheric deposition (Selin et al., 2008) and Sunderland and Mason (2007) model for surface-1500 m depth
Source: Sunderland et al., 2009, Global Biogeochemical Cycles
USGS


Pelagic Fish Hg Levels Correlated with Feeding Depths
Median Depth of Occurrence (m)
Source: Choi et al., 2009, PNAS
USGS


Maximum Observed MeHg vs Oxycline Position
OXYGEN [UMOL/KG]
DEPTH [M]
20°N
30°N
40°N
50°N
Maximum Observed MeHg Concentration
USGS


North Pacific Seawater MeHg Levels
Detectable MeHg in surface waters (mean 10±5% total Hg)
Methylated Mercury (fM)
Depth (m)
0
200
400
600
800
1000
30°N
40°N
50°N
400
300
200
100
Subsurface peak in methylated Hg concentrations (mean 19±6% total Hg)
Source: Sunderland et al., 2009, Global Biogeochemical Cycles
USGS


Eq. Pacific Seawater MeHg Levels
Methylated Hg (fM)
Depth (m)
170°W
160°W
150°W
140°W
130°W
120°W
110°W
Source: Mason and Fitzgerald, 1991; 1993


Distribution of Methylated Hg in Ocean Waters
r^2=0.66; p<0.001
Methylated Mercury [fM]
500
400
300
200
100
0
40°N
55°N
48°N
35°N
29°N
23°N
y = 55±15(x)
1
3
5
7
OCRR [μmol kg^{-1} a^{-1}]
OCRR = Organic Carbon Remineralization Rate, which reflects the ocean's biological pump
Source: Sunderland et al., 2009

Summary

- Total Hg concentrations in North Pacific subsurface waters elevated relative to previous cruises.
- Potential increase in integrated seawater profile concentrations are supported by results from intermediate/deep ocean model.
- Likely cause is enhanced Hg(II) deposition in Asian coastal waters and transport in intermediate water circulation (NPIW).
- Maximal methylated Hg concentrations in low oxygen subsurface waters with high levels of bacterial activity.
- Positive linear relationship between methylated Hg and organic carbon remineralization rates.

USGS

Acknowledgements

- USGS Toxics Program, NSF Chemical Oceanography, Analytical support from John De Wild, Tom Sabin and Shane Olund

Questions and Answers

Q. *Are mercury concentrations lower in fish in the southern hemisphere? Would you expect lower concentrations?*

A. We are collecting more data to try to answer these types of questions. We do not have enough data yet, but one study that hasn't been published yet is showing similar data. The data is spatially varied.

Q. *Can you speculate on what's happening in the troposphere?*

A. Once elemental mercury is in the troposphere, it has about a one-year lifetime. The contribution of Asian mercury sources is important, but all sources are well mixed. The local aspect is generally the fraction released as divalent mercury or particulate matter.

Q. *Can you make some suggestions as to what EPA should be doing with regard to the work you've done?*

A. Currently, only 0.6 FTE are dedicated to mercury research in EPA Office of Research and Development (ORD). Mercury is still a regulatory issue and there are excellent people that are not being utilized. Also, marine issues are very important and should be more heavily investigated.

Q. *There are very high mercury concentrations in the North Pacific region. Could the sparseness of the North Pacific biological system be affecting the concentrations (i.e., there is diminished biotic uptake in the area)? The biological affinity of mercury is so great that it seems the mercury would be taken up by the biota.*

A. I wouldn't agree that a huge fraction of mercury is always contained in the biota, because the biota first has to be exposed to the mercury. You have to have transfer from the sediment to the water column. I think it's a function of different production characteristics in the area.

A Comparison of Non-Lethal Techniques for the Measurement of Mercury in Fish Tissue

Kristofer R. Rolfhus, Chemistry Department, University of Wisconsin–La Crosse, La Crosse, WI

Biosketch

Mr. Kristofer Rolfhus is a professor in the Department of Chemistry at the University of Wisconsin-La Crosse, where he has taught general, analytical, and environmental chemistry courses for the past 8 years. His research interests are focused on the biogeochemical cycling of mercury in the environment, ranging from marine systems to soils to food webs. His earlier work focused on making chemical speciation measurements of mercury in the open ocean and in the coastal waters and, more recently, on the Lake Superior system and National Parks of the Upper Midwest. Current investigations are focusing on the effects of periodic inundation on the rates of methylmercury synthesis in soils and sediment, as well as the trophic transfer of mercury in the lower food web of aquatic ecosystems.

Abstract

Contamination of fishery resources with methylmercury is of widespread concern because consumption of fish is the principal pathway of human exposure to this highly toxic contaminant. Health risks of methylmercury exposure have prompted the issuance of fish consumption advisories in most U.S. states and Canadian provinces and led to the establishment of sampling and analytical programs to assess mercury (Hg) contamination of fish. Existing approaches for monitoring Hg in sport fishes involve the dissection of sampled fish and the subsequent analysis of axial muscle tissue or edible fillets, which is a substantial process that requires the removal of analyzed fish from the sampled population. Therefore, alternative approaches for non-lethal, non-invasive sampling for monitoring Hg in game fish that minimize sampling effort and disturbance are desirable.

Several non-lethal methods have been evaluated against fillet Hg content in fish. These methods include clipping fins, conducting tissue biopsies (needle and punch), drawing blood, and collecting scales. Several confounding factors potentially add variability to such procedures, including surficial contamination of the tissue, partitioning of Hg within an organism and sub-sample, species specificity, and regional variation. Some techniques are more accurate than others, and method selection ultimately depends on such issues as cost, ease of use, and the desired level of predictive power within a sampled system.

A Comparison of Non-lethal Techniques for the Measurement of Mercury in Fish Tissue

Kristofer Rolfhus
Chemistry Department/River Studies Center
University of Wisconsin-La Crosse

Why the interest in Mercury?

- Human health
  - Neurotoxicity of methylmercury
  - Fetal development (600,000 at risk in US; K. Mahaffey)
  - Nearly all states have consumption advisories
- Mobility in the environment
  - Atmospheric deposition
  - Reactivity and chemical speciation
  - Landscapes, food webs
- Bioaccumulation through food webs
  - 6-7 orders of magnitude (water to fish)
- Anthropogenic forcing
  - Currently est. 50-75% emissions, approx 3-5x baseline

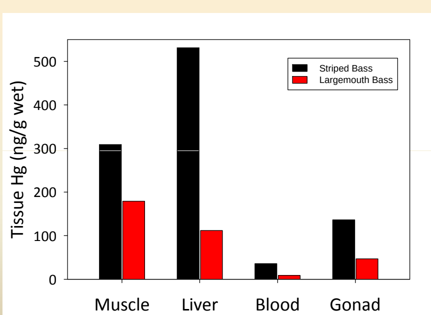
Rationale for Non-Lethal Measurement

- Disadvantages of whole fish collection:
  - Cost, time, effort, space requirements
  - Direct and indirect effects on food web structure
- Potential for repeated measures (temporal studies) and larger sample sizes
- Some tissues are already being routinely collected (or perhaps easily initiated)

Potential Sources of Hg Variation to Proxy Methods

- Differential partitioning into tissues (biopsy, fin, scale)
- Chemical form of mercury with distribution in tissues (fin, scale)
- Surficial contamination of tissues (fin, scale)
- Survival of organism for repeated measures, ecological concern (biopsy)
- Analytical variables (blood, scale)
- Temporal variability (blood)

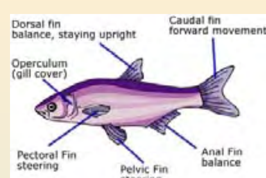
Differences in Tissues



Lake Mead, USA (Cizdziel et al., 2003)

Fin Clipping

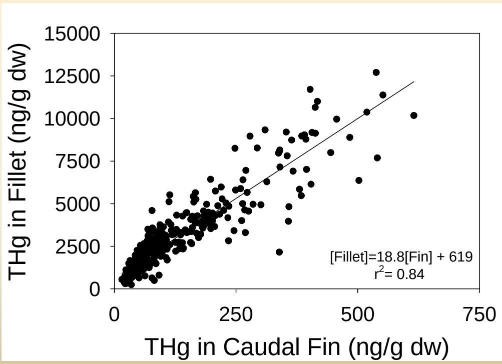
Rolfhus et al. (2008):



- 401 Northern Pike, 79 Walleye, 19 Arctic Grayling, 14 Winter Flounder
- Fins were 83% methylmercury
- Total Hg in fins ranged from 2.7-8.9% of fillet total Hg
  Mean % similar between lakes/species
- Individual lake correlations vary: r^2=0.13 to 0.96, median r^2=0.56
- Walleye: pelvic fin vs axial muscle r^2=0.63, caudal fin r^2=0.73
- Northern Pike: caudal fin r^2=0.84 (2 outliers), 40-50 cm length r^2=0.95

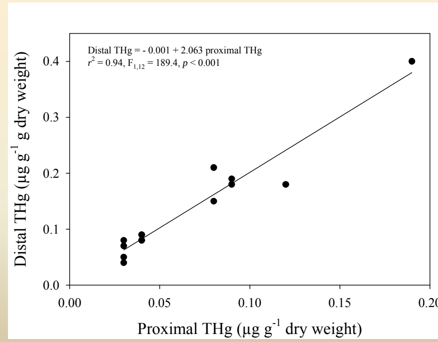
Fin Clipping

Northern Pike Caudal Fin



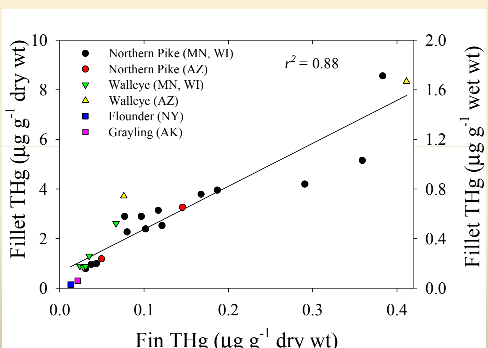
Fin Clipping

2x as much THg in Distal Fin Tissue



Fin Clipping

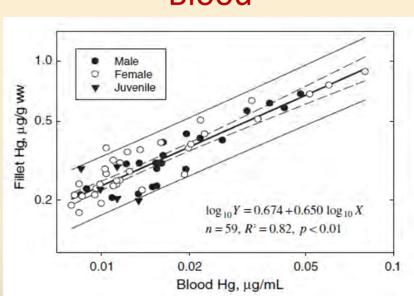
Across Region and Species



Blood

- < 1 mL taken
- Heparinized (anti-coagulant) needle and syringe
- Caudal veinipuncture

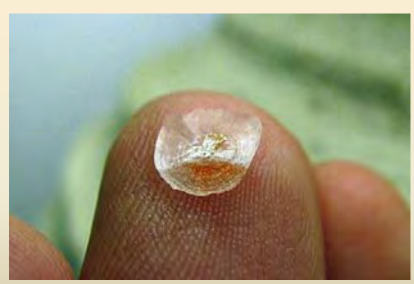
Blood



Schmitt and Brumbaugh (2007)

- 62 Smallmouth Bass from southeastern Missouri rivers, r^2 from 0.82 to 0.92
- Similar to Cizdziel et al. (2003), r^2 from 0.73 to 0.94

Scales

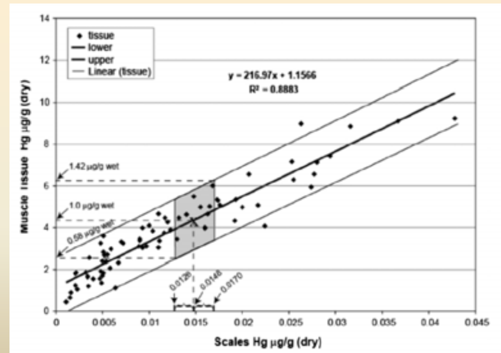


Scales

- Lake et al. (2006):
  76 Largemouth Bass from interior Rhode Island
- 4-15 scale composites, Precision: mean % CV=7%
- Tested pre-cleaning treatments to reduce variability
- Pilot study treatments (scales vs muscle tissue):

	r^2	Hg (ng/g dry)
no treatment:	0.74	77
cold DI water wash:	0.78	26
warm DI water wash:	0.81	16
detergent solution:	0.77	15
soap solution:	0.90	15

Scales



Lake et al. (2006)

Axial Muscle Biopsy

Biopsy Needle
14 gauge
50 mg tissue

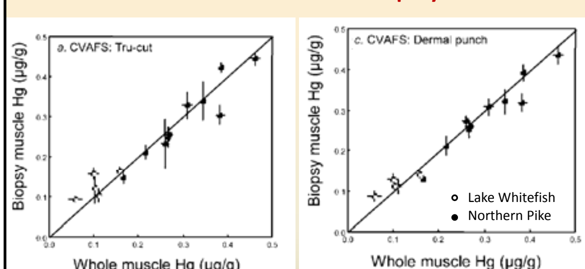
Dermal punch
4-6 mm diam.
100-250 mg tissue

…wounds closed with sterile tissue adhesive (e.g., Nexaband)

Axial Muscle Biopsy

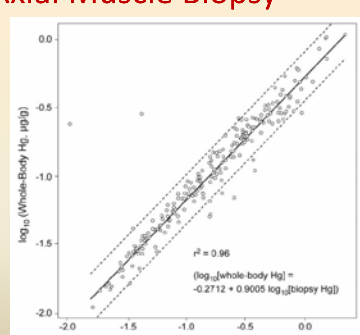
(Photo courtesy Paul Blanchfield)

Axial Muscle Biopsy



Baker et al (2004):
- Slopes within 6% of dissection procedure, r^2 between 0.93-0.97
- Precision was not statistically different between needle/punch/dissection—also observed by Schmitt and Brumbaugh (2007)…< 2.5 %CV
- Punch required more time, effort than needle (40 s versus 10 s)

Axial Muscle Biopsy



Peterson et al. (2004):
Tissue plugs from 13 different species from 12 western US states, n=208

Axial Muscle Biopsy

- Tissue Partitioning: dorsal muscle area best predictor
  Pearson (2000), Cizdziel et al. (2002)
- Survival: No drop in survival relative to controls:
  - Dermal punch:
    Tyus et al. (1999), Waddell and May (1995), Hamilton et al. (2002), Baker et al. (2004)
  - Biopsy needle:
    Uthe (1971), Baker et al. (2004)

Analytical Issues

Which chemical form should be analyzed? Total Hg.

- Piscivores generally contain > 95% of total mercury as methylmercury
  Methylmercury analysis more expensive, laborious than total mercury (2-fold)
- Sample Precision: Biopsy and Blood 2-4% CV, Scales 7%, Fins 8%
- Automation—new analyzers and techniques
  - CVAFS vs CVAAS precision issues
  - Total Hg: autosampler combustion analysis with catalyst ($40 k)
  - Methylmercury: autosampler ethylation technique ($50 k)

Dermal Punch
- Best correlations, easy to perform
- Cleaning of instruments, cross-contamination, sealing wounds

Biopsy Needle
- Best correlation, easy to perform
- Collecting enough analytical mass, sealing wounds

Blood
- Correlations not quite as good as tissue biopsy
- More difficult to perform
- [Hg] can be near analytical LOD

Scales
- Easy to collect
- Weaker correlation, lower precision (location on the body?)
- Potential for contamination

Fins
- Easy to collect, at least partial re-growth
- Weaker correlation, lower precision
- Potential for contamination, partitioning

…Which Method to Use?

…it depends upon your study question and how much time/effort afforded

1) Prediction for individual fish: biopsy, blood

2) Screening studies for water bodies, regions:
   all techniques, including scales and fins

Dermal punch > Biopsy needle > Blood > Fins = Scales

Acknowledgments

Co-authors: Mark Sandheinrich, James Wiener, Sean Bailey, Kristen Thoreson, Chad Hammerschmidt
Wisconsin Focus on Energy Research Program
Great Lakes Indian Fish and Wildlife Commission (GLIFWC)
National Parks Service

Section II-D
Risk Assessment and Toxicology

Moderator:

Randall Manning, Georgia Department of Natural Resources

Dr. Randall O. Manning (Ph.D.) is the Coordinator of the Environmental Toxicology Program in the Georgia Department of Natural Resources, Environmental Protection Division. He received a Ph.D. in 1986 from the University of Georgia, and served as a Postdoctoral Research Associate and an Assistant Research Scientist in the Department of Pharmacology and Toxicology at the University of Georgia from 1986 to 1990. His interest in fish consumption advisories began in 1991 when he coordinated the development of guidelines for a fish-monitoring strategy and risk-based advisories for Georgia. Continuing interests include uncertainties regarding fish consumption rates and patterns and potential benefits from fish consumption as they relate to risk communication. Dr. Manning is a member of the Society of Toxicology and a Diplomate of the American Board of Toxicology. He also holds adjunct appointments in the Departments of Pharmaceutical and Biomedical Sciences in the College of Pharmacy at the University of Georgia, and Environmental and Occupational Health at Emory University's Rollins School of Public Health.

Presentations

Updates to Michigan's Fish Screening Levels Using References Doses, Starting with Toxaphene

Jennifer Gray, Michigan Department of Community Health

Toxicology of Perfluoroalkyl Acids

Christopher Lau, Office of Research and Development, U.S. EPA

U.S. EPA's Provisional Health Advisory Values for PFOA and PFOS

Joyce Donohue, Health and Ecological Criteria Division, Office of Water, U.S. EPA

Comparability and Standardization of Methods for PFC Analysis in Fish Fillets

Michelle Malinsky, 3M Environmental Laboratory

PFCs in Fish—Data Presentations Followed by Questions and Answers Panel Discussion

Moderator: Randall Manning, Georgia Department of Natural Resources

PFCs in Fish—Introduction and Survey Results

Randall Manning

Minnesota and Wisconsin Data, Minnesota Fish Consumption Advisory

Pat McCann, Minnesota Department of Health

Southeast Data

Neil Sass, Alabama Department of Public Health

Washington Data

Chad Furl, Washington State Department of Ecology

Delaware River Basin Commission Data

Thomas Fikslin, Delaware River Basin Commission

Updates to Michigan's Fish Screening Levels Using References Doses, Starting with Toxaphene

Jennifer Gray, Michigan Department of Community Health, Lansing, MI

Biosketch

Dr. Jennifer Gray is a toxicologist in the Division of Environmental Health at the Michigan Department of Community Health. In this position, she assesses human health risk at sites of environmental contamination through a cooperative agreement with the Agency for Toxic Substances and Disease Registry. Dr. Gray received her Ph.D. in Microbiology and Environmental Toxicology at Michigan State University in 2007.

Abstract

Michigan's fish consumption advisories began in the 1970s, overseen by what is now the Michigan Department of Community Health (MDCH). Since that time, numerous additions of both chemicals and procedures have been made to the advisories. Currently, MDCH has begun planning updates with the overall goal of standardizing and simplifying the fish consumption advisories. As part of the work toward that goal, MDCH developed a toxaphene reference dose (RfD) to determine the need for advisories because of the presence of this chemical in fish. The published literature was searched, and two no-observed-adverse-effect-levels (NOAELs) were selected for the development of an RfD. One RfD was for technical toxaphene, allowing the use of current analytical methods and previous years of fish tissue data. An RfD for the sum of three persistent toxaphene congeners, known to bioaccumulate in human, was proposed as a more relevant value for toxaphene toxicity in humans. This RfD will require changes to the analytical method and several years to acquire fish tissue data. This presentation covers the selection of the NOAELs, the development of the RfDs, and sample screening values for the Michigan fish consumption advisory program.

Updates to Michigan's fish screening levels using references doses, starting with toxaphene

Jennifer Gray, Ph.D.
Michigan Department of Community Health
grayj@michigan.gov

MDCH's overall goals

- Standardization of advisories
  - Meal categories
  - Comparison methods
- Less complexity
  - Easier to explain/less mystery

www.michigan.gov/fishandgameadvisory

Updating Michigan's fish advisory

- Provide scientific support for screening levels
  - Some trigger levels are based on FDA values
- Provide written technical support documents (for future updates)
  - Michigan's fish advisories began in the 1970s with mercury

visibleearth.nasa.gov/view_rec.php?id=1244

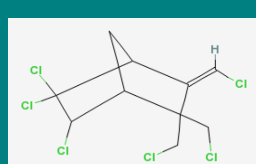
Toxaphene first

- Letter from Michigan resident
- Still measured - detectable levels in some fish species
- Currently no advisories due to toxaphene (other chemicals are driving advisories)

www.epa.gov/glindicators/fishtoxics/sportfishb.html

What is toxaphene?

- Polychlorinated camphenes (and bornanes)
- Technical toxaphene can have a range of congeners
  - More than 670 congeners possible (~200 in technical mix)
  - Chlorination of ~68%
  - Parlar labeling system: time off column



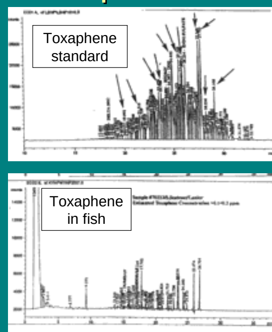
pubchem.ncbi.nlm.nih.gov/summary/summary.cgi?cid=5375921&loc=ec_rcs

Toxaphene is a pesticide

- Insecticide and accicide (mites)
  - Agricultural use
- Used to kill unwanted fish in lakes before stocking with sports fish (1950s-1970s)
  - Killed sports fish too
- Indirect source to Great Lakes (Southeastern U.S. agricultural fields; Ma et al. 2005)

Weathering of toxaphene

- Technical toxaphene
  - Originally produced toxaphene
- Weathered toxaphene
  - Results in reduction in number of congeners (Parlars) present and amount of chlorine



http://www.atsdr.cdc.gov/hac/PHA/terrycreek/tcd_fe1.gif

Weathered toxaphene

- Degradation products
  - Major: Hx-Sed and Hp-Sed
    - Large proportion in soil
  - Minor: Parlars 26, 40, 41, 44, 50, and 62, and more
    - Large proportion in animals
- Bioaccumulation of the minor products

Dechlorination in:
- UV light
- High temperatures (>120°C)
- High pH

Measuring toxaphene in Michigan fish

- MDCH Analytical Chemistry Laboratory
  - "Apparent" toxaphene measured in fish tissue
  - Technical standard
  - Less than 32 minute retention time not included in the value (interference)
- Compared to 5 ppm toxaphene trigger level

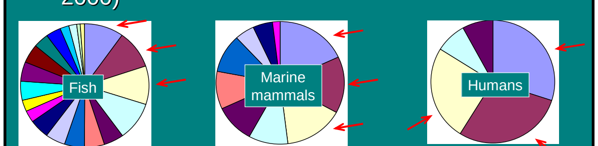
Toxaphene in Michigan fish

- Siscowet trout from Lake Superior
  - 1984 to 1999: 2.63 ± 0.23 ppm (n = 100; range 0.05 to 10 ppm)
  - 2000 to 2006: 0.41 ± 0.10 ppm (n = 30; range 0.05 to 2.264 ppm)

http://www.nps.gov/archive/isro/NR_Profile_Internal/NR_stills/fish_imag/pages/siscowet_gif.htm

Biomonitoring data

- 8-25% total toxaphene in fish was Parlar 26, 50, 62 – profiles varied by species (Chen & Yeboah 2000)



- Parlars 26 and 50
  - Approximately 50 to 90% of total toxaphene (Skopp et al. 2002, Newsome and Ryan 1999, Gill et al. 1996)

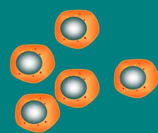
Toxicology of technical toxaphene in non-human primates

- Feeding study with technical toxaphene for 52 weeks in non-human primates (Bryce et al. 2001)
  - Effects: increased relative organ weights, increased hepatic microsomal activity, inflammation/enlargement of tarsal glands (LOAEL = 1.0 mg/kg/day)
  - Four toxaphene congeners representing a majority of the total: Parlars 26, 44, 50, and 62 (Andrews et al. 1996)
    - Leveled off at 10 weeks (blood) and between 15 to 20 weeks (adipose)

Immunotoxicity of technical toxaphene in non-human primates

- Feeding study with technical toxaphene for 75 weeks in non-human primates (Tryphonas et al. 2001)
  - Immune function testing after 33 weeks (NOAEL = 0.1 mg/kg/day)

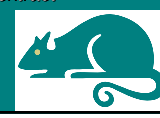
Reduced antibodies to sheep red blood cells (two of the three doses)



Reduced absolute B cell number (one of three doses)

Toxicology of weathered toxaphene in rats

- Partially hepactomized rats treated with initiator were subcutaneously injected for 20 weeks (Besselink et al. 2008)
  - Effects: altered hepatic foci expressing placental glutathione-S-transferase (measure of tumor promotion)
  - NOAEL = 0.0021 mg/kg/day sum of three persistent congeners (Σ3PC) from cod liver oil extract (weathered toxaphene)



Carcinogenic endpoint for RfD

- Guidelines for Carcinogen Risk Assessment (EPA 2005)
- RfD if nonlinear mode of action
  - not mutagenic or genotoxic
- Toxaphene = tumor promoter
  - Interference with cell-to-cell communication
  - Not shown to be mutagenic or genotoxic in mammalian cells

Two possibilities for an RfD:

- Technical toxaphene
  - Similar method (currently measuring apparent toxaphene)
  - Able to use previously measured fish tissue levels
- Individual Parlars - more accurate or appropriate
  - Concern is only with a few Parlars
  - Would need to adjust method and have no historic fish tissue data

Two NOAELs selected

- Technical toxaphene
  - Altered immune system function (Tryphonas et al. 2001)
  - NOAEL = 0.1 mg/kg/day
- Weathered toxaphene (sum of Parlars 26, 50, and 62)
  - Preneoplastic foci (carcinogenic effect; Besselink et al. 2008)
  - NOAEL = 0.0021 mg/kg/day

$$\text{RfD} = \frac{\text{NOAEL or other POD}}{\text{Uncertainty and modifying factors}}$$

Development of an RfD

- Uncertainty factors (for both NOAELS):
  - Animal to human (10), human to human (10), subchronic to chronic (10)
    - RfD (Σ3PC) = 0.0021 µg/kg/day
- Additional modifying factor added for possible developmental effects (3; technical toxaphene only)
  - RfD = 0.033 µg/kg/day

Sample screening values for technical toxaphene:

RfD = 0.033 µg/kg/day		
Population	Fish toxaphene concentration (ppm)	Fish Meals
General Population	≤ 0.019	Unrestricted
	> 0.019 to ≤ 0.081	One meal/week
	> 0.081 to ≤ 0.351	One meal/month
	> 0.351 to ≤ 0.703	Six meals/year
	> 0.703	Do not eat
Sensitive Population (women of childbearing age and children under 15)	≤ 0.016	Unrestricted
	> 0.016 to ≤ 0.069	One meal/week
	> 0.069 to ≤ 0.297	One meal/month
	> 0.297 to ≤ 0.595	Six meals/year
	> 0.595	Do not eat

Sample screening values for sum of three Parlars (26, 50, and 62):

RfD = 0.0021 µg/kg/day		
Population	Fish Σ3PC concentration (ppb)	Fish Meals
General Population	≤ 1.2	Unrestricted
	> 1.2 to ≤ 5.1	One meal/week
	> 5.1 to ≤ 22.2	One meal/month
	> 22.2 to ≤ 44.3	Six meals/year
	> 44.3	Do not eat
Sensitive Population (women of childbearing age and children under 15)	≤ 1.0	Unrestricted
	> 1.0 to ≤ 4.3	One meal/week
	> 4.3 to ≤ 18.6	One meal/month
	> 18.6 to ≤ 37.3	Six meals/year
	> 37.3	Do not eat

Future objectives:

- Setting screening levels
  - Proposed or different
    - Decisions: body weight, trimming and cooking, meal cutoffs, etc
- Implementation as resources are available
- Thanks to: Linda Dykema, Kory Groetsch, Joe Bohr, MDCH Analytical Lab

Questions and Answers

Q. *Calculated toxaphene using EPA technical methods are much lower than the calculated FDA values. Will you encounter any difficulty moving to the more conservative method?*

A. In Michigan, we have low values, so I don't think it will be very difficult.

Q. *Can you speculate on how conservative your PCB concentrations are compared to EPA method?*

A. Labs have seen a difference of about 2%, which is fairly close to the levels we are seeing.

Toxicology of Perfluoroalkyl Acids

Christopher Lau, RTD, NHEERL, ORD, U.S. Environmental Protection Agency,
Research Triangle Park, NC

Biosketch

Dr. Christopher Lau (Ph.D.) is the Acting Chief for the Developmental Toxicology Branch of the Toxicity Assessment Division, National Health and Environmental Effects Research Laboratory (NHEERL) in EPA's Office of Research and Development. Dr. Lau earned his Ph.D. in Pharmacology from Duke University and joined the Reproductive Toxicology Division of NHEERL at EPA in 1990 as a pharmacologist. From 2002–2004, he served as Adjunct Assistant Professor at North Carolina Central University (Department of Biology). He presently also holds appointments of Adjunct Assistant Professor at Duke University (Department of Pharmacology and Cancer Biology) and Adjunct Professor at North Carolina State University (Department of Molecular Biomedical Sciences, College of Veterinary Medicine). Dr. Lau is a member of the Society for Neuroscience, Society of Toxicology, Teratology Society, and International Society for Developmental Origins of Heath and Disease. He has served on the Editorial Board (2004–2009) and as a Guest Editor for *Reproductive Toxicology* and is a current Editorial Board Member of *Toxicology, Brain Research Bulletin,* and *PPAR Research*. Dr. Lau's research interests and activities have focused on characterizing the chemically induced developmental toxicity during embryonic and perinatal life stages, understanding their modes of action, and applying such information to human health risk assessment.

Abstract

The perfluoroalkyl acids (PFAAs) are a family of organic chemicals consisting of a perfluorinated carbon backbone (4–12 in length) and an acidic functional moiety (carboxylate or sulfonate). These compounds are chemically stable, have excellent surface-tension reducing properties, and have numerous industrial and consumer applications. However, they are ubiquitously distributed and highly persistent in the environment, and present in humans and wildlife. The rates of PFAA elimination and their body burden accumulation appear to be dependent on carbon-chain length, functional moieties, and animal species. Recent laboratory studies have indicated a host of adverse health effects associated with exposure to PFAAs; these include carcinogenicity, hepatotoxicity, developmental toxicity, immunotoxicity, neurotoxicity, and endocrine disruption. The modes of PFAA actions are not well understood, but are thought to involve, in part, activation of nuclear receptor molecular signals. In general, extent of the PFAA toxicity corresponds to chain lengths of the chemical, which likely reflects the pharmacokinetic properties of these fluorochemicals as well as their potency of actions.

*NOTE: This abstract does not necessarily reflect U.S. EPA policy.

Toxicology of Perfluoroalkyl Acids

Christopher Lau

Toxicity Assessment Division
Research Triangle Park, NC

Perfluoroalkyl Acids (PFAAs)

$CF_3(CF_2)_n - S(=O)_2 - O^-$

Perfluoroalkyl sulfonic acid (PFSA)

$CF_3(CF_2)_n - C(=O) - O^-$

Perfluoroalkyl carboxylic acid (PFCA)

$CF_3(CF_2)_n - P(=O)(O^-) - O^-$

Perfluoroalkyl phosphonic acid (PFPA)

What are PFAAs?

- Stable, synthetic chemicals, produced last ~50-60 years
- Their hydrophobic and oleophobic properties make them ideal surfactants (water and oil resistant).
- The most useful PFAAs are the 8-carbon (C8) chemicals:
  Perfluorooctane Sulfonate (PFOS)
  Perfluorooctanoic Acid (PFOA)
- PFOS, PFOA (Telomer Alcohols) and their derivatives have over 200 industrial and consumer applications:

Fabric coatings	Fire-fighting foam
Carpet coatings	Airplane gear lubricant
Paper coatings	Mining/oil well surfactants
Floor polish/wax	Acid rust/dust suppressants
Alkaline cleaners	Metal electroplating
Denture cleaners	Electronic etching bath
Shampoos	Polymer additives
Insecticides (ant/roach)	Emulsifiers for polymer production

PFAAs Commonly Found in the Environment

- Perfluorooctane Sulfonate (PFOS, C8)
- Perfluorooctanoic Acid (PFOA, C8)
- Perfluorononanoic Acid (PFNA, C9)
- Perfluorohexane Sulfonate (PFHxS, C6)
- Perfluorohexanoic Acid (PFHxA, C6)
- Perfluorobutane Sulfonate (PFBS, C4)
- Perfluorobutyric Acid (PFBA, C4)
- Perfluorodecanoic Acid (PFDA, C10)
- *Perfluorophosphonic Acids (C6, C8, C10)*

Why do we care?

- They are everywhere and environmentally persistent
  - globally distributed, detected in water, air, soil, sediment and sludge
- They are present in humans and wildlife

(ppb)	PFOS	PFOA	PFHxS	PFNA
NHANES 99-00	**30.4**	**5.2**	**2.1**	**0.5**
NHANES 03-04	**20.7**	**3.9**	**1.9**	**1.0**
NHANES 05-06	**15.5**	**3.5**	**1.6**	**1.0**
Lake trout	121	4.4	0.6	2.9
Polar bear	~1,200	~10	--	~100

- They hang around

Serum $t_{1/2}$	PFBS	PFHxS	PFOS	PFBA	PFOA
Human	**10-20 d**	**8.7 yrs**	**5.4 yrs**	**2-4 d**	**2.3-3.8 yrs**

- They *may* be harmful (based on animal studies)
  - hepatotoxicity, carcinogenicity, immunotoxicity, hormonal imbalance, neurotoxicity, developmental toxicity

General Properties of PFAAs

- Hydrophobic and lipophobic
- Well absorbed orally (> 95% within 24 h)
- Distributed mainly in serum, liver and kidney (lung)
- Highly bound to proteins
- Not metabolized
- Elimination dependent on carbon-chain length (poor with long carbon-chains): urinary and fecal excretion
- Body burden increases linearly with cumulative doses
- Steep dose-response relationship

Hepatotoxicity

- Produce hepatocellular hypertrophy associated with vacuole formation and peroxisome proliferation
- Induce lipid metabolism and alter lipid transport
- Down-regulate cholesterol and bile acid synthesis
- Alter steroid and lipoprotein metabolism
- Actions largely mediated by PPARα molecular signals (PFNA > PFOA > PFOS), but other nuclear receptors such as CAR, PXR, LXR may be involved
- Interfere with cell-cell communication

Gene signatures of PFAAs in mouse liver: PPARα

	PFOA	PFOS
➢Peroxisome biogenesis	+++	+++
➢Xenobiotic metabolism	++	+
➢Acute phase response	++	
➢Proteasome activation	++	
➢Cholesterol biosynthesis	++	
➢Phospholipid metabolism	++	+
➢Bile acid biosynthesis	++	+
➢Glucose metabolism	++	+
➢Lipid metabolism and transport	+++	+++

Rosen et al., 2008 (Tox. Path.); 2009 (Reprod. Tox.)

Comparison of PFAA Activities on PPARα

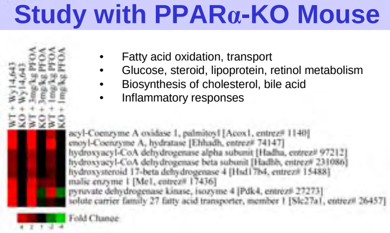
	C_{20max} (μM)	
Compound	Mouse	Human
PFNA (C9)	5	11
PFOA (C8)	6	16
PFDA (C10)	20	no activity
PFHxA (C6)	38	47
PFBA (C4)	51	75
PFHxS (C6)	76	81
PFOS (C8)	94	262
PFBS (C4)	317	206

Wolf et al., 2008

Carcinogenicity

- PFOA
  - Liver adenomas
  - Pancreatic acinar cell tumors
  - Testicular Leydig cell adenomas
  - *Ovarian tubular hyperplasia*
- PFOS
  - Liver adenomas
  - Thyroid adenomas/carcinomas

Study with PPARα-KO Mouse



	PFOA 1 mg/kg	PFOA 3 mg/kg	WY 14,643
WT	206	879	902
PPAR-KO	35	176	10

Involvement of Constitutive Androstane Receptor (CAR) pathway?

Rosen et al., 2008 (Tox. Path.)

Immunotoxicity

- PFOA reduced thymus and spleen weight: associated with decreases of thymocyte and splenocyte production
- Suppression of adaptive immune responses by PFOA: activation of T and B cells attenuated, IgM synthesis suppressed
- Suppression of NK cell function and decreases of IgM production after *in utero* exposure to PFOS
- Suppression of innate immune (inflammatory) responses by PFOA
- Actions mediated by both PPARα-dependent and independent signals

Yang et al., 2002; Pedan-Adams et al., 2008
Kiel et al., 2008; DeWitt et al., 2008; Qazi et al. 2009

Hormone Imbalance

- Reduction of serum tT4 and T3, but a lack of feedback elevation of TSH (PFOA, PFOS, PFHxS, PFNA)
- Profile of changes does not resemble that of classical hypothyroidism
- PFOS-induced hypothyroxinemia (T4) likely related to displacement of hormones from binding protein – physiological significance remains to be defined
- Decrease in serum testosterone and increase in serum estradiol in male rats (PFOA) -- effects associated with induction of hepatic aromatase
- Estrogenic mechanism in rainbow trout by PFOA – associated with hepatocellular carcinoma

Chang et al., 2007; 2008; Liu et al., 1996; Tilton et al., 2008

Neurotoxicity

- *In vitro* study with PC12 cells: Altered cell replication, differentiation and induced oxidative stress
  - PFOSA > PFOS > PFBS = PFOA
- Behavioral study: Neonatal exposure to PFOS or PFOA in mice led to deranged spontaneous behavior, reduced habituation, and hypoactive response to nicotine challenge at adult age
- Enhanced transport of PFOS into immature rat brain
- However, no significant adverse effects of PFOS were indicated in the developmental neurotoxicity testing with rat
- No overt neurotoxicity after a single dose of PFOS or PFOA at sublethal doses

Slotkin et al., 2008; Johansson et al., 2008; Butenhoff et al., 2009; Seto et al., 2009

Developmental Toxicity

Effects of PFAA exposure by daily oral gavage treatment during pregnancy in the Sprague-Dawley rat and CD-1 mouse

PFOS, PFOA, PFNA, PFBA

Common Features of Maternal Effect

- Exposure to PFAAs during pregnancy did not alter maternal weight gains, except at the very high doses
- PFAAs, particularly the carboxylates produced significant increases in maternal liver weight

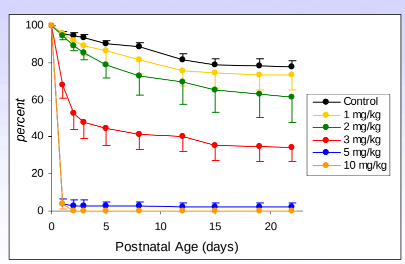
Common Findings of Prenatal Evaluation

- *In utero* exposure to PFAA did not significantly alter implantation, viability or weight of the fetus at term
- A few structural abnormalities and developmental delays were noted, primarily in the highest dose groups of PFOS and PFOA

Thibodeaux et al., (2003)

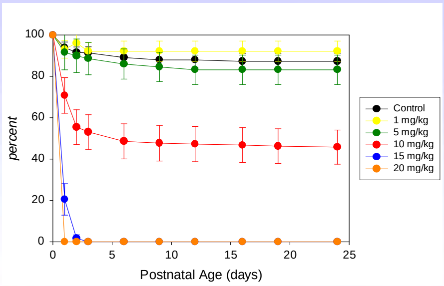
Postnatal Evaluation

PFOS compromised postnatal survival of neonatal rats



Lau et al., (2003); Luebker et al., (2005) PFOS

Postnatal Survival: Mouse



Summary of PFOS Postnatal Findings

- While all rats and mice were born alive, postnatal survival was severely compromised
- Neonatal mortality was likely associated with pulmonary insufficiency
- Small growth deficits and developmental delays were noted in the surviving pups
- Persistent liver hypertrophy was seen in the developing mice

Developmental Toxicity of PFOA

- Unremarkable findings in the rat model: *no mortality at birth, slight postnatal growth deficits*
- Likely associated with rapid clearance of the chemical in female rat

Serum $t_{1/2}$	**Male**	**Female**
Rat	6 - 7 days	2 - 4 hours
Monkey	21 days	30 days
Human	2.3 - 3.8 years	

- No gender differences in PFOA elimination in humans or primates

Alternative Model

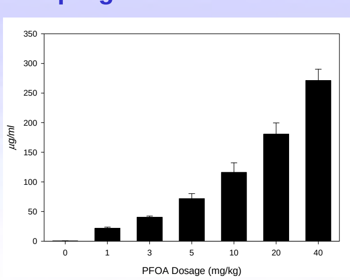
Serum Levels of PFOA

Species	Dose *(mg/kg)*	Males *(µg/mL)*	Females *(µg/mL)*
Rat	10	111 ± 10	0.7 ± 0.2
Mouse	20	199 ± 19	171 ± 15

Serum half-life (days)	**Male**	**Female**
Rat	6 - 7	0.08 – 0.16
Mouse	21.7	15.6

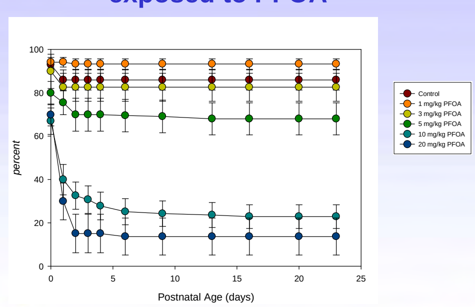
Lau et al. (2006); Lou et al. (2009)

Accumulation of PFOA in pregnant mice at term



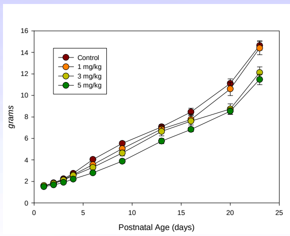
Lau et al., 2006

Postnatal survival of Mice exposed to PFOA

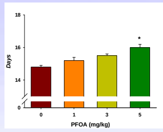


Neonatal Growth and Development

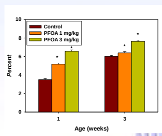
Body Weight



Eye Opening



Relative liver weight



Summary of PFOA Postnatal Findings

- In contrast to the rat, neonatal survival was severely compromised in the mouse, likely reflecting the ability of the females in this species to accumulate PFOA
- The profile of mortality rate was slightly different from that seen with PFOS
- Significant growth deficits and developmental delays were observed among the surviving pups
- Neonatal liver weights were significantly increased

Developmental Effects of PFNA in Rat

- Deficits of maternal weight gain detected at 3 mg/kg or higher doses, severe toxicity seen at 10 mg/kg
- No effect on prenatal parameters
- No effect on neonatal survival
- Small but significant lags in early neonatal growth at 3 mg/kg or higher doses

	Male	Female
Serum $t_{1/2}$	30.7 days	1.8 days

Tatum et al., (submitted); Das et al., (submitted)

Developmental Effects of PFNA in Mouse

- No effect on maternal weight gain during pregnancy at doses up to 5 mg/kg
- No effect on prenatal parameters
- No significant mortality was seen at birth, but pups exposed to 5 mg/kg died in the first two weeks of life
- Significant lags in early neonatal growth were observed at doses as low as 1 mg/kg
- These effects are likely due to the ability of pregnant mice to accumulate PFNA

	Male	Female
Serum $t_{1/2}$	64.4 days	40.7 days

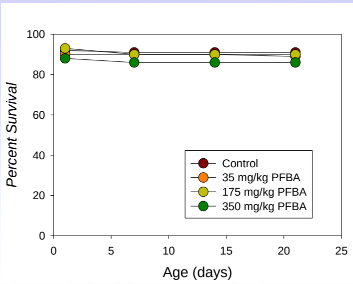
Tatum et al., (submitted); Das et al., (submitted)

Summary of PFNA Postnatal Findings

- Similar to PFOA, exposure to PFNA led to neonatal mortality in mouse, but not in rat, likely due to the ability of female mice to accumulate the chemical
- The profile of mortality rate was slightly different from those seen with PFOS or PFOA
- Significant growth deficits and developmental delays were observed among the surviving pups, and neonatal liver weights were significantly increased
- Actions of PFNA appeared to be more potent than those of PFOA

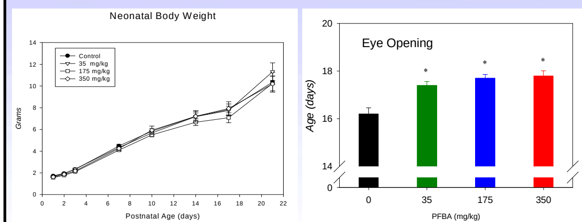
Do all PFAAs produce developmental toxicity?

PFBA did not alter neonatal survival



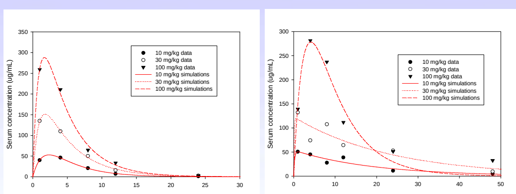
Das et al., (2008)

Neonatal Growth and Development



Elimination of PFBA in Mouse

Female Male



	Male	Female
Serum $t_{½}$	11.6 hrs	2.9 hrs

Chang et al., (2008)

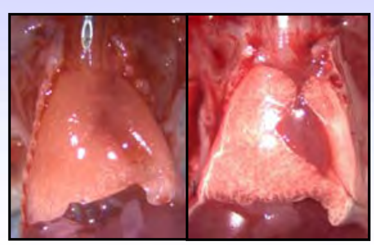
Summary of PFBA Postnatal Findings

- Exposure to high doses of PFBA (up to 350 mg/kg, which matched the effective doses (AUC) of PFOA) did not adversely affect neonatal survival or growth, although some developmental delays were noted
- Transient liver hypertrophy was seen at PD 1, but the liver weight returned to control level by PD 10
- The relative lack of adverse developmental effects of PFBA (compared to PFOA) is in part, due to the rapid elimination of this chemical

Pathophysiological mechanisms of developmental toxicity

Ho: PFOS dev tox = Altered lung function

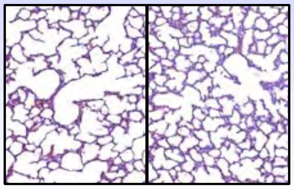
Control PFOS



Grasty et al., (2005)

Lung Histology and Morphometry

Control **PFOS**



Dose (mg/kg)	Air Space (%)	Septal Space (%)
0	63.9 ± 1.5	31.6 ± 1.3
5	56.7 ± 2.1	41.2 ± 2.0 *
10	55.2 ± 2.2*	43.6 ± 1.9 *

ORD NHEERL

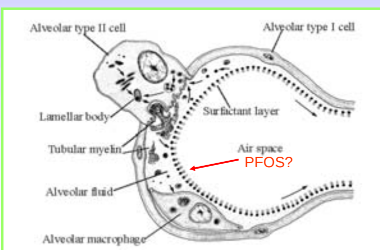
Does PFOS alter lung maturation?

- Surfactant levels and phospholipid composition in newborn rat lungs were not altered.
- Glycogen stores (indicator of lung maturation) was not affected.
- Surfactant transport and secretion were not perturbed significantly.
- Therefore, lung maturation *per se* was not likely hampered by PFOS.
- *Speculation: Rather, PFOS may impede the function of endogenous surfactant to prevent the lung from collapsing.*

ORD NHEERL

Alveolar Structure

Surfactant prevents lungs from collapsing during end-expiration by reducing the surface tension at the air-liquid interface



Modified from Hawgood and Clements (1990)

ORD NHEERL

PFOS and Pulmonary Surfactant

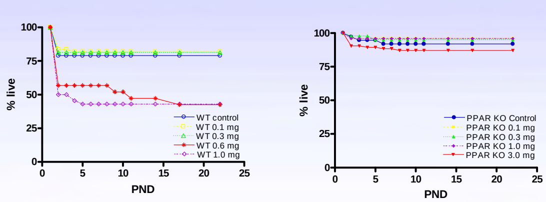
- PFOS was detected in amniotic fluid that bathed the fetal lung
- Oral gavage of newborn rats failed to cause mortality – chemical has to reach within the lung
- PFOS interacts with phospholipids
  - Dipalmitoylphosphatidylcholine (DPPC) is a major component of lung surfactant
  - *In vitro* study: PFOS had strong tendency to partition into and disrupt DPPC bilayers
  - PFOS > PFOA >>OS
- Definitive evidence is needed

Xie et al., (2007)

ORD NHEERL

PPARα Involvement in PFOA Neonatal Mortality

Wildtype Mice **PPARα-null Mice**



Abbott et al., (2008)

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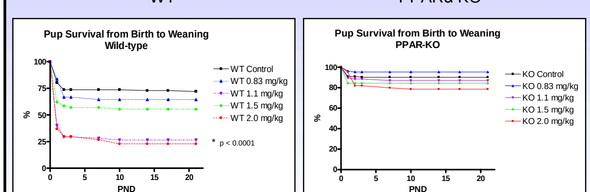
PPARα Involvement in PFNA Neonatal Mortality

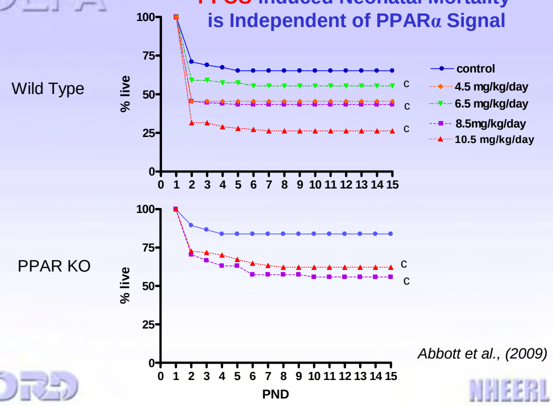
WT PPARα KO



Wolf et al., (submitted)

ORD NHEERL

PFOS-induced Neonatal Mortality is Independent of PPARα Signal



Abbott et al., (2009)

Summary

- Although *in utero* exposure of both PFOS and PFOA caused neonatal mortality, the adverse effects may be mediated by separate mechanisms
- PFOS likely interacts with phospholipids of lung surfactant and interferes with lung inflation and pulmonary function
- PFOA and PFNA likely acts through the PPARα signaling pathway that *regulates intermediary metabolism*

PFAA toxicity depends on carbon-chain length and functional group

- Pharmacokinetics

Serum Half-life	PFBS (C4)	PFHS (C6)	PFOS (C8)	PFBA (C4)	PFHxA (C6)	PFOA (C8)	PFNA (C9)	PFDA (C10)
Rat			7 d	2 h 9 h	0.42 h 1 h	2-4 h 6-7 d	2 d 31 d	59 d 40 d
Mouse				3 h 12 h		16 d 22 d	41 d 64 d	
Monkey	3-4 d	87 d 141 d	150 d	41 h 40 h	2.4 h-0.8 d 5.3 h-1.5 d	30 d 21 d		
Human	1 m	8.5 y	5.4 y	1-4 d		2.3-3.8 y		

- Toxicodynamics
  - Endpoints dependent on MOA, some share, some do not
  - Rank order of potency among PFAAs with the same MOA
- PFAAs *in toto*

PFAA Analysis Team

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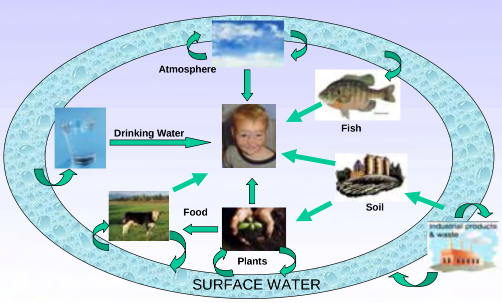
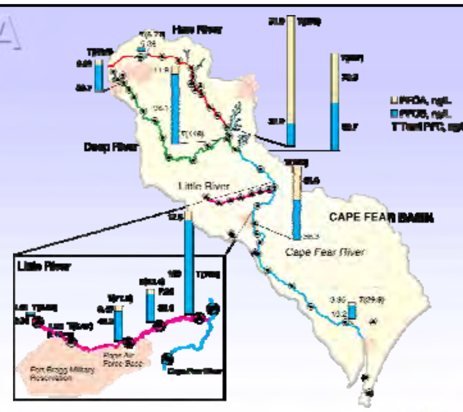
Human Exposure Pathways





Nakayama et al, (2007)

Method Development for Fish Samples

- **Homogenization**
  - water:fish = 3:1; Polytron
- **Alkaline Digestion**
  - 1ml fish homogenate + 9ml 0.1M NaOH in MeOH, for 16 h
- **SPE Clean-up** (Waters 3 cc WAX cartridge)

Condition	Load	Wash	Elute
4 ml NH_4OH/MeOH 4 ml MeOH 4 ml H_2O	1 ml digest 9ml H2O	4 ml Acetate Buffer 4 ml MeOH	4 ml NH_4OH/MeOH

Delinsky et al., (2009)

PFAAs in Bluegill Fillets from MN and NC

(ng/g wet weight) (Delinsky et al., 2009)

Sample Site	PFOS	C10	C11	C12
Miss. River, MN	102 (32.8 – 130)	1.73 (0.56 – 2.78)	1.21 (0.53 – 2.70)	1.07 (0.36 – 3.03)
St. Croix River, MN	2.08 (1.22 – 7.17)	< LOQ	< LOQ	< LOQ
Lake Calhoun, MN	275 (205 – 339)	6.09 (3.40 – 7.05)	4.50 (2.14 – 6.02)	5.91 (2.70 – 6.08)
Haw River, NC	30.3 (15.9 – 47.5)	9.08 (6.07 – 22.8)	23.9 (14.3 – 42.2)	6.60 (4.16 – 16.1)
Deep River, NC	62.2 (21.4 – 136)	2.90 (0.56 – 22.7)	9.15 (1.31 – 50.5)	3.46 (0.36 – 24.3)

MN Fish Consumption Advisory:
PFOS: 40 ng/g (once/week); 200 ng/g (once/month)

C10? C11? C12?

Summary

- PFAA signatures in NC fish fillet generally reflect those of the river water
- Species differences in fillet PFAA concentrations were observed
- Ratios of fillet:whole fish and liver:whole fish will help to better understand the PFAA disposition, and to relate the fish liver PFAA values reported in the literature to human exposure (fillet)

Contributors and Collaborators

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PFAA Days II at US EPA, RTP, NC
June 2008
***Reproductive Toxicology* vol. 27, 2009**

PFAA Days III at US EPA, RTP, NC
June 8-10, 2010

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Questions and Answers

Q. *Do you feel that the PFOA data could change the way we look at PFOAs in terms of fish and human data? There is a lot of debate between the scientists.*

A. There are advisories internationally. The associations we are seeing in epidemiological findings are generally significant but not terribly strong. We should be waiting until the studies with large cohorts have been completed before making a call. Also, we need to pay attention to the many different exposure routes. We do have drugs to intervene for the PFCs, but the subtle effects are very difficult to detect.

Q. *Is your take-home message that we need to be paying attention to the findings, but not necessarily running back to start an advisory program?*

A. You may be able develop a general red line–green line system to flag any exceedingly high numbers. Also, water and fish PFC data relate quite well if you need to use a surrogate number to make preliminary determinations.

U.S. EPA's Provisional Health Advisory Values for PFOA and PFOS

Joyce Donohue, Senior Health Scientist, Human Health Risk Assessment Branch of the Health and Ecological Criteria Division, Office of Water, U.S. Environmental Protection Agency, Washington, DC

Biosketch

Dr. Joyce Donohue is a senior health scientist in the Human Health Risk Assessment Branch of the Health and Ecological Criteria division in the Office of Water. She has served as the lead scientist for risk assessments used by the office for the Stage 2 Disinfection Byproducts Rule, as well as Regulatory Determinations 1 and 2. She also worked on protocol development for Contaminant Candidate List 3 and the first 6-year review of regulations. Dr. Donohue's fields of expertise are biochemistry and nutrition. Because of her background, she is the chemical manager for a number of environmental contaminants that are essential nutrients in the human diet yet also generate health concerns because of the adverse effects that result when exposures exceed nutritional needs. Dr. Donohue is an instructor for the Water Quality Standards Academy, where she teaches the unit on the derivation of ambient water quality criteria for the protection of human health. She was a coauthor the 2008 IRIS risk assessments for four polybrominated diphenyl ethers and is presently working on the Office of Water assessment for perfluorooctanoic acid.

Abstract

In response to detection of perfluorinated octanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) in public and private drinking water supplies, the Office of Water (OW) issued a provisional Health Advisory (HA) for each chemical in January 2009. The provisional short-term PFOA HA of 0.4 µg/L was calculated using a lower confidence bound on the benchmark dose for a 10% response ($BMDL_{10}$) of 0.46 mg/kg/day for an increase in maternal liver weight at term in a developmental study in mice (Lau et al., 2006) plus component uncertainty factors of 10 for variation in susceptibility within the human population, 3 for toxicodynamic differences between animals and humans and 81 for toxicokinetic differences. The provisional PFOS HA value of 0.2 mg/L is based on a no observable adverse effect level (NOAEL) of 0.03 mg/kg/day for changes in thyroid-related hormones and reduced high-density lipoproteins levels in monkeys (Seacat et al., 2002). A total uncertainty factor of 390 was applied to the NOAEL based on component uncertainty factors of 10 to account for differences within the human population, 3 for toxicodynamic differences between animals and humans and 13 for toxicokinetic differences. Both provisional HA values were calculated based on a 10 kg child consuming 1 liter of water per day with 20% of the total exposure contributed by drinking water. The OW is presently evaluating the literature on PFOA and PFOS in order to develop long-term benchmarks for each chemical that will be protective for cancer and noncancer effects.

* NOTE: The views expressed represent those of the author and are not necessarily representative of the views and policies of the U.S. EPA.

Provisional Health Advisories for PFOA and PFOS

Fish Forum
Portland, Oregon
November 3, 2009

Topics Covered

- Health Advisory Background
- Perfluorooctanoic acid (PFOA) Background
  - Derivation of the PFOA Provisional Health Advisory
- Perfluorooctanesulfonate (PFOS) Background
  - Derivation of the PFOS Provisional Health Advisory
- Other State Standards
  - Differences among advisory values
- Next Steps for EPA
- Fish Tissue Considerations

Health Advisories

- Guidance for State and Local Health Departments and Utilities
- Provides less than lifetime values for regulated and unregulated contaminants
  - Spills and short term exposures
- Provides lifetime values for noncancer effects from long-term exposures to unregulated contaminants
  - No lifetime Health Advisory for carcinogens that have a linear response to dose and where the mode of action for the cancer response cannot be determined.
- Subject to change as new data become available

Health Advisory Derivation

- Determine the Point Of Departure (POD)
  - BMDL, NOAEL, or LOAEL ÷ Uncertainty Factors (UF)
- Determine the Drinking Water Equivalent Level (DWEL)
  - DWEL = POD/UF x body weight ÷ drinking water intake/day
  - Consider sensitive life-stage when choosing the body weight and drinking water intakes for the DWEL calculation
- Health Advisory = DWEL X Relative Source Contribution (RSC)
  - RSC = contribution to total exposure from water
    - Allows for the presence of chemical in food, air, soils, etc.
    - RSC Data derived where possible
    - Options for 20%, 50% or 80% defaults depending on data

BMDL = Lower confidence bound on the benchmark dose; NOAEL = No Observed Adverse Effect Level; LOAEL = Lowest Observed Adverse Effect Level

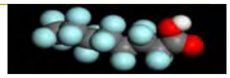
Uncertainty Factors (UFs)

- Factors Considered:
  - Intra-human variability
  - Interspecies variability
  - Use of a exposure duration less than the duration of concern
  - Use of a LOAEL rather than a BMDL or NOAEL
  - Deficiencies in the database
- Individual factors are data derived or assigned values of 1, 3, or 10 depending on the supporting data and combined to a composite UF

Duration Considerations

- Short Term
  - 1-day
  - 10-day
  - Mostly for spills
- Longer-term
  - About seven years
  - Values usually provided for an child and an adult
- Lifetime
  - 70 years

PFOA Characteristics

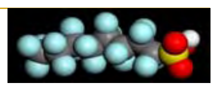


- Distinctly different species half lives and times to steady state
  - Years for humans, hours/days for rats and mice, intermediate for monkeys
  - Requires toxicokinetic interspecies adjustments for risk assessment
- Noncancer effects
  - Humans
    - Serum levels lower than those causing effects in animals
    - Significant associations observed in occupation cohorts for some animal health effects (serum lipids, hormones, some tumors); not consistent across studies
  - Laboratory animals (rats, mice and monkeys)
    - Liver (↑ liver weight a hallmark of exposure)
    - Hormone changes (estrogenic)
    - Altered serum lipids; hematological changes
    - Reproductive and developmental effects
      - Neonatal death; alteration of mammary gland development
- Tumorigenic effects
  - Carcinogenic in rats
    - Liver, Leydig cell, and pancreatic tumors

PFOA Provisional Health Advisory

- Determine the Point Of Departure (POD)
  - 0.46 mg/kg/day (BMDL) ÷ 2430 (UF) = 0.000189 mg/kg/day
  - Critical Effect – increased maternal liver weight in a mouse developmental study (17 day exposure)
  - Uncertainty factors
    - Intraspecies = 10
    - Interspecies = 243
      - 81 for toxicokinetic differences between human and animals
        - It takes 81 times longer for PFOA to reach steady state conditions in serum in humans than it does in mice
      - 3 for toxicodynamic differences between humans and animals
- Determine the Drinking Water Equivalent Level (DWEL)
  - DWEL = 0.000189 mg/kg/day x 10 kg (one-year old child) ÷ 1 L/day = 0.00189 mg/L
- Health Advisory = DWEL X 0.2 = 0.00038 mg/l rounded to 0.4 ug/L
  - 20% default RSC

PFOS Characteristics



- Distinctly different species half lives and times to steady state
  - Years for humans and hours/days for rats and mice; monkeys intermediate
- Noncancer effects
  - Humans
    - Serum levels lower than those causing effects in animals
    - Significant associations observed in occupation cohorts for some animal health effects (decreased cholesterol, thyroid); not consistent across studies
  - Laboratory animals (rats, mice and monkeys)
    - Liver (↑ liver weight a hallmark of exposure)
    - Hormone changes (thyroid)
    - Altered serum lipids
    - Reproductive and developmental effects
      - Neonatal deaths; decreases in sperm counts
- Tumorigenic effects
  - Carcinogenic in rats
    - Liver adenomas

PFOS Provisional Health Advisory

- Determine the Point Of Departure (POD)
  - 0.03 mg/kg/day (NOAEL) ÷ (UF) = 0. 0000769 mg/kg/day
  - Critical Effect: for ↑ thyroid stimulating hormone levels in male monkeys, ↓ triiodothyronine (T3) and ↓levels of high-density lipoproteins in females (182 day exposure)
  - Uncertainty factors
    - Intraspecies = 10
    - Interspecies = 39
    - 13 for toxicokinetic differences between human and animals
      - It takes 13 times longer for PFOS to reach steady state conditions in serum in humans than it does in monkeys
    - 3 for toxicodynamic differences between humans and animals
- Determine the Drinking Water Equivalent Level (DWEL)
  - DWEL = 0.0000769 mg/kg/day x 10 kg (one-year old child) ÷ 1 L/day = 0.000769 mg/L
- Health Advisory = 0.000769 X 0.2 = 0.000154 mg/L rounded to 0.2 ug/L
  - 20% default RSC

State Guidelines

Three States have established drinking water guidelines for PFOA and one for PFOS. The State Standards are listed below.

- PFOA
- Minnesota (MN)
  - 0.3 µg/L
- New Jersey (NJ)
  - 0.04 µg/L
- North Carolina (NC)
  - 2 µg/L

- PFOS
- Minnesota (MN)
  - 0.2 µg/L

Differences among PFOA Assessments

Critical Studies

EPA	$BMDL_{10}$: 0.46 mg/kg/day	↑ liver weight	17 days	female rat	Lau et al., 2007
MN	LOAEL 3 mg/kg/day; $BMDL_{10}$: 23 mg/L serum	↑ liver weight	26 weeks	monkey	Butenhoff et al., 2002
NJ	NOAEL1.6 mg/kg/day; 18000 µg/L serum	↓ body wt.,↓ red blood cell effects	2 year	female rat	Sibinski 1987
NC	LOAEL: 1 mg/kg/day	↑ liver weight, ↓ body wt.	~13 weeks	male rat	Buttenhoff et al 2002; York et al., 2002

Differences among PFOA Assessments

Assessment	UF	Body Weight	Water intake	Relative Source	Value
OW	2430	10Kg	1 L/day	20%	0.4 mg/L
MN	38,960 equivalent	0.053 L/kg/day (95th percentile water intake to body weight ratio for time to steady state- 19 years)		20%	0.3 mg/L
NJ	~280,700 equivalent	70 kg assumed	2L/day assumed	20%	0.04 mg/L
NC	30,000	70 kg	2 L/day	20%	2 mg/L

The toxicokinetic adjustments to the BMDL, NOAEL or LOAEL by MN and NJ have been converted to an UF equivalent and combined with UFs given in the state assessment. The NJ value applies to a lifetime exposure. Thus, adult body weight and drinking water intakes were assumed when making the comparison across assessments

Differences between PFOS Assessments

Critical Studies					
OW	NOAEL : 0.03 mg/kg/day	↑ TSH, ↓T3 and HDL	182 days	monkey	Seacat et al., 2002
MN	NOAEL 0.03 mg/kg/day (35 mg/L serum)	↑ TSH, ↓T3 and HDL	182 days	monkey	Seacat et al., 2002;

Differences between PFOS Assessments

Assessment	UF	Body Weight	Water intake	Relative Source	Value
OW	390	10 Kg	1 L/day	20%	0.2 µg/L
MN	375 equivalent	0.049L/kg/day (95th percentile water intake to body weight ratio for time to steady state - 27 years)		20%	0.3 µg/L

The toxicokinetic adjustments to the NOAEL by MN has been converted to an UF equivalent and combined with UFs given in the MN assessment.

Next Steps for EPA

- Draft the toxicology chapters for the document that will support a CCL3 Regulatory Determination in the future
  - Cancer and noncancer effects
  - Short-term and chronic
  - National finished water monitoring data needed for regulatory determination
- Peer review the assessment
- Prepare and issue a Health Advisory based on the peer reviewed assessment

Fish Tissue Considerations

- PFOA and PFOS are oleophobic and do not accumulate in fatty tissues
- PFOA and PFOS bind to serum proteins.
  - Can lead to presence in fish tissues.
- Muscle tissues have lower concentrations per gram tissue than liver, kidney, and other organs
  - Portion size and tissue concentration are both important variables for fish as a food source
- Monitoring studies indicate that PFOS is usually found at higher concentrations than PFOA

Questions and Answers

Q. *I have seen many different endpoints from many different studies. If this kind of uncertainty exists, shouldn't we have the most conservative endpoint? Can EPA work aggressively to get a consistent approach that is very protective?*

A. EPA is working aggressively to develop an approach by 2010, but we would love to have outside input.

Q. *You used a child's body weight in developing a provisional health advisory, but not an uncertainty. Is there no chronic level?*

A. Our health advisory is not meant to be used as chronic advisory level, only a developmental level. There is an ongoing debate on whether a full chronic investigation is needed. The Superfund program has put together something, but calls the level "sub-chronic."

Q. *Is the PFC ratio biased by the methods being flawed? Do you think that the PFC ratio in water is truly 100–138 times higher than in serum?*

A. You have to look at what was being done when the compounds were evaluated. Our human and water studies are very accurate.

Q. *The Pollution Control Agencies Axis method and 3M methods seem to be comparable. Can you comment on their comparability with EPA's method?*

A. We have not done any interlaboratory studies.

Comparability and Standardization of Methods for PFC Analysis in Fish Fillets

Michelle D. Malinsky, 3M Environmental Laboratory, Environmental, Health, and Safety Operations, 3M Company, St. Paul, MN

Biosketch

Dr. Michelle D. Malinsky (Ph.D.) joined 3M in 2000. In her 9 years at 3M's Environmental Laboratory, her work has primarily focused on trace-level perfluorochemical analysis in water and other various biological tissues using liquid chromatography/tandem mass spectrometry. She has also provided technical leadership to the trace-level air analysis team within the 3M Environmental Laboratory utilizing gas-phase Fourier transform infrared spectroscopy and gas chromatography/mass spectrometry technology platforms. Dr. Malinsky holds a B.S. in Chemistry from the University of Illinois and a Ph.D. in Physical/Analytical Chemistry from Northwestern University.

Abstract

Environmental, Health, and Safety Operations, 3M Company, St. Paul, MN

Perfluorochemical (PFC) analysis of fish and other biological tissues has historically been faced with several unique analytical challenges that question the accuracy and precision of published data. Challenges include the lack of standardized test methods and reference materials, matrix ionization effects, and laboratory contamination issues. Recent availability of both native- and isotopically labeled PFC standards has greatly improved the overall comparability and accuracy of PFC fish analysis. This presentation will provide a brief historical overview of PFC fish analysis and discuss the three primary extraction techniques commonly used: ion-pairing extraction, solid-phase extraction, and protein precipitation. Common PFC matrix interferents and quality control measures (e.g., method validation) required to evaluate method accuracy and precision will also be discussed. Finally, a protein precipitation extraction method recently developed and validated at the 3M Environmental Laboratory will be presented. The 3M method provides a simple extraction procedure with minimal preparation steps and has been used to measure a large suite of PFCs: perfluorocarboxylic acids (PFCAs C4-C12), perfluorosulfonates (C4, C6, and C8), and perfluorosulfonamide. Method validation results in bluegill fillet control tissue and application to at least six other species of environmentally exposed fish will be provided.

Comparability and Standardization of Methods for PFC Analysis in Fish Fillets

Michelle D. Malinsky, Ph.D.
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Environmental, Health, and Safety Operations
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Maplewood, MN 55144-1000

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Main Points

- Historical Background
- Key Issues
  - Sources of Quantitative Bias
- 3M Method
  - Method Validation/QC
  - Mississippi River Results

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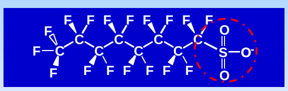
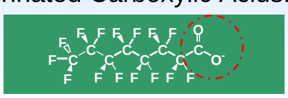
Perfluorinated Compounds (PFCs)

- Perfluoroalkane Sulfonates: PFAS



Perfluorooctane sulfonate (PFOS)

- Perfluorinated Carboxylic Acids: PFCAs



Perfluorooctanoate (PFOA, C8 Acid)

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PFC Analytical Challenges

Historically there has not been

- PFC Reference Test Methods (until 2008)
  - EPA Method 537 (Drinking Water)
- Standard Reference Materials
  - e.g. NIST SRMs (serum, soil, sludge, etc..)
  - SRM 1957 (serum) and 1954 (milk) – October 2009
- Stable Isotope Internal Standards i.e. [1,2,3,4-$^{13}C_4$]PFOS
- Electrospray LC-MS/MS
  - Relatively new technology platform (1996)
  - Phys/chem properties of PFCs not amenable to traditional techniques (GC, GC-MS, LC-UV)
  - Trace level analysis (ppm>ppb>ppt)
  - Instrument/Laboratory Contamination

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Method Validation Basics

*Defined Selectivity, Accuracy, Precision, Recovery, Calibration, Stability, Sensitivity, and Reproducibility

- *LC-MS/MS
  - ***Matrix-Matched Calibration*** **(Method of Standard Addition, MSA)**
- Challenges Specific to Fish Analysis
  - Suitable Control Matrix free of PFCs
  - Not all Fish are Created Equal
  - More Work

*"Guidance for Industry, Bioanalytical Method Validation", U.S. Department of Health and Human Services, FDA, May 2001

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Fish Extraction Techniques

Ion Pairing (IPE)
Generation 1
(1999-2005)

Protein Precipitation (PPT) with SPE
Generation 2
(2005-2007) – 3M

"New" Techniques
(2007-2008)
(1) Carbon clean-up, direct inject (Powley)
(2) Ion-pairing with fluorophilicity clean-up (Mabury)
(3) Basic digestion with SPE (EPA)

Key Issues
•Sample Preparation
•Extract Clean-Up
•Analyte List

(1) Powley, C. R. et al., *Chemosphere*, 2007, (70), 664-672.
(2) Furdui, V. I. et al., *Environ. Sci. Technol*. 2008, (42) 4739-4744.
(3) Ye, X. et. al., Environ. Pollut. 2008, (156) 1227-1232.

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2005 PERFORCE

1st Worldwide Interlaboratory Study on PFCs in Environmental and Human Samples

**Van Leeuwen et al. Environ. Sci. Technol. (2006) Vol. 40, p. 7854-7860.*

- Fish Fillet Results Most Variable, *Why???*
- Ion Pairing Extraction
- Solvent Quantitation without IS
- Matrix Effects

*Fish Fillet Results	PFOS	PFOA
Spiked Concentration (ng/g)	37	10
Analytical Results (ng/g)		
Minimum	2.8	0.54
Median	40	13
Maximum	295	204
%RSD	125	201
Evaluation of Results		
%Satisfactory	17	25
%Questionable	-	30
%Unsatsifactory	83	45

"PFC determinations in various matrices are not yet fully mastered"

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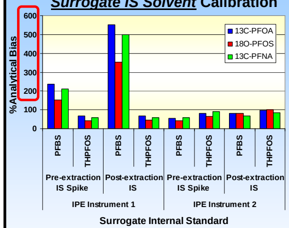
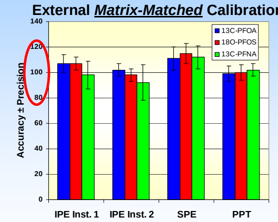
Quantitative Bias: Solvent vs. Extracted Calibration

Analytical Bias: IPE Human Sera with *Surrogate IS Solvent* Calibration



Human Sera Method Validation: Various Extraction Techniques External *Matrix-Matched* Calibration



- Surrogate IS *Not* Representative of the Target Analyte
- Matrix Ionization Suppression/Enhancements
- Matrix-matched (extracted) Calibration is the great equalizer

Reagen et. al *Analytica Chimica Acta* 2008 (628) 214-221.

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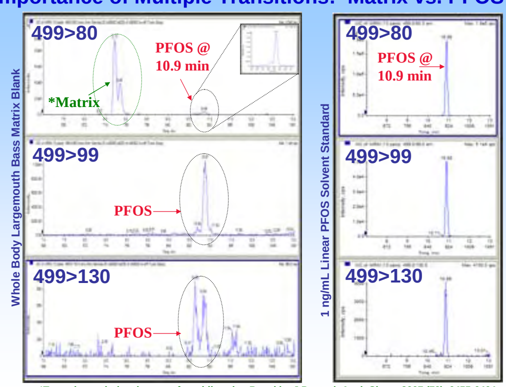
Importance of Multiple Transitions: Matrix vs. PFOS



*Taurodeoxycholate isomers from bile salt – Benskin, J.P. et. al. Anal. Chem. 2007 (79), 6455-6464.

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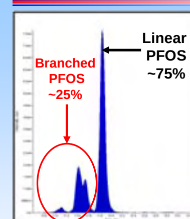
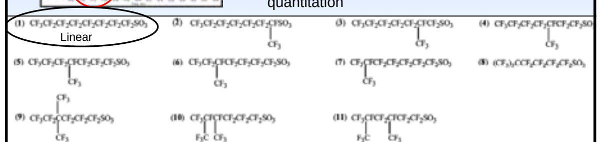
Quantitative Bias: Isomers



Riddell, N. et. al, *Environ Sci. Technol.* 2009 (43) 7902-7908.

- Eleven *known* isomers of PFOS in tech grade.
- 499>80 and 499>99 transitions have different relative response factors for the linear and the branched isomers.
- Quantitative biases possible depending on standard type and MRM transitions used for quantitation



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2008 PERFORCE

2nd Worldwide Interlaboratory Study on PFCs in Environmental Samples (Water and Fish)

• Van Leeuwen et al. J. Chromatogr. A (1216) 2009 p.401-409.

- Method of Standard Addition (MSA)
- Stable Isotope ISs – Solvent Calibration for most analytes
- New Extraction Techniques

Fish Results	PFOS		PFOA	
Spiked Conc. (ng/g)	145		22.6	
Analytical Results (ng/g)	Solvent	MSA	Solvent	MSA
Min	49.9	34.5	9.2	8.6
Mean	150	200	18.0	21.5
Max	230	388	23.6	41.5
%RSD	29	47	23	39

"Analytical Methods for PFCs in water and fish have improved considerably."

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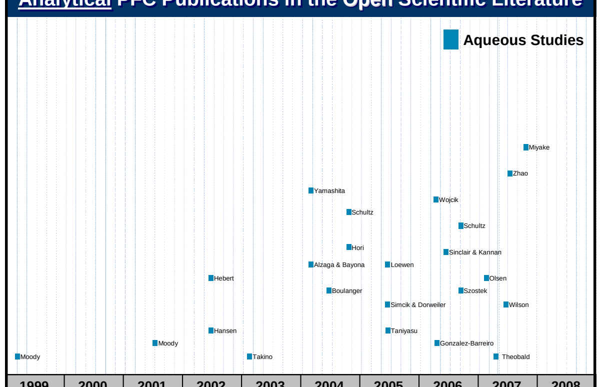
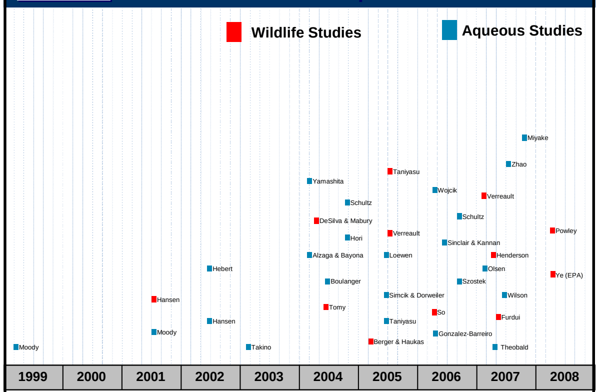
Analytical PFC Publications in the Open Scientific Literature



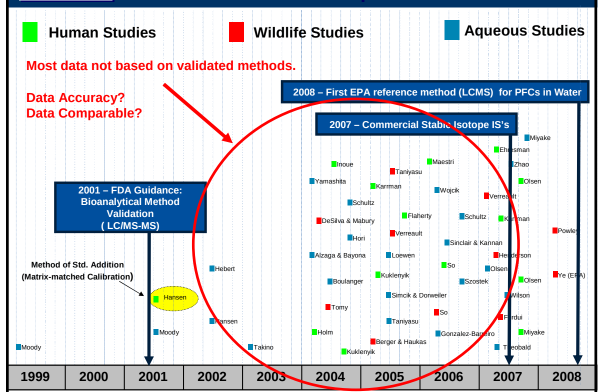
*Jahnke A, Berger U; Journal of Chromatography A 1216 (2009) 410-421

Analytical PFC Publications in the Open Scientific Literature



*Jahnke A, Berger U; Journal of Chromatography A 1216 (2009) 410-421

Analytical PFC Publications in the Open Scientific Literature*



*Jahnke A, Berger U; Journal of Chromatography A 1216 (2009) 410-421

Limitations in Published PFC Methods

- Method validation *generally* not performed and/or reported.
  - Defined Selectivity, Accuracy, Precision, Recovery, Calibration, Stability, Sensitivity,and Reproducibility
- Matrix biases/interferents not fully evaluated
  - Solvent calibration without stable isotope ISs
  - Species specificity (not all fish are created equal)
  - Biological matrix components with common MRM transitions
- Complicated Sample Prep and Clean-Up procedures.

Carefully consider the analytical method before using a reported PFC value.

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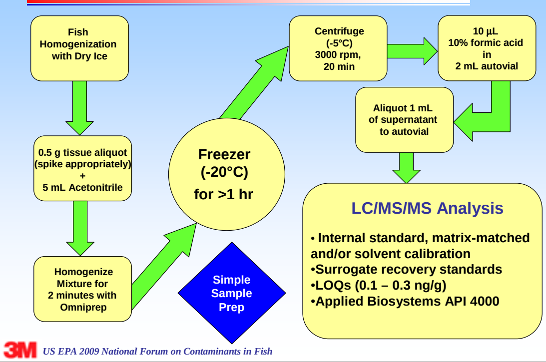
New 3M PFC Fish Method
Sample Preparation & Analysis



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3M PFC Fish Method: Target Analytes & ISs

Target Analyte	MRM Transition	IS	MRM	Surrogate
PFBA (C4 Acid)	213>169	[1,2,3,4 -$^{13}C_4$]PFBA	217>172	[1,2 -$^{13}C_2$]PFOA 415>370
* PFPeA (C5 Acid)	263>219	*[1,2,3,4 -$^{13}C_4$]PFBA	217>172	
PFHxA (C6 Acid)	313>269, 313>119	[1,2 -$^{13}C_2$]PFHxA	315>270	
* PFHpA (C7 Acid)	363>319, 363>169	*[1,2,3,4-$^{13}C_4$]PFOA	417>372	
PFOA (C8 Acid)	413>369, 413>219, 413>169	[1,2,3,4-$^{13}C_4$]PFOA	417>372	
PFNA (C9 Acid)	463>419, 463>219, 463>169	[1,2,3,4,5-$^{13}C_5$]PFNA	468>423	
PFDA (C10 Acid)	513>469, 513>269, 513>219	[1,2 -$^{13}C_2$]PFDA	515>470	
PFUnA (C11 Acid)	563>519, 563>269, 563>219	[1,2 -$^{13}C_2$]PFUnA	565>520	
PFDoA (C12 Acid)	613>569, 613>319, 613>169	[1,2 -$^{13}C_2$]PFDoA	615>570	
PFBS (C4 Sulfonate)	299>80, 299>99	[$^{18}O_2$]PFBS	303>84	[$^{18}O_2$]PFOS 503>84
PFHS (C6 Sulfonate)	399>80, 399>99	[$^{18}O_2$]PFHS	403>84	
PFOS (C8 Sulfonate)	499>80, 499>99, 499>130	[1,2,3,4- $^{13}C_4$]PFOS	503>80	
* FOSA (C8 Sulfonamide)	498>70	[1,2,3,4- $^{13}C_4$]PFOS	503>80	

- •13 Target Analytes
- •10 IS
- •2 Surrogates
- •43 MRM Transitions

Two Injections
- •C4-C6 Acids analyzed using different column/mobile phase
- •Multiperiod method for rest

* Surrogate IS used for this compound.

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LC Conditions

C4-C6 Acid

Step	Total Time (min)	Flow Rate (µL/min)	%A	%B
0	0	300	90	10
1	3.0	300	90	10
2	3.5	300	30	70
3	9.0	300	5.0	95
4	15.0	300	5.0	95
5	15.1	300	90	10
6	19.0	300	90	10

A: 5 mM Ammonium Acetate with 0.01% Acetic Acid (aq)
B: Methanol
Analytical Column: PRISM RP
50 mm x 2.1 mm; 5 µ particle size
Injection Volume: 20 µL
Divert first 3 minutes to waste

PFCAs (C7-C12),PFASs, FOSA

Step	Total Time (min)	Flow Rate (µL/min)	%A	%B
0	0	400	97	3.0
1	3.0	400	97	3.0
2	3.5	400	70	30
3	13.5	400	40	60
4	15.5	400	40	60
5	16.0	400	10	90
6	18.0	400	10	90
7	18.3	400	97	3.0
8	21.0	400	97	3.0

A: 2 mM Ammonium Acetate (aq)
B: Acetonitrile
Extraction Pre-Column: Waters® Oasis HLB (20 mm x 3.0 mm)
Analytical Column: Betasil C18
100 mm x 2.1 mm; 5 m particle size
Injection Volume: 25 µL
Divert first 5 minutes to waste

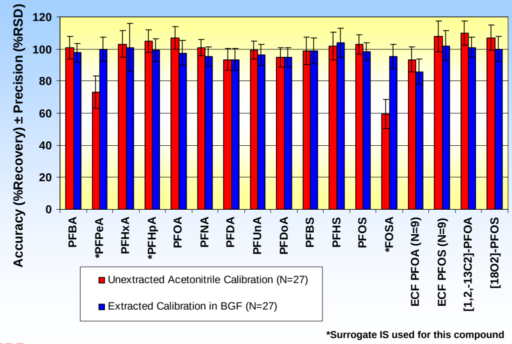
3M US EPA 2009 National Forum on Contaminants in Fish

Method Validation

- **Accuracy & Precision – Stable IS Quantitation**
  - Method of Standard Addition (*Bluegill Fillet Control Matrix)
  - Unextracted (Solvent) Calibration
  - Triplicate lab control spikes at three levels
- **Quantitation of branched PFOS/PFOA isomers from ECF source**
- **Quantitation of low-level analytes (ppb) in the presence of high level PFOS (ppm)**
- **Specificity**

Note: All fish investigated for method validation were purchased from a supplier for scientific studies. Control fish are NOT environmental samples.

Method Validation Summary



*Surrogate IS used for this compound

Application to Environmental Samples: 2008 MPCA Mississippi River Sampling

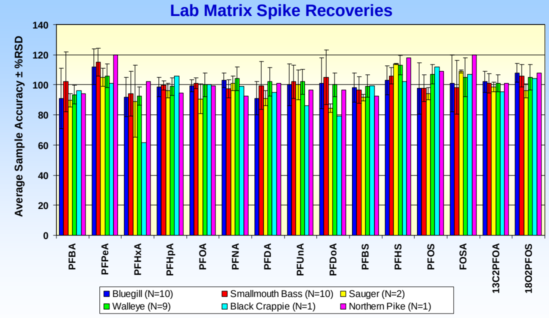
33 Fillet Samples
- Bluegill (N=10)
- Smallmouth Bass (N=10)
- Walleye (N=9)
- Sauger (N=2)
- Black Crappie (N=1)
- Northern Pike (N=1)

Samples extracted in Duplicate

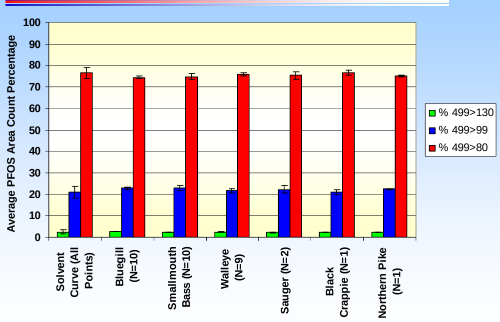
Lab Matrix Spike (LMS) prepared for each sample

Minnesota Pollution Control Agency Home Page.
http://www.pca.state.mn.us/publications/pfc-2008mpcametrolakesfishpfcdata-final9.pdf

Mississippi River Sample Accuracy

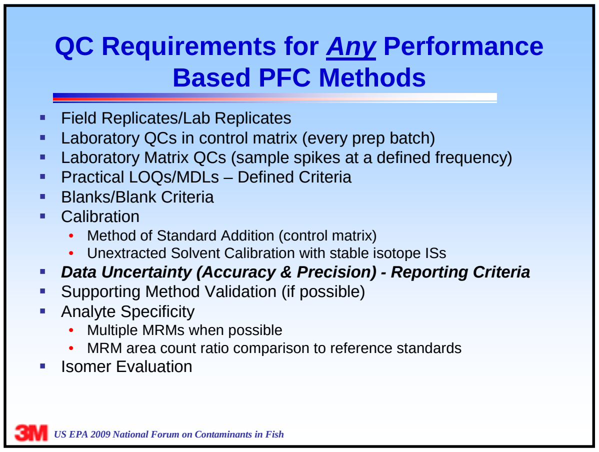


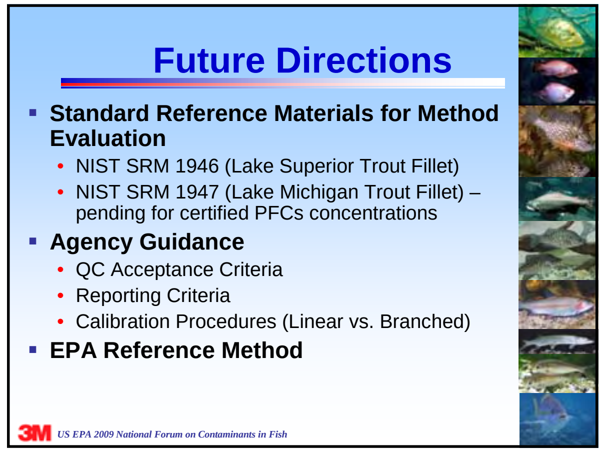
PFOS Specificity: MRM Transition Analysis



3M PFC Method Conclusions

- Simple Extraction Procedures
- Accuracy & Precision
  - 100±30% for most analytes
- Expanded Analyte List
- **Stable Isotope IS Quantitation**
  - MSA
  - Solvent Quantitation
- Validation in Bluegill Fillet
  - Applicable to 6+ additional freshwater species (fillet)
  - Whole-body
- Isomer Quantitation of PFOS/PFOA


QC Requirements for *Any* Performance Based PFC Methods
Field Replicates/Lab Replicates
Laboratory QCs in control matrix (every prep batch)
Laboratory Matrix QCs (sample spikes at a defined frequency)
Practical LOQs/MDLs – Defined Criteria
Blanks/Blank Criteria
Calibration
Method of Standard Addition (control matrix)
Unextracted Solvent Calibration with stable isotope ISs
Data Uncertainty (Accuracy & Precision) - Reporting Criteria
Supporting Method Validation (if possible)
Analyte Specificity
Multiple MRMs when possible
MRM area count ratio comparison to reference standards
Isomer Evaluation
3M
US EPA 2009 National Forum on Contaminants in Fish


Future Directions
Standard Reference Materials for Method Evaluation
NIST SRM 1946 (Lake Superior Trout Fillet)
NIST SRM 1947 (Lake Michigan Trout Fillet) – pending for certified PFCs concentrations
Agency Guidance
QC Acceptance Criteria
Reporting Criteria
Calibration Procedures (Linear vs. Branched)
EPA Reference Method
3M
US EPA 2009 National Forum on Contaminants in Fish

PFCs in Fish—Introduction and Survey Results

Moderator: Randall Manning, Georgia Department of Natural Resources

Dr. Randall O. Manning (Ph.D.) is the Coordinator of the Environmental Toxicology Program in the Georgia Department of Natural Resources, Environmental Protection Division. He received a Ph.D. in 1986 from the University of Georgia, and served as a Postdoctoral Research Associate and an Assistant Research Scientist in the Department of Pharmacology and Toxicology at the University of Georgia from 1986 to 1990. His interest in fish consumption advisories began in 1991 when he coordinated the development of guidelines for a fish-monitoring strategy and risk-based advisories for Georgia. Continuing interests include uncertainties regarding fish consumption rates and patterns and potential benefits from fish consumption as they relate to risk communication. Dr. Manning is a member of the Society of Toxicology and a Diplomate of the American Board of Toxicology. He also holds adjunct appointments in the Departments of Pharmaceutical and Biomedical Sciences in the College of Pharmacy at the University of Georgia, and Environmental and Occupational Health at Emory University's Rollins School of Public Health.

Abstract

Thirty-eight state fish advisory program managers responded to an e-mail survey designed to determine which state programs had data on perfluorochemical (PFC) levels in fish fillets. Of the states that responded to the survey, nine reported having data and shared these data for a presentation at the 2009 U.S. Environmental Protection Agency Forum on Contaminants in Fish. A panel of presenters will describe these data. Presentations will include information on why PFC in fish monitoring was initiated, the sampling design, the laboratory used, and the analytes measured, as well as a summary of results.

PFCs in Fish—Data Presentations Followed by Questions and Answers Panel Discussion

Minnesota and Wisconsin Data, Minnesota Fish Consumption Advisory

Pat McCann, Minnesota Department of Health

Southeast Data

Neil Sass, Alabama Department of Public Health

Washington Data

Chad Furl, Washington State Department of Ecology

Delaware River Basin Commission Data

Thomas Fikslin, Delaware River Basin Commission

PFCs in Fish— Data Presentations Followed by Questions and Answers Panel Discussion

Minnesota and Wisconsin Data, Minnesota Fish Consumption Advisory

Pat McCann, Minnesota Department of Health, Fish Consumption Advisory Program

Biosketch

Ms. Pat McCann has managed the Minnesota Department of Health's Fish Consumption Advisory Program since 1997. She is involved in planning, sampling fish for contaminants, researching health effects of fish contaminants, developing consumption advice, and communicating this advice to the public. She holds an 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.

PFCs in Fish: Minnesota & Wisconsin Data

MDH Fish Consumption Guidelines

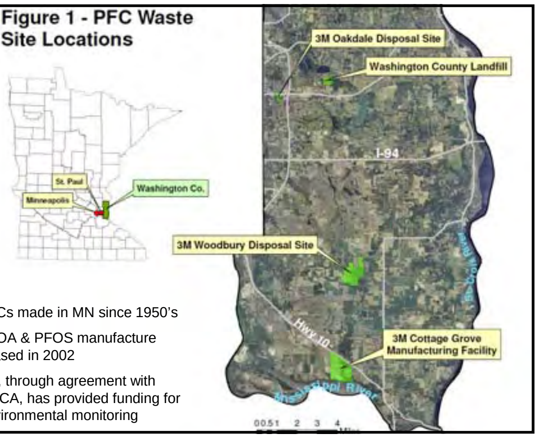
Pat McCann, MN Dept of Health
Contributors:
Helen Goeden, MN Dept of Health
Bruce Monson, MN Pollution Control Agency
Candy Schrank, WI Dept of Natural Resources
Henry Anderson, WI Division of Public Health

MDH

Overview

- PFOS
  - most common PFC detected in fish fillets
  - highest concentrations
- PFOS measured in fish from MN lakes with no known point source
- Not able to predict which lakes will be higher
- Fish PFOS levels not predicted by typical influencing factors – trophic level, length/age, lipid…
- PFOS levels appear to be lower in rural lakes than in urban lakes

Figure 1 - PFC Waste Site Locations



PFCs made in MN since 1950's

PFOA & PFOS manufacture ceased in 2002

3M, through agreement with MPCA, has provided funding for environmental monitoring

Health-based Guidance for PFBA, PFOA, PFBS, PFHxS and PFOS

FSTRAC
October 21, 2009

Helen Goeden, Ph.D.
Minnesota Department of Health

PFOS RfD$_{MDH(2007)}$

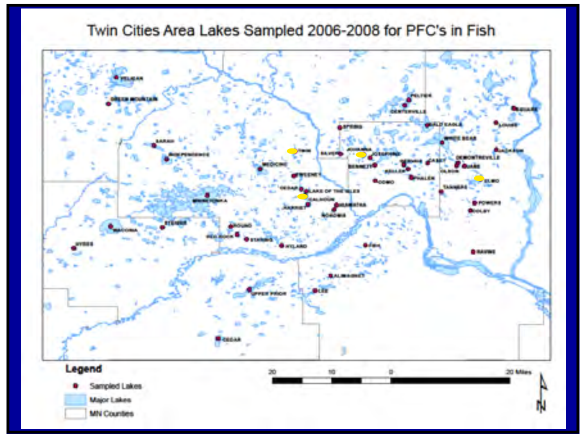
- RfD = 0.08 µg/kg-d
  - 26 week monkey study
  - POD = 35 ug/mL serum level corresponding to the BMDL10 for cholesterol and liver weight effects.
  - HED = 0.00245 mg/kg-d
    - SS, Human t ½ = 1971 days, one compartment model
  - UFs = 30 (3A, 10H)

Meal Advice Categories

Meal Advice	PFOS Concentration (ng/g)
No restrictions	< 40
1 meal / week	> 40 - 200
1 meal / month	> 200 - 800
Do not eat	> 800

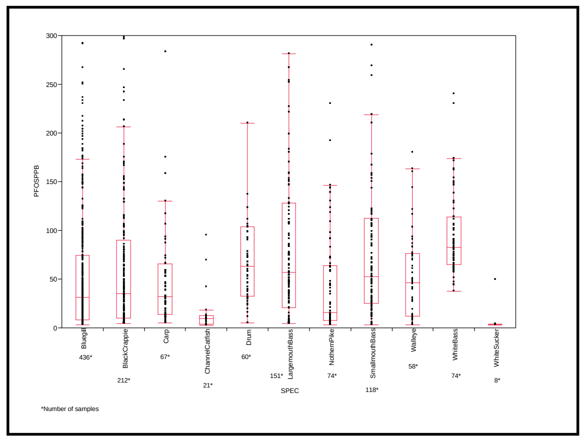
MDH Fish Consumption Advice - PFOS

- Spring 2006 - 1st Advisory Issued
  - Bluegill from Mississippi River Pool 2
- 2007 PFOS Consumption Advice
  - Mississippi River Pools 2 – 6
  - Calhoun (Brownie, Cedar, Isles, Harriet)

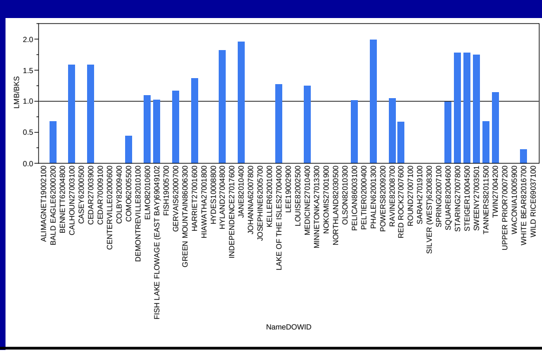


Wisconsin

- WI analyzed fish from Mississippi River
  - Analyzed by AXYS
  - WI and MN combined data
  - Utilized the MN risk assessment to provide consumption guidance
- WI lab has developed capability to analyze PFCs in fish.
  - Analyzing fish for National Park Service, Great Lakes Network



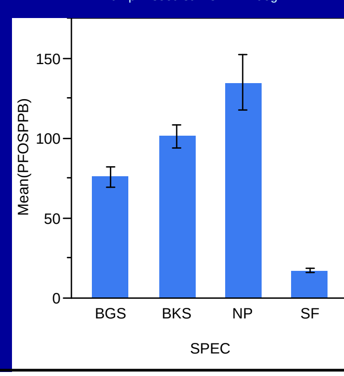
PFOS ratio -- Largemouth Bass/Crappie

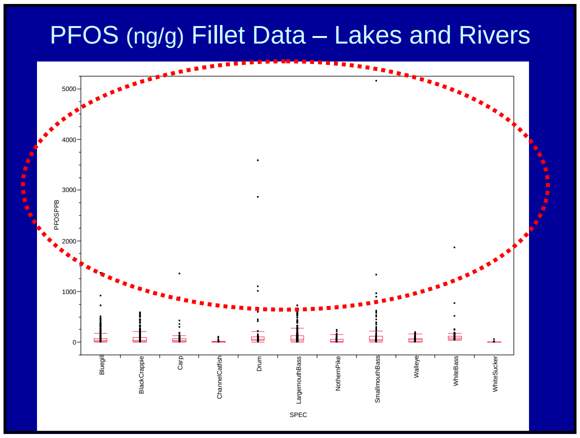


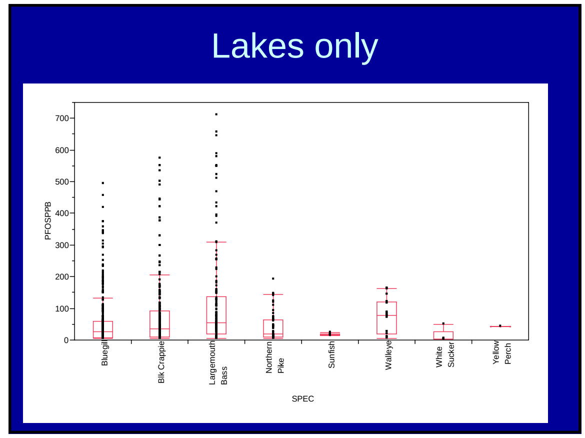
Fish Lake 190057, Dakota Co.

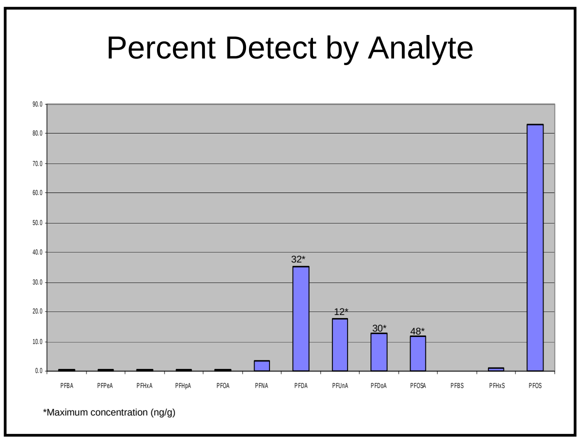
***Pumpkinseed sunfish << Bluegill

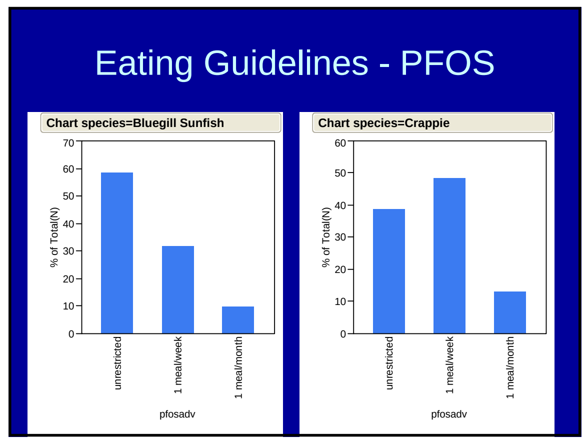
N=2




PFOS (ng/g) Fillet Data – Lakes and Rivers
PFOSPPB
SPEC


Lakes only
PFOSPPB
Bluegill
Blk Crappie
Largemouth Bass
Northern Pike
Sunfish
Walleye
White Sucker
Yellow Perch
SPEC


Percent Detect by Analyte
32*
12*
30*
48*
*Maximum concentration (ng/g)


Eating Guidelines - PFOS
Chart species=Bluegill Sunfish
Chart species=Crappie
% of Total(N)
unrestricted
1 meal/week
1 meal/month
pfosadv

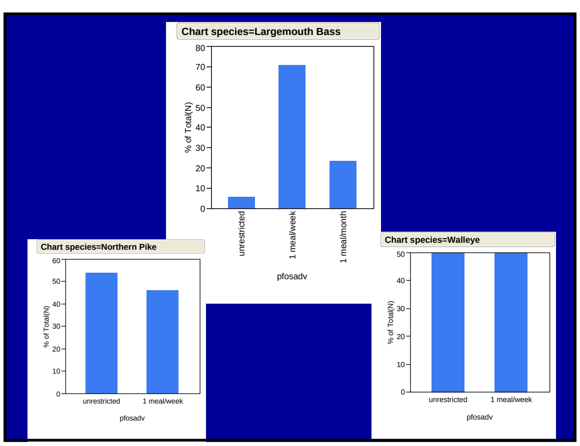
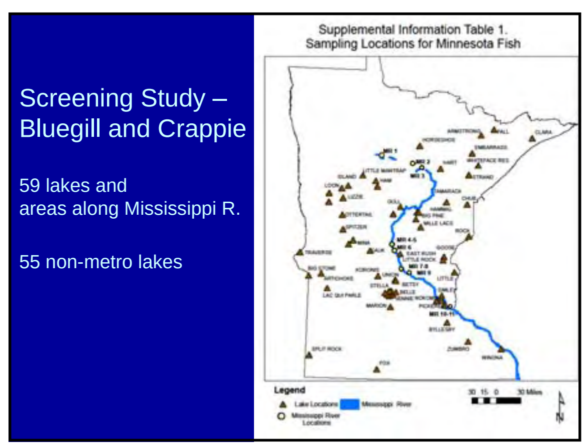
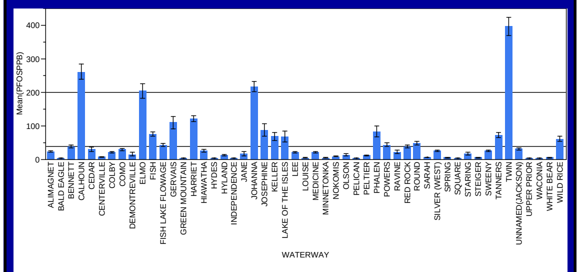


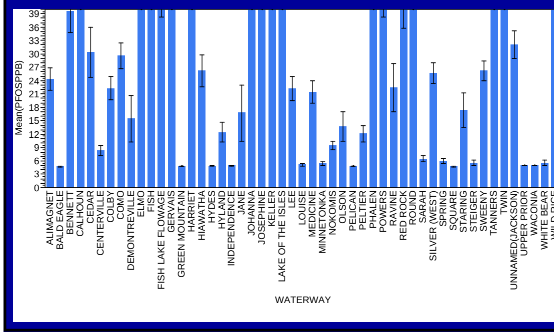
Chart species=Largemouth Bass
Chart species=Northern Pike
Chart species=Walleye
% of Total(N)
unrestricted
1 meal/week
1 meal/month
pfosadv


Screening Study – Bluegill and Crappie
59 lakes and areas along Mississippi R.
55 non-metro lakes
Supplemental Information Table 1. Sampling Locations for Minnesota Fish
Legend

Bluegill

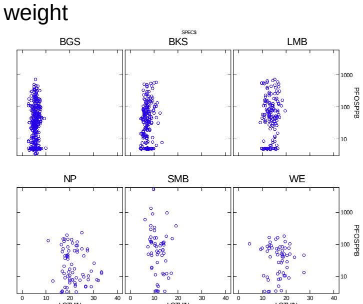


Bluegill (scale 0 – 40 ppb)



PFOS in Fish

- No relationship to:
  - Length, age, weight
  - Lipid



2009 Sampling Locations

50+ lakes & rivers

Areas of PFC Investigation in MN

- **Fire Fighting Training Sites**
- **Large Fires**
- **Landfills**
- **Waste Water Treatment Plants**
- **Ambient Environment**
  - **Surface water**
  - **Wildlife (esp. fish)**
- **Other studies:**
  - **Biomonitoring**
  - **Vegetables**

Minnesota Health-Based Numbers

- Drinking Water Criteria (ug/L)
  - PFBA (7), PFOA (0.3), PFOS (0.3), PFBS (7)
- Soil Criteria – PFBA, PFOA, PFOS
  - Residential & Industrial
- Surface Water Criteria - PFOA & PFOS
  - Mississippi River (Pool 3)
  - Lake Calhoun

For more information . . .

- Minnesota Department of Health web sites –
  - PFCs - http://www.health.state.mn.us/divs/eh/hazardous/topics/pfcs/index.html
  - Fish Consumption Guidelines – http://www.health.state.mn.us/divs/eh/fish/index.html
  - Health-based guidance for water - http://www.health.state.mn.us/divs/eh/risk/guidance/gw/index.html
- Minnesota Pollution Control Agency PFC – http://www.pca.state.mn.us/cleanup/pfc/index.html

Questions and Answers

Q. *In Hocking, OH, the occurrence of PFCs was prevalent across the river. Atmospheric transportation processes existed as well. Do you know if it remobilizes or if primary sources are there to affect these isolated lakes?*

A. If there were local atmospheric sources, you would think there would be higher concentrations in connecting lakes as well. There are no local atmospheric sources we know of, so we speculate the mercury is from runoff or some other emission type.

Q. *Has there been any investigation into temporal variability with the same age and size classes?*

A. We have some temporal data in lakes and in the Mississippi River, but there is so much variability in the waters that trends aren't detectable. There was no clear trend over three years, but a temporal investigation would be good.

We do not yet have enough data to draw conclusions.

Southeast Data

Neil L. Sass, Alabama Department of Public Health

Biosketch

Dr. Neil L. Sass has the responsibility of overseeing the possible impact on the health of Alabama citizens from assorted sources of contaminants (e.g., inhalation of materials due to a leak from industrial or transportation sources, ingestion of contaminants entering the food/water supply). Incorporated into this role is the responsibility for issuing the Alabama Fish Consumption Advisories. As Counterterrorism Coordinator, Dr. Sass directs activities within the Alabama Department of Public Health that are designed to increase the level of preparedness of the medical assets within the state should a catastrophic event occur, be it of natural, accidental, or terrorist origins. Dr. Sass is also the Director of the Chemical Terrorism/Biomonitoring Laboratory and is involved in determining whether individuals might have been exposed to chemical weapons of terrorism or chemicals in the environment. He serves as a consultant to law enforcement officers, including the United States Postal Service and the Federal Bureau of Investigation, in cases in which it is believed that chemicals or chemical weapons may have been employed in the commission of a felony. In 1999, prior to his employment with the State of Alabama, Dr. Sass retired from active federal service, where he served in the U.S. Public Health Service (USPHS) as Special Assistant to the Director, Center for Food Safety and Applied Nutrition (CFSAN), FDA, while simultaneously serving as Director, Division of Toxicological Research, CFSAN/FDA. Dr. Sass was also one of the U.S. Representatives to WHO and was involved in developing agreements regarding the humane use of animals in research. He also developed and commanded the USPHS Preventive Medicine Unit, which was designed to minimize casualties following natural disasters.

Perfluorochemicals in the Southeastern U.S.

Neil L. Sass, Ph.D.
Alabama Department of Public Health

Southeastern U.S. Includes:

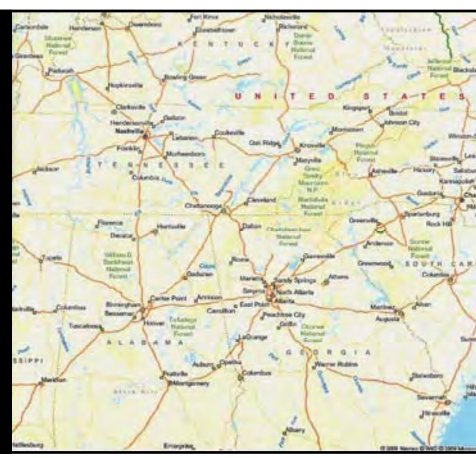
North Carolina
South Carolina
Georgia
Florida
Alabama
Mississippi
Tennessee
Louisiana

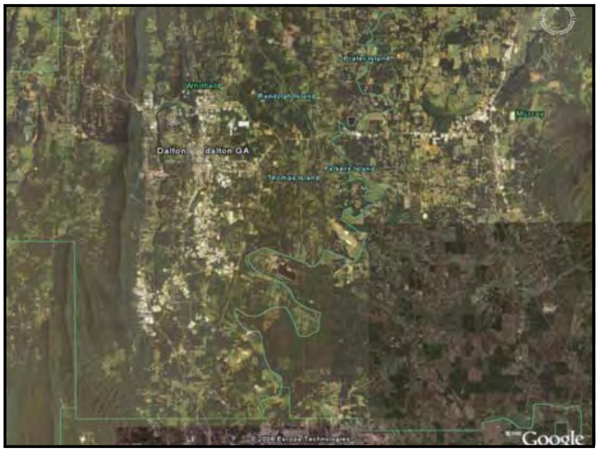
Plus:
Ohio
West Virginia

Given –

PFCs Are Everywhere

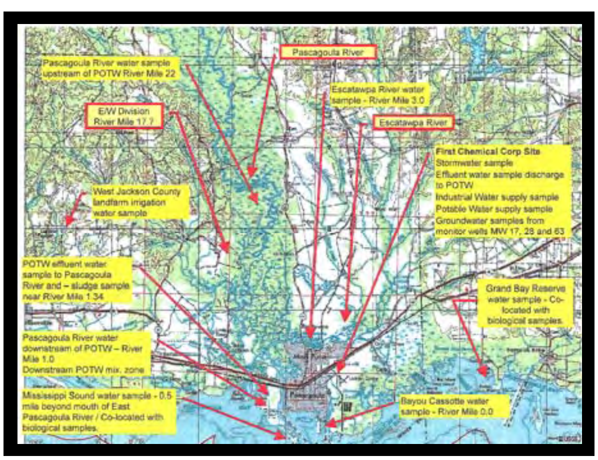
Georgia





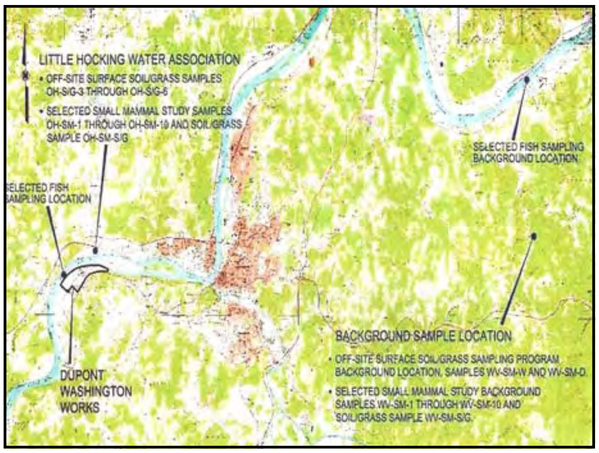
Site	Species	PFOA		PFOS	
		Liver	Filet	Liver	Filet
Resaca	Spotted Bass	0.84	ND	545.60	197.77
	Blue Catfish	1.64	ND	305.90	ND
LAS	Spotted Bass	ND	ND	1170.11	155.73
	Blue Catfish	1.70	ND	1.32	14.92
Tilton	Spotted Bass	ND	ND	1736.59	114.30
	Blue Catfish	2.86	ND	238.29	400.84

Mississippi



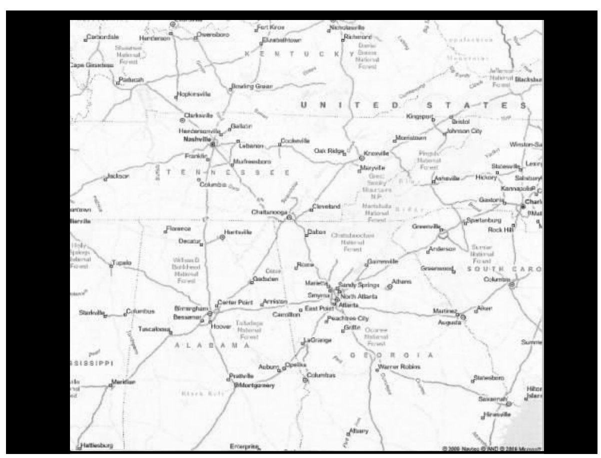
Sample Location	Sample Media	Carcass or Soft Tissue PFOA (ng/g = ppb)	Filet PFOA (ng/g = ppb)	Carcass or Soft Tissue PFOS (ng/g = ppb)	Filet PFOS (ng/g = ppb)
Mississippi Sound	Speckled Trout	1.53	1.35	7.21	1.2
	Catfish	1.67	1.35	19.37	2.18
	Blue Crab	PLC	NA	1.04	NA
	Oyster	ND	NA		NA
Grand Bay	Speckled Trout	Not Sampled	Not Sampled	Not Sampled	Not Sampled
	Catfish	1.6	1.46	39.8	3.54
	Blue Crab	0.099	NA	0.73	NA
	Oyster	ND	NA	0.91	NA

West Virginia / Ohio



Sample Media		Ohio River below Outfall 005 PFOA (µg/kg = ppb)	Ohio River Background PFOA (µg/kg = ppb)
Largemouth Bass		1.25	0.95
Channel Catfish		1.67	0.99

Alabama



Site	Species	PFOA	PFOS
Wheeler Reservoir (2 mi upsteam of Bakers Creek	Largemouth Bass	PLC	105.83
	Channel Catfish	PLC	4.04
Bakers Creek (confluence w/Tennessee River)	Largemouth Bass	PLC	1170.11
	Channel Catfish	PLC	1.32
Bakers Creek (upstream of confluence)	Largemouth Bass	PLC	1736.59
	Channel Catfish	PLC	238.29
Wheeler Reservoir (20 mi downstream of Bakers Creek	Largemouth Bass	PLC	59.28
	Channel Catfish	PLC	1.32

Given –

PFCs Are Everywhere

Contact:

Neil L. Sass, Ph.D.
334/206-5973
neil.sass@adph.state.al.us

Questions and Answers

Q. *What was the sample preparation method for catfish and largemouth bass? New York uses skin-off catfish and skin-on everything else.*

A. We used skin-off fillets.

Q. *Were the non-detects in oysters surprising?*

A. We could not be guaranteed that oysters do not flush the PFCs out.

Q. *Are there any speculative suggestions for why the study found such sporadic results?*

A. We are trying to identify sources and hopefully, with more characterization of the watersheds, we will. We also need more investigation into half-lives and food webs (e.g., do PFCs transfer through the food webs, do different food webs produce different results, are differences in spawning areas important) to answer these questions.

Q. *PFC half-lives may be longer in terrestrial animals. Did your study obtain any wild game results?*

A. The Dalton Georgia facility is planning to test turkey and deer.

Q. *Are there any other states with data on PFCs in shellfish?*

A. I'm not aware of existing data, but University of Washington is planning to look into it. 3M has looked at freshwater mussels but got non-detects for Tennessee River.

Q. *If other states begin to measure and assess PFCs and high levels are found, should states take some precautionary measures or wait for EPA?*

A. Any time an advisory is issued in Alabama, a TMDL has to be created. I don't think there is enough information about PFCs to create a TMDL. The advisory might also be enforced upon commercial fishing operations. My preference is to wait and see.

Washington Data

Chad Furl, Washington State Department of Ecology, Environmental Assessment Program

Biosketch

Mr. Chad Furl is the Persistent, Bioaccumulative, and Toxic Chemical Coordinator for the Washington State Department of Ecology's Environmental Assessment Program. During his time with the Department of Ecology, Mr. Furl has conducted numerous studies, investigating legacy and emerging contaminants in water, sediment, and fish. Mr. Furl received his M.E.S. from Baylor University, where he studied contaminant fate and transport.

Why study PFCs?

- Ecology PBT rule
  - Set forth criteria used to establish PBTs
  - List of 27 contaminants and metals of concern.
- Chemical Action Plans (CAPs)
  - Identify, characterize and evaluate all uses and releases of a specific PBT chemical.
  - Ultimate goal is to reduce and phase-out the use, release, and exposure to PBTs in Washington.
  - PBT chemicals eligibility for CAP development determined through a screening process.

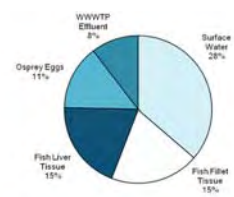
Why study PFCs?

PBT List			
Metals	**Flame Retardants**	**Banned Pesticides**	**Organic Chemicals**
Methyl-mercury	*PBDEs*	Aldrin/Dieldrin	1,2,4,5-TCB
	Tetrabromobisphenol A	Chlordane	**Perfluoro-octane sulfonate**
	Hexabromocyclododecane	DDT/DDD/DDE	Hexachlorobenzene
	Pentachlorobenzene	Heptachlor Epoxide	Hexachlorobutadiene
		Toxaphene	Short-chain chlor parraffin
		Chlordecone	Polychlorinated Naphthalenes
		Endrin	
		Mirex	
Combustion By-Products	**Banned Flame Retardants**	**Banned Organic Chemicals**	**Metals of Concern**
PAHs	Hexabromobiphenyl	PCBs	Cadmium
PCDD			*Lead*
PCDF			
PBDD/PBDF			

Monitoring is conducted through Ecology's PBT program which receives funds from the State Toxics Account.

Study Design

- Exploratory survey characterizing surface water, wastewater, fish tissues (fillet and liver), and osprey eggs.
- Broad spatial coverage and contamination potential.



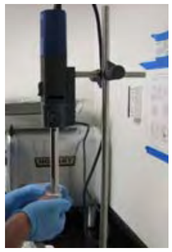
PFC Sampling Sites in Washington State.

Fish Tissue Sites

- Background sites
  - Quinault River
  - Entiat River
- Dense urban
  - Lake Washington
  - Spokane River
  - Lower Columbia River
- Other
  - FDR Reservoir
  - West Medical Lake

Sample Collection and Processing

- Collected fish during Fall 2008.
- Targeted 2 species from each waterbody ideally a predator and a bottom dweller.
- Analyzed skin-off fillet and liver composites of 3-5 fish.
- Homogenized fish with stainless steel sonicator.



Analytical Methods

- EPA Office of Research and Development – RTP, NC
- 10 PFCs, 3 sulfonates (PFBS, PFHS, PFOS), 7 carboxylics (C6 – C12)
- SPE LC/MS/MS
- Delinsky et al. 2009

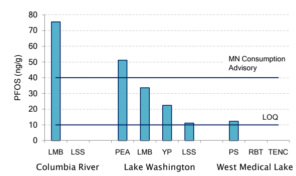
Results

LOQ (ng/g)		5	5	5	5	5	5	5	10	5	5
Waterbody	Species	C12	C11	C10	C9	PFOA	C7	C6	PFOS	PFHS	PFBS
Quinault R.	Cutthroat trout	< LOQ	ND	ND	< LOQ	ND	ND	< LOQ	< LOQ	< LOQ	< LOQ
Entiat R.	Rainbow trout	ND	ND	ND	< LOQ	ND	ND	< LOQ	< LOQ	ND	ND
"	Brook trout	ND	ND	ND	< LOQ	ND	ND	< LOQ	ND	< LOQ	ND
Spokane R.	Largescale sucker	ND	ND	< LOQ	< LOQ	ND	ND	< LOQ	< LOQ	< LOQ	< LOQ
Lower Columbia R.	Largemouth bass	ND	ND	< LOQ	< LOQ	ND	ND	< LOQ	**75.54**	< LOQ	< LOQ
"	Largescale sucker	< LOQ	ND	< LOQ	< LOQ	ND	ND	< LOQ	< LOQ	< LOQ	ND
L. Washington	Largemouth bass	< LOQ	< LOQ	< LOQ	< LOQ	ND	ND	< LOQ	**33.58**	< LOQ	< LOQ
"	Yellow perch	< LOQ	< LOQ	< LOQ	< LOQ	ND	ND	< LOQ	**22.45**	< LOQ	< LOQ
"	Peamouth	**5.5**	**7.15**	< LOQ	< LOQ	ND	ND	< LOQ	**51.21**	< LOQ	< LOQ
"	Largescale sucker	< LOQ	< LOQ	< LOQ	< LOQ	ND	ND	< LOQ	**11.14**	< LOQ	< LOQ
West Medical L.	Pumpkinseed	< LOO	< LOO	**7.5**	< LOO	ND	ND	< LOO	**12.29**	< LOO	< LOO
"	Rainbow trout	ND	ND	< LOQ	< LOQ	ND	ND	< LOQ	< LOQ	ND	< LOQ
"	Tench	ND	ND	< LOQ	< LOQ	ND	ND	< LOQ	< LOQ	< LOQ	< LOQ
FDR Reservoir	Smallmouth bass	ND	ND	< LOQ	< LOQ	ND	ND	< LOQ	< LOQ	< LOQ	< LOQ
"	Walleye	ND	ND	< LOQ	< LOQ	ND	ND	< LOQ	< LOQ	< LOQ	ND

- 15 samples from 11 species
- PFOS and C10 – C12 and were the only PFCs quantified
- Of 150 assays 9 (6%) > LOQ

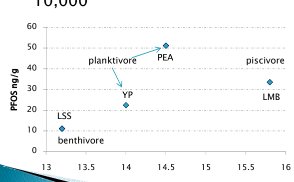
Results

- PFOS > LOQ (10 ng/g) in 6 of 15 (40%) samples representing 3 waterbodies (Lower Columbia R., L. Washington, West Medical L.)
- No PFCs found at background sites, Spokane R., or FDR Reservoir
- Not expected to efficiently bioaccumulate in piscivorous food web.
- Bioconcentration factors > 1,000 for blood, carcass, and liver.



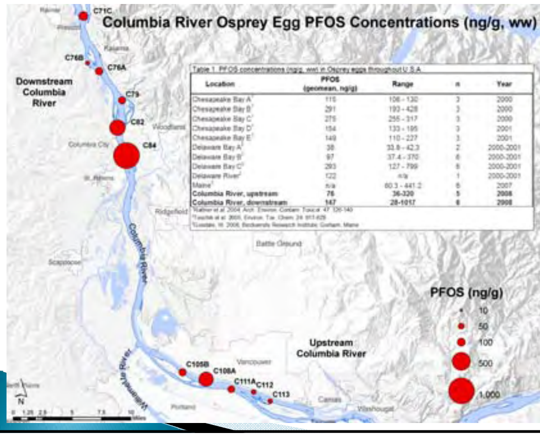
Lake Washington

- Dense urban landscape. Likely sources include stormwater, CSOs, atmospheric transport
- Well studied food web
- PFOS = 5.27 ng/L in fall sampling
- BCF range from 2,000 – 10,000



Osprey Eggs

- 11 eggs collected from nests upstream and downstream of Willamette R.
- Osprey diet consists of ≈ 85% LSS by weight
- Birds winter in rural Mexico and Central America
- LSS fillet and liver sample from study area < LOQ.



Additional information

- Report out spring 2010.
- PFC CAP construction begins in 2010.
- For more information on toxics monitoring by Ecology visit: http://www.ecy.wa.gov/programs/eap/toxics/toxicsmonitoring_by_Ecology.htm

Fish Size and Age

	Length	Weight	Age	n
QUINRCTTL	276	175	3.25	4
ENTRRBTL	216	107	4.67	3
ENTRBKTL	143	75	3.5	2
SPKRLSSL	530	1614	10.25	4
COLRLMBL	208	128	0	5
COLRLSSL	469	1008	10.75	4
WASHLLMBL	215	131	1	5
WASHLYPL	198	82	2	3
WASHLPEAL	297	241	7.6	5
WASHLLSSL	473	1186	9	4
WMLPSL	149	79	3	5
WMLRBTL	377	520	1	4
WMLTENCL	325	519	3.3	3
FDRSMBL	266	273	2	5
FDRWAL	342	306	2	5

Liver

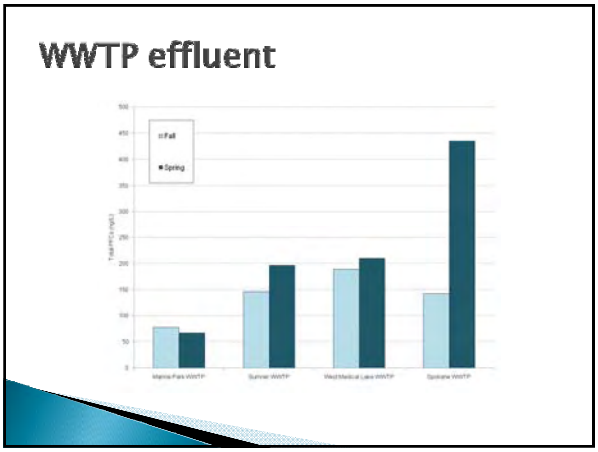
LOQ (ng/L)			10	10	25	10	10	10	10	10	10	10
Sample	Actual Mass liver	conversion factor	C12	C11	C10	C9	PFOA	C7	C6	PFOS	PFHS	PFBS
QUINRCTTL	0.1208	0.966										
ENTRRBTL	0.122	0.9762										
ENTRBKTL	0.1201	0.961										
SPKRLSSL	0.1204	0.9628								20.79		
COLRLMBL	0.1175	0.9398								527.25		
COLRLSSL	0.1212	0.9694										
WASHLLMBL	0.1254	1.0028		10.32						257.1		
WASHLYPL	0.1203	0.962								118.54		
WASHLPEAL	0.1217	0.9736	20.99	46.06						363.17		
WASHLLSSL	0.1192	0.9538		15.5						100.34		
WMLPSL	0.1201	0.9604			21.03					47.5		
WMLRBTL	0.126	1.0078								65.19		
WMLTENCL	0.1194	0.955								35.26		
FDRSMBL	0.11955	0.9564										
FDRWAL	0.1224	0.9792								47.62		

Water Spring – (ng/L)

Sample ID	Waterbody	Collection Date	PFDoDA	PFUnDA	PFDA	PFNA	PFOA	PFHpA	PFHxA	PFPeA	PFBA	PFDS	PFOS	PFHS	PFBS
08190011	Columbia River at McNary Dam	5/8/2008	< 1	< 1	< 1	< 1	**1.06**	**2.33**	< 1	ND	< 0.2	< 1	< 0.2	< 1	< 0.2
08190008	Duwamish River	5/7/2008	< 1	< 1	< 1	ND	< 1	**1.44**	< 1	ND	< 0.2	ND	ND	< 1	ND
08190009	Entiat River	5/7/2008	< 1	< 1	< 1	< 1	**1.41**	**3.77**	**1.06**	ND	ND	< 1	< 0.2	< 1	ND
08190005	F.D.R. Lake	5/6/2008	**1.07**	< 1	< 1	< 1	< 1	**1.66**	< 1	ND	ND	< 1	< 0.2	< 1	ND
08190007	Lake Washington	5/12/2008	ND	< 1	**1.50**	**1.06**	**6.85**	**4.31**	**4.27**	**1.47**	< 0.2	< 1	**5.93**	**2.45**	**1.09**
08190002	Lower Columbia River	5/5/2008	< 1	< 1	< 1	< 1	< 1	< 1	< 1	ND	ND	< 1	< 0.2	< 1	ND
08190003	Marine Park WWTP	5/5/2008	< 1	**1.18**	**5.99**	**3.50**	**20.6**	**4.12**	**14.2**	**3.55**	< 0.2	ND	**9.86**	**3.65**	**1.31**
08190001	Nooksack River	5/12/2008	< 1	< 1	< 1	< 1	**2.93**	**4.13**	< 1	ND	ND	< 1	< 0.2	< 1	ND
08190017	Puyallup River	5/12/2008	< 1	< 1	< 1	< 1	**1.25**	**3.14**	**1.39**	ND	< 0.2	< 1	< 0.2	< 1	ND
08190004	Quinault River	5/6/2008	< 1	< 1	< 1	< 1	< 1	**1.86**	< 1	ND	< 0.2	ND	< 0.2	< 1	ND
08190016	S. Fork Palouse River	5/9/2008	< 1	< 1	**1.46**	**1.23**	**9.07**	**3.84**	**9.91**	**2.52**	**4.27**	< 1	**1.67**	**1.31**	**1.15**
08190006	Snohomish River	5/7/2008	< 1	< 1	< 1	< 1	< 1	**1.14**	< 1	ND	ND	< 1	ND	< 1	ND
08190015	Spokane River at Ninemile Dam	5/9/2008	< 1	< 1	< 1	< 1	**1.84**	**3.56**	**3.95**	ND	< 0.2	< 1	< 0.2	< 1	< 0.2
08190014	Spokane WWTP	5/8/2008	< 1	< 1	**13.3**	**18.5**	**136**	**35.6**	**137**	**30.6**	**3.99**	< 1	**36.2**	**20.2**	**3.00**
082000017	Sumner WWTP	5/12/2008	< 1	**1.27**	**12.0**	**10.5**	**88.2**	**7.37**	**44.8**	**20.7**	**3.04**	< 1	**5.56**	**1.63**	**1.71**
08190010	Upper Columbia River	5/7/2008	< 1	< 1	< 1	< 1	**1.47**	**4.00**	**1.38**	ND	ND	< 1	< 0.2	< 1	ND
08190012	West Medical Lake	5/8/2008	< 1	< 1	**4.63**	**18.2**	**107**	**27.3**	**79.8**	**25.7**	**3.90**	**1.65**	**11.6**	**5.03**	**1.71**
08190013	West Medical Lake WWTP	5/8/2008	< 1	< 1	**3.37**	**6.84**	**83.3**	**12.9**	**58.7**	**28.5**	**2.70**	< 1	**4.35**	**3.21**	**5.46**

Water Fall – (ng/L)

Sample ID	Waterbody	Collection Date	PFDoDA	PFUnDA	PFDA	PFNA	PFOA	PFHpA	PFHxA	PFPeA	PFBA	PFDS	PFOS	PFHS	PFBS
083700029	Columbia River at McNary Dam	9/9/2008	< 5	< 0.5	**0.53**	< 0.5	**0.74**	**4.95**	< 0.5	< 0.5	< 0.5	< 0.5	**0.53**	< 0.5	< 0.5
083700026	Duwamish River	9/11/2008	< 5	< 0.5	**0.78**	**1.12**	**1.90**	**3.21**	**1.19**	**0.57**	< 0.5	< 0.5	**1.01**	**0.84**	**0.74**
083700027	Entiat River	9/8/2008	< 5	< 0.5	< 0.5	< 0.5	< 0.5	**0.95**	**0.64**	< 0.5	< 0.5	< 0.5	**0.66**	< 0.5	< 0.5
083700023	F.D.R. Lake	9/9/2008	< 5	< 0.5	< 0.5	< 0.5	< 0.5	**1.31**	**1.87**	**0.55**	**0.81**	< 0.5	**0.54**	< 0.5	< 0.5
083700025	Lake Washington	9/11/2008	< 5	< 0.5	**0.69**	< 0.5	**2.19**	**2.06**	**1.42**	**1.23**	< 0.5	< 0.5	**5.27**	**1.63**	**0.78**
083700020	Lower Columbia River	9/12/2008	< 5	< 0.5	< 0.5	< 0.5	**0.81**	**0.86**	**1.59**	< 0.5	< 0.5	< 0.5	**1.04**	< 0.5	**0.54**
083700021	Marine Park WWTP	9/12/2008	< 5	< 0.5	**4.42**	**5.7**	**22.1**	**3.52**	**10.9**	**12.6**	**1.91**	< 0.5	**11.7**	**3.97**	< 0.5
083700019	Nooksack River	9/12/2008	< 5	< 0.5	< 0.5	< 0.5	< 0.5	**1.19**	**1.19**	< 0.5	< 0.5	< 0.5	**0.66**	< 0.5	**0.52**
083700035	Puyallup River	9/12/2008	< 5	< 0.5	**0.58**	< 0.5	< 0.5	**2.02**	< 0.5	< 0.5	< 0.5	< 0.5	**0.50**	< 0.5	< 0.5
083700022	Quinault River	9/8/2008	< 5	< 0.5	< 0.5	< 0.5	< 0.5	**1.54**	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	**0.63**
083700034	S. Fork Palouse	9/10/2008	< 5	< 0.5	**3.14**	**2.46**	**24.0**	**6.88**	**12.4**	**13.0**	**2.70**	< 0.5	**6.36**	**1.93**	**1.98**
083700024	Snohomish River	9/11/2008	< 5	< 0.5	< 0.5	< 0.5	< 0.5	**0.97**	< 0.5	< 0.5	< 0.5	< 0.5	**0.55**	< 0.5	< 0.5
083700033	Spokane River at Nine Mile	9/10/2008	< 5	< 0.5	**0.63**	< 0.5	**1.82**	**3.30**	**1.43**	**1.40**	< 0.5	< 0.5	**3.25**	**1.26**	**0.62**
083700032	Spokane WWTP	9/10/2008	< 5	< 0.5	**3.67**	**7.72**	**36.6**	**12.9**	**29.8**	**16.0**	**2.80**	< 0.5	**18.1**	**11.9**	**2.40**
083700036	Sumner WWTP	9/12/2008	< 5	**0.68**	**13.2**	**13.8**	**59.9**	**9.74**	**17.1**	**21.7**	**4.25**	< 0.5	< 0.5	**2.72**	**3.15**
083700028	Upper Columbia River	9/9/2008	< 5	< 0.5	< 0.5	< 0.5	< 0.5	**0.90**	< 0.5	< 0.5	< 0.5	< 0.5	**0.67**	< 0.5	< 0.5
083700030	West Medical Lake	9/10/2008	< 5	< 0.5	**3.72**	**6.83**	**47.3**	**21.9**	**36.1**	**31.0**	**5.40**	**1.27**	**7.44**	**4.40**	**1.54**
083700031	West Medical Lake WWTP	9/10/2008	< 5	< 0.5	**6.08**	**5.89**	**63.1**	**12.8**	**29.4**	**46.7**	**5.43**	< 0.5	**10.2**	**2.19**	**6.58**


WWTP effluent
Fall
Spring

Delaware River Basin Commission Data

Thomas Fikslin, Modeling, Monitoring, and Assessment Branch, Delaware River Basin Commission

Biosketch

Dr. Thomas Fikslin (Ph.D.) is the manager of the Modeling, Monitoring and Assessment Branch for the Delaware River Basin Commission. The Commission manages the water resources of the Delaware River Basin, which spans the states of Delaware, New Jersey, New York, and Pennsylvania. The branch is responsible for conducting and coordinating monitoring activities within the Basin, the development and application of hydrodynamic and water quality models, and the development and implementation of TMDLs for toxic and conventional pollutants. Prior to joining the Commission, Dr. Fikslin worked for EPA Region 2 in the regional laboratory and the National Pollutant Discharge Elimination System program.

PFCs in Fish Tissue in the Delaware River

Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
UNITED STATES OF AMERICA

2009 National Forum on Contaminants in Fish

Portland, OR
November 2009

Presentation Themes

- ✓ Background
  - Delaware River Basin
  - Program objectives
  - Why sample for PFCs?
- ✓ Program Details
  - Sampling Design
  - Analytical Methods
  - 2004-2007 Results
    - Background levels
- ✓ Summary

Basin Facts

- Largest un-dammed river east of the Mississippi – 330 miles
- 13,539 square mile drainage
- 17 million water users
- 216 tributaries
- Three reaches included in National Wild and Scenic River System
- One of the world's largest freshwater tidal estuaries
- Delaware Bay- 782 sq. miles

Background

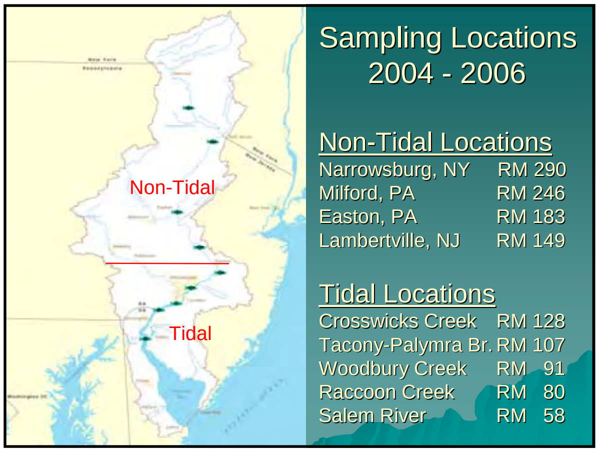
- Issues:
  1. Why monitor fish?
     - Interstate waters
     - Funding for programs
     - Coordination w/ State partners.
  2. Design considerations:
     - Locations – tidal vs. nontidal?
     - Species – resident or migratory?
     - Analytical parameters
  3. Why monitor for PFCs?

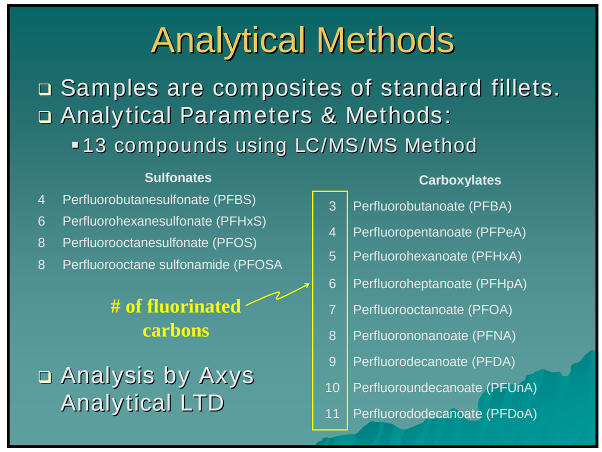
Sampling Design

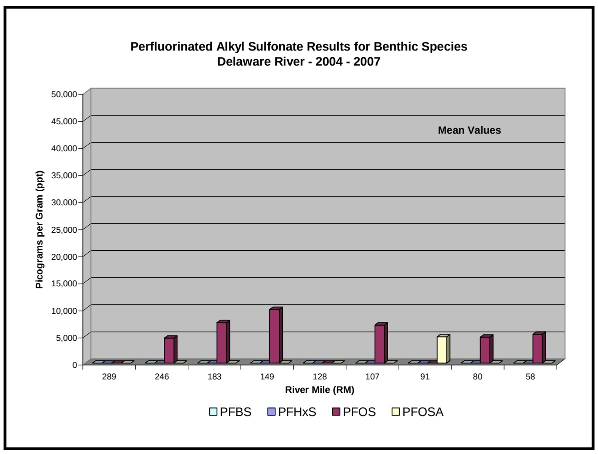
- Historically, water quality near the urban areas surrounding Philadelphia was severely degraded with dissolved oxygen conditions near 0 mg/l.
- When conditions improved in the 1980s, fish returned to this area, but were contaminated with several chemicals including PCBs.
- Fish contaminant monitoring was initiated in tidal waters in the 1990s with PCBs and chlorinated pesticides the target contaminants.
- In 2000, monitoring was extended to non-tidal areas.
- In 1994, PFCs, PBDEs and dioxin/furans were added as target contaminants.

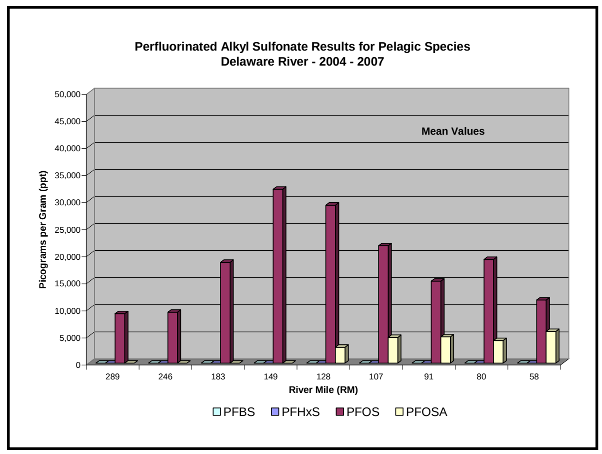
Sampling Design

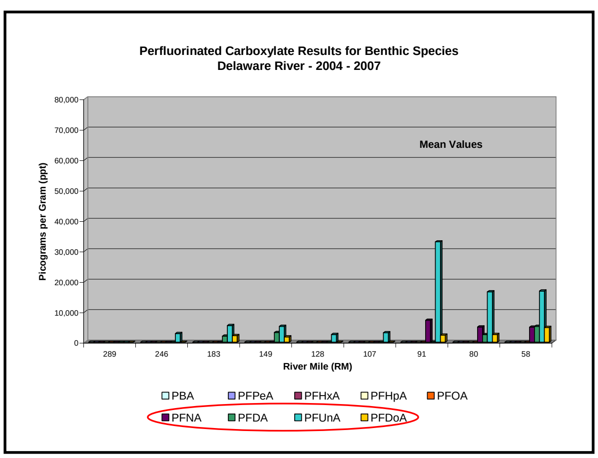
- Fish samples were collected from 8 stations in both the tidal and non-tidal portion of the Delaware River.
- Two species of fish are collected at each site representing resident benthic and pelagic trophic levels.
  - Tidal species: white perch, channel catfish
  - Non-tidal species: smallmouth bass, white sucker
- Samples are collected by electrofishing or hook & line, and consist of 4 to 5 fish of similar size and weight.

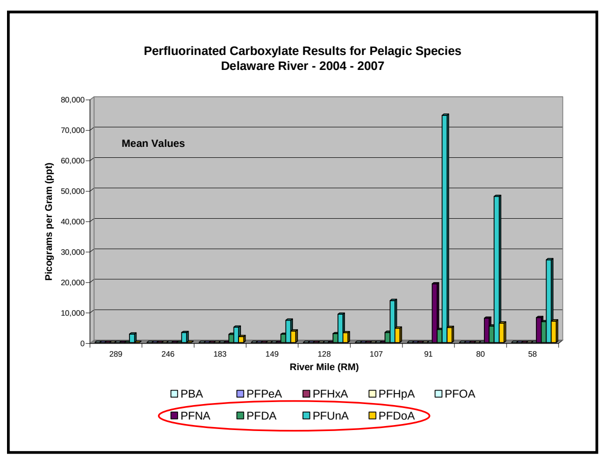

Sampling Locations 2004 - 2006
Non-Tidal
Tidal
Non-Tidal Locations
Narrowsburg, NY RM 290
Milford, PA RM 246
Easton, PA RM 183
Lambertville, NJ RM 149
Tidal Locations
Crosswicks Creek RM 128
Tacony-Palymra Br. RM 107
Woodbury Creek RM 91
Raccoon Creek RM 80
Salem River RM 58


Analytical Methods
Samples are composites of standard fillets.
Analytical Parameters & Methods:
13 compounds using LC/MS/MS Method
Sulfonates
4 Perfluorobutanesulfonate (PFBS)
6 Perfluorohexanesulfonate (PFHxS)
8 Perfluorooctanesulfonate (PFOS)
8 Perfluorooctane sulfonamide (PFOSA
# of fluorinated carbons
Carboxylates
3 Perfluorobutanoate (PFBA)
4 Perfluoropentanoate (PFPeA)
5 Perfluorohexanoate (PFHxA)
6 Perfluoroheptanoate (PFHpA)
7 Perfluorooctanoate (PFOA)
8 Perfluorononanoate (PFNA)
9 Perfluorodecanoate (PFDA)
10 Perfluoroundecanoate (PFUnA)
11 Perfluorododecanoate (PFDoA)
Analysis by Axys Analytical LTD


Perfluorinated Alkyl Sulfonate Results for Benthic Species
Delaware River - 2004 - 2007
Mean Values
Picograms per Gram (ppt)
River Mile (RM)
289 246 183 149 128 107 91 80 58
PFBS PFHxS PFOS PFOSA


Perfluorinated Alkyl Sulfonate Results for Pelagic Species
Delaware River - 2004 - 2007
Mean Values
Picograms per Gram (ppt)
River Mile (RM)
289 246 183 149 128 107 91 80 58
PFBS PFHxS PFOS PFOSA


Perfluorinated Carboxylate Results for Benthic Species
Delaware River - 2004 - 2007
Mean Values
Picograms per Gram (ppt)
River Mile (RM)
289 246 183 149 128 107 91 80 58
PBA PFPeA PFHxA PFHpA PFOA
PFNA PFDA PFUnA PFDoA


Perfluorinated Carboxylate Results for Pelagic Species
Delaware River - 2004 - 2007
Mean Values
Picograms per Gram (ppt)
River Mile (RM)
289 246 183 149 128 107 91 80 58
PBA PFPeA PFHxA PFHpA PFOA
PFNA PFDA PFUnA PFDoA

Background Concentrations

- The northernmost sampling locations should reflect background concentrations since they are located within National Park Service units.

Type	Parameter	Mean (ppb)	Std Dev (ppb)
PFASs	PFOS	9.4	3.4
	PFOSA	U	-
PFCAs	PFNA	U	-
	PFDA	U	-
	PFUnA	3.1	0.7
	PFDoA	U	-

Background Concentrations

- The northernmost sampling locations should reflect background concentrations since they are located within National Park Service units.

Type	Parameter	Mean (ppb)	Std Dev (ppb)
PFASs	*PFOS*	*9.4*	3.4
	PFOSA	U	-
PFCAs	PFNA	U	-
	PFDA	U	-
	PFUnA	*3.1*	0.7
	PFDoA	U	-

Summary

- DRBC conducted analysis of fish tissue samples from 9 locations for PFCs in the Delaware River Basin from 2004-2007.
- PFC concentrations were higher in pelagic compared to benthic species tested.
- Results indicated higher concentrations of PFOS/PFOSA (up to 35 ppb) in pelagic species near urban areas.
- Results indicated detectable concentrations of PFCAs with 8 fluorinated carbons or more (PFNA, PFDA, PFUnA and PFDoA).

Summary

- Highest tissue concentrations (~75 ppb) were observed for PFUnA in a pelagic species near the Philadelphia urban area.
- DRBC also conducted ambient water surveys in the tidal portion of the Delaware River from 2007 to 2009 to provide data for bioaccumulation and impairment assessments.
- Additional fish tissue sampling for PFCs is planned in 2010 as part of the DRBC's routine surveys.

Questions and Answers

Q. *Do you have information on PFCs in popular fish from your area?*

A. We did not include these fish in this study, but we have some data on anadromous species such bass spawn come back. They are relatively free of PFCs until they near Trenton. We suspect that chemicals are picked up readily during migration.

Remembering Kate Mahaffey

Rita Schoeny

Katy honored me with her friendship. I would hope that my words do honor to her, but I'm afraid I'm inadequate to the task; Katy is such a lifeforce that I can't describe her, can't do her life justice, can't contain her spirit in a few remarks. So I will share some memories of mine, as well as some words sent by friends and colleagues.

On her intelligence

Alan Stern (New Jersey DEP) sent a piece entitled "What I learned from Katy Mahaffey." Here's an excerpt:

"Environmental Health and Public Health questions are sometimes large issues. . . . [and] often involve large, entrenched interests with financial concerns to protect. Inevitably, the discussion of such questions becomes strained at best, and nasty and personal at worst. One of the favorite tactics of such entrenched interests is to impugn the objectivity of the scientists whose findings endanger their interests. They . . . understand the potential weakness of scientists claiming both objectivity and mission."

Alan goes on to say that what he learned from Katy was this: "do good science. Not just good science, but meticulous science. Do meticulous, unassailable, ground-breaking, science. Let the science create the mission rather than have mission dictate the science and the resulting passion is true and valid and, in the end, unassailable."

And that's what Alan and I and all of us saw Katy do, at all times in all places. My friend Martha Keating's favorite Katy quote (in response to some spurious attack) is simple: "Facts are stubborn things."

Katy's will to act

This is a remembrance from Phillippe Grandjean, a colleague from Denmark: "It's difficult to find the words that will both provide comfort to others who miss Katy, but also reflect why we miss her so much. The best I can do is to refer to the Danish philosopher Kierkegaard, who wrote:

> 'What an individual is capable of may be measured by how far his understanding is from his willing. What a person can understand he must also be able to make himself will. Between understanding and willing lie the excuses and evasions.'

Katy was one of those rare individuals, who acted on what she understood. She did not need excuses or evasions. And because she understood so much, she involved herself in many different efforts to make this a better world for all of us to share."

Her courage

Katy had chutzpah, cojones, or what we feminists prefer to call “ovaries.” This is from Tony David a young scientist with the St. Regis Mohawk Tribe: “She was a true champion of public health. At the last EPA Fish Forum . . . from the audience, she took on a panel comprised mostly from [Ivy league school to remain nameless] . . . that postulated the risks of Hg exposure were overstated and advisories do more harm than good. They were making a convincing argument on the audience until Kate stood up and said, with no equivocation, “You’ve grossly misrepresented EPA’s mercury RfD.” She continued succinctly and effectively--beautifully, really. I didn’t exhale until I thought it was safe. The [Ivy leaguers] tried unsuccessfully to recover but Kate took the hot air from their balloon and spared us all.”

Katy’s actions did spare a lot of us, and she seemed unafraid of the consequences. Maybe she was angry, maybe amused, but not fearful.

Katy’s sense of fun

A favorite memory from Annie Jarabek (an EPA colleague and friend) is of Katy dancing at my 50th birthday party (which happened at some undisclosed time in the past). Jane Hightower shared a story of how after a meeting with the California Deputy Attorney General in Oakland, they would end up having dinner at some biker bar for which they were somewhat overdressed. During the many, many negotiations on the Mercury Study Report to Congress we would often play “good cop, bad cop”. Sometimes we would switch characters just for kicks, and have to choke on our incipient laughter. Recently we most often met for “important discussions” over lunch, always with desert, if not with wine. We would dissect the bizarre behavior of those who did not support public health, bemoan the state of interference in science, remark on the general craziness of the world. Katy would end the conversation with a plangent “ooooh, Rita!” Which would just about sum everything up.

Before the election there were a lot of occasions to wonder what people in power were ***thinking***. After one such setback, I was discouraged, wondering what to do next. I asked Katy if she had the strength for this fight. She said, “I always have strength for the fight!” I take comfort in the thought that her last night she went to bed thinking “tomorrow—another busy day.”

Katy honored me with her friendship. I hope that I, that we, can honor her life by staying engaged in what is important, and bring intelligence, will, courage, joy and elegance to the fight.

Plenary Presentation

Update on U.S. EPA Dioxin Reassessment

Rita Schoeny, Office of Science and Technology, Office of Water, U.S. EPA

Biosketch

Dr. Rita Schoeny (Ph.D.) is Senior Science Advisor for EPA's Office of Water. She received her B.S. in Biology from the University of Dayton and her Ph.D. in Microbiology from the School of Medicine of the University of Cincinnati. After completing a post-doctoral fellowship at the Kettering Laboratory, Department of Environmental Health, she was appointed Assistant Professor in the Department of Environmental Health of the College of Medicine of the University of Cincinnati. Dr. Schoeny has held several adjunct appointments and regularly lectures at colleges and universities on risk assessment. She has given lectures and taught courses on risk assessment in many areas of the world. Dr. Schoeny joined EPA in 1986, and prior to her current position, she was Associate Director of the Health and Ecological Criteria Division of the Office of Science and Technology, Office of Water. She has been responsible for major assessments and programs in support of the Safe Drinking Water Act, including scientific support for rules on disinfectant by-products, arsenic, microbial contaminants, and the first set of regulatory determinations from the Contaminant Candidate List. She has held various positions in EPA's Office of Research and Development, including Chief of the Methods Evaluation and Development Staff, Environmental Criteria and Assessment Office, Cincinnati; Associate Director, National Center for Environmental Assessment, Cincinnati; and Chair of the Agency-wide workgroup to review cancer risk assessments. Dr. Schoeny has published in the areas of metabolism and mutagenicity of polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons; assessment of complex environmental mixtures; health and ecological effects of mercury; drinking water contaminants; and principles and practice of human health risk assessment. She was a lead and coauthor of the Mercury Study Report to Congress and a principal scientist and manager for Ambient Water Quality Criterion for Methylmercury. Recently, she has been the chair of an EPA working group on the use of genetic toxicity data in determining mode of action for carcinogens. She participates in many EPA scientific councils, as well as national and international scientific advisory and review groups. Dr. Schoeny is the recipient of several awards, including several EPA Gold, Silver and Bronze Medals; EPA's Science Achievement Award for Health Sciences; the Greater Cincinnati Area Federal Employee of the Year Award; the University of Cincinnati Distinguished Alumnae Award; the Staff Choice Award for Management Excellence; and the FDA Teamwork Award for publication of national advice on mercury-contaminated fish.

Abstract

U.S. EPA has been actively engaged in generating a revised dose-response assessment and hazard characterization for dioxin and dioxin-like compounds since about 1986. This presentation will give a brief history of this activity and present the latest plan from the current U.S. EPA Administrator for completion of the work. Major points made by the National Research Council regarding the most recent U.S. EPA reassessment document will also be addressed.

Dioxin Assessment Update

National Forum on Contaminants in Fish

Portland OR, 11/03/09

Rita Schoeny, Ph.D.
Senior Science Advisor,
Office of Water

1

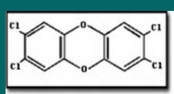
Disclaimer

- The views expressed in this presentation are those do the author and do not represent the policy of the U.S. EPA.

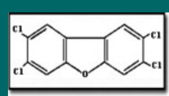
Some of this is EPA policy

2

Dioxin(s)



2,3,7,8-Tetrachlorodibenzo-p-dioxin

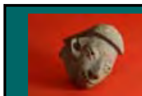


2,3,7,8-Tetrachlorodibenzofuran

3,3',4,4',5,5'-Hexachlorobiphenyl

http://cfpub.epa.gov/ncea/CFM/nceaQFind.cfm?keyword=Dioxin

3



Ancient History

- EPA Health Assessment Document for Polychlorinated Dibenzo-p-dioxins: 1985 TCDD B2
- Dioxin reassessment actually started around 1986
- 1987 IRIS files for Hexachlorodibenzodioxin
  - No RfD or RfC
  - Cancer: B2, probable human carcinogen; slope factor of 6.2 $X10^3$ per (mg/kg)/day
- RAF purple books
  - 1987 Interim Procedures for Estimating Risks Associated with Exposures of Mixtures of Chlorinated Dibenzo-P-Dioxins and-Dibenzofurans (Cdds and Cdfs)
  - 1989 Adopt the WHO TEFs

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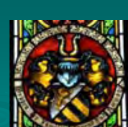
Less Ancient

- Charge from Administrator: 05 /91
- Chapter development, peer review: 91-94
- Science Advisory Board review: 95
- Peer review, public comment on draft Dose Response Modeling chapter (per SAB); 06/97.
- Revision, internal & inter-agency review: 95-00
- SAB re-review: 00-01
- Revision, internal & inter-agency review: 02-04



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This is What We Said in 2003

http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=87843

6

Key Findings of the Reassessment *Exposure Document* -- 1

- Environmental levels have declined since the '70s
- Current US regulatory efforts have addressed most of the known large industrial sources
  - ~80% reduction between '87 and '95; further reductions anticipated)
- Open burning of household wastes is the biggest unaddressed contemporary source identified so far.
- There remain many uncharacterized sources that could be significant
  - e.g.. burning, ceramics, forest fires, secondary steel, reservoir sources
- Exposure to general population has declined but currently averages ~1pg/kg/day

7

Latest and Greatest

- From Matt Lorber
- Background intake
  - 2004 reassessment: 61.0 pg / day
  - Lorber et al 2009: 40.6 pg / day
- Body burden
  - Surveys mid '90s: 22.9 ppt lwt
  - NHANES 21.7 ppt lwt

8

Key Findings of the Reassessment *Exposure Document* -- 2

- General Population Exposure is from animal fats in the commercial food supply
  - Local sources make little contribution to most peoples' exposure
  - Environmental levels in meat & dairy production are major contributor
- Air deposition onto plants consumed by domestic meat and dairy animals is the principal route for contamination of commercial food supply

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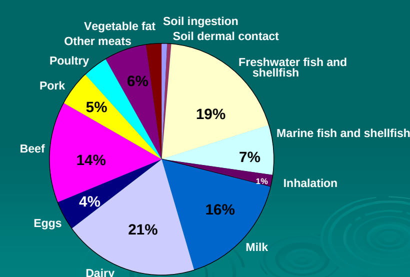
Adult Average Daily Intake of CDDs/CDFs/dioxin-like PCBs



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Key Findings of the Reassessment *Exposure Document* -- 3

- Reservoir sources are a significant component of current exposure and may dominate future exposure
  - accounts for most coplanar PCB exposure
  - unknown contribution for Dibenzofurans
- Special populations may be more exposed but prevalence is not well substantiated

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Key Findings of the Reassessment *Health Document* -- 1

- Variety of noncancer effects in animals & humans
  - Developmental Toxicity
  - Immunotoxicity
  - Endocrine Effects
  - Chloracne
  - Others
- Toxic equivalents (TEQ) provide the best means for evaluating mixtures
  - Use WHO_{98} TEFs
  - Include coplanar PCBs

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Key Findings of the Reassessment *Health Document* -- 2

- Body burden is the best dose metric for estimating risk
- Environmental mixtures of dioxin-like compounds are likely to be carcinogenic to humans; 2,3,7,8-TCDD is carcinogenic to humans.

This was before the 2005 Cancer Guidelines but reflected a lot of the thinking.

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Key Findings of the Reassessment *Risk Characterization* -- 1

- Cancer slope factor
  - Based primarily on recently published analyses of human data
  - Revised upward by factor ~ 6 from 1985 value (based on 1978 rat study)
- Cancer risk to general population from background (dietary) exposure
  - May exceed 10^{-3} (1 in 1000)
  - Likely to be less and even zero for some individuals

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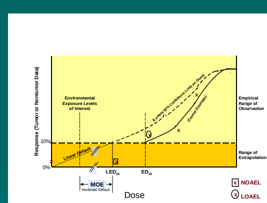
Key Findings of the Reassessment *Risk Characterization* -- 2

- Non-cancer effects observed in animals and humans at levels within 10X background
- Likely that part of the general population is at or near exposure levels where adverse effects can be anticipated.



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Then What?

- National Academy of Sciences review: 04-06
- NAS report 07/11/06
- Administrator Jackson releases EPA's Science Plan for Activities Related to Dioxins in the Environment: 05/26/09

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NAS 2006

- "Health Risks from Dioxin and Related Compounds: Evaluation of the EPA Reassessment.
- Three focus areas
  - Better justification of approaches to dose-response modeling for cancer and non-cancer endpoints
  - Increased transparency and clarity in the selection of key data sets for analysis
  - More transparency, thoroughness and clarity in quantitative uncertainty analysis.

http://www.nap.edu/catalog.php?record_id=11688

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NAS Recommends

- NRC was OK with TEF, body burden
  - But should use PBPK for animal data.
- Cancer
  - Split re "human carcinogen" for TCDD
  - "likely carcinogen" OK for others
  - May want to call mixtures "human carcinogen"
- Want more on repro and developmental
- And immunotoxic effects
  - Want estimate of risk

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NAS on Dose Response

- Wants RfD
- Cancer
  - EPA did not adequately characterize the POD; needs rationale for BMR
  - Should do both linear and non-linear extrapolation
    - MOA is receptor binding; thus, should be non-linear
    - But POD is close to environmental levels so do linear
- Want quantitative uncertainty analysis, and probabilistic approaches for PODs

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EPA's *Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds* **"DIOXIN REASSESSMENT"**

EPA will release a draft report that responds to the recommendations and comments included in the National Academy of Sciences' (NAS) 2006 review of EPA's 2003 draft dioxin reassessment by December 31, 2009.

- *The draft response will be provided for public review and comment and independent external peer review.*
- *The peer review will be conducted by the EPA Science Advisory Board*

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EPA's Dioxin Science Plan

- U.S. Environmental Protection Agency is currently addressing several issues related to dioxins and dioxin-like chemicals in the environment.
- http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=209690

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EPA's Science Plan for Activities Related to Dioxins in the Environment

"We are…redoubling our efforts to provide guidance on the science of dioxin health effects to inform cleanup decisions at this site and protect other communities, in Michigan and across the country, facing dioxin contamination."

EPA Administrator Jackson
May 26, 2009

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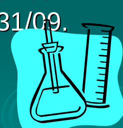
Components of Science Plan

- May or may not revise sections of the 2003 document
- Review info on exposure study by U. Michigan by 09/30/09 (?).
- Evaluate information on basis for soil clean up levels; to OSWER 12/31/09.



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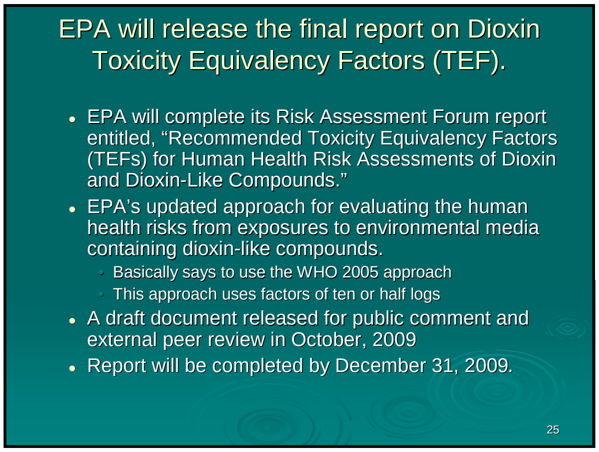
DIOXIN Dose-Response Assessment

EPA will release the final response to comments report and focus on completion of the dioxin reassessment.

- *By the end of 2010, EPA will release the final response to comments report.*
- *By the end of 2010, EPA will complete the final dioxin human health and exposure assessment and release it to the public, subject to further consideration of the science.*

24


EPA will release the final report on Dioxin Toxicity Equivalency Factors (TEF).
• EPA will complete its Risk Assessment Forum report entitled, "Recommended Toxicity Equivalency Factors (TEFs) for Human Health Risk Assessments of Dioxin and Dioxin-Like Compounds."
• EPA's updated approach for evaluating the human health risks from exposures to environmental media containing dioxin-like compounds.
◦ Basically says to use the WHO 2005 approach
◦ This approach uses factors of ten or half logs
• A draft document released for public comment and external peer review in October, 2009
• Report will be completed by December 31, 2009.
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Questions and Answers

Q. *Estimation of intakes and the levels appear to differ by a factor of 2.*

A. The estimates are empirical. We made top-down exposure estimates.

Q. *Can you provide some information on the dioxin assessment discussion about whether or not 2, 3, 7, 8-TCDD should be considered a carcinogen?*

A. It was not clear whether it supported its own class of carcinogen. If TCDD is a carcinogen , then you may want to say that all of the mixtures that contain it are a carcinogen.

Q. *How would you go about setting a new reference dose? You could set it on body burden.*

A. One can calculate a reference dose but if it is below the background level, it isn't informative. I think we can look at sensitivity, but I'm not clear what will be concluded with the dioxin assessment.

Section II-E
Risk Communication

Moderator:

Robert Brodberg, California Environmental Protection Agency

Dr. Robert K. Brodberg (Ph.D.) is a senior toxicologist in the Office of Environmental Health Hazard Assessment, which is part of the California Environmental Protection Agency. Dr. Brodberg received his B.S. in Biology from Heidelberg College, and his M.S. and Ph.D. in Biology from Bowling Green State University. Dr. Brodberg has worked as a risk assessor for the State of California since 1989. He has worked on human health assessments for pesticides, sediment quality objectives, and water quality issues. He is currently Chief of the Fish and Water Quality Evaluation Section, which 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.

Presentations

A Qualitative Study of How Women Make Meaning of Contradictory Media Messages about the Risks of Eating Fish

Jennifer Vardeman-Winter, University of Houston

Fishers Weigh In: Benefits and Risks of Eating Great Lakes Fish from the Consumer's Perspective

Judy Sheeshka, University of Guelph

Communicating Advisories on the Risk of Mercury in Fish to the Chinese-Canadian Community

Maxine Fung, University of Guelph

Qualitative Evaluation of Sport Fish Consumption Advisories in California and Strategies for Effective Communication

Alyce Ujihara, California Department of Public Health

Exploring the Potential of a Point System for Communicating Fish Consumption Guidance

Chung Nim Ha, Alaska Division of Public Health

Development, Validation, and Dissemination of a Seafood Safety Wallet Card

Charles Santerre, Purdue University

New Media Risk Messaging: From Brochures to Blogs

Lars Ullberg, Director, Applied Creative Training

A Qualitative Study of How Women Make Meaning of Contradictory Media Messages about the Risks of Eating Fish

Jennifer Vardeman-Winter and Linda Aldoory, University of Houston, Jack J. Valenti School of Communication

Biosketch

Dr. Jennifer Vardeman-Winter is an assistant professor at the University of Houston's Jack J. Valenti School of Communication, where she teaches both undergraduate and graduate courses in issues management and crisis communication. She received her Ph.D. and M.A. in Communications from the University of Maryland at College Park, and she received her B.S. in Public Relations from the University of Texas at Austin. Her studies are concentrated in public relations campaigns, health communication, and multicultural feminist research. She has presented her research at the annual meetings of the Association for Education in Journalism and Mass Communication, the International Communication Association, and the National Communication Association. Dr. Vardeman-Winter brings practical experience to her teaching and research, based on her experience in high-technology and healthcare public relations. Prior to graduate school, Dr. Vardeman-Winter worked for Lois Paul & Partners, a public relations firm focusing on the high-technology market, where she spent several years managing and implementing strategic and tactical communications programs for clients. She most recently worked for Macro International, where she consulted for governmental health agencies such as the CDC's Radiological Studies Branch, the Department of Homeland Security's Citizen Corps, and the National Cancer Institute's Survey of Health and Medical Science Reporters and Editors. She currently is helping Baylor College of Medicine's Teen Health Clinics develop evidence-based online videos for teens to encourage them to seek safe-sex information.

Abstract

This study employed qualitative, in-depth focus groups with women to determine their perceptions of contradictory information portrayed in media about fish consumption safety. The women's perceptions were understood in terms of how much they recognized eating fish to be a problem, how personally relevant the problem of eating fish was for them, and whether they perceived barriers to eating fish safely. Findings from this study indicate possible factors that influence information-seeking behavior when women are confronted with contradictory health information in the media.

A QUALITATIVE STUDY OF HOW WOMEN MAKE MEANING OF CONTRADICTORY MEDIA MESSAGES ABOUT THE RISKS OF EATING FISH

Jennifer Vardeman-Winter, Ph.D.
Assistant Professor
Jack J. Valenti School of Communication
University of Houston

Linda Aldoory, Ph.D.
Associate Professor
Department of Communication
University of Maryland

Study Purpose

- **Funding:** Joint Institute for Food Safety & Applied Nutrition (JIFSAN) grant
- **Purpose**: To explore women's behaviors regarding conflicting media information about mercury in fish
- **Citation**: Vardeman, J. E., & Aldoory, L. (2008). A Qualitative Study of How Women Make Meaning of Contradictory Media Messages About the Risks of Eating Fish. *Health Communication, 23*(3), 282 — 291.
- Acknowledgement: Dr. David Lineback (former JIFSAN director) and Dr. Marjorie Davidson (of the FDA)

Context of Study

- 2001 and 2004 EPA-FDA news releases, warning about fish contamination and suggesting limited fish consumption to particular audiences
- News media highlighted conflicts in advisories
  - Farm-raised salmon contained contaminants exceeding FDA guidelines for safe consumption, but that "in contrast, the FDA has said that the levels of contaminants detected in the sampled fish are not high enough to justify the limit on consumption" (*News & Record*, Mayer & Ramsey, 2004, p. D2)
- News media cast skepticism on advisories
  - "Despite singling out albacore tuna as moderately high in mercury, the [FDA] guidelines were praised by the canned-tuna industry for emphasizing the health benefits of eating fish" (*San Francisco Chronicle*, Kay, 2004, p. A1)

Literature Reviewed

- MEDIA EFFECTS: Contradictory health messages
  - Affective and cognitive responses
- TARGET AUDIENCE: Women and Food Safety Risk
- COMMUNICATION BEHAVIOR: Situational Theory of Publics
  - IVs
    - Problem recognition
    - Level of involvement
    - Constraint recognition
  - DV – extent of active information-seeking

Research Questions (RQs)

- **RQ1:** How do women recognize the risk (problem) of eating unsafe fish when presented with contradictory media messages about eating fish?
- **RQ2:** What are the dimensions of women's level of involvement in the context of a contradictory media environment?
- **RQ3:** What constraints do women perceive about eating fish safely after being presented with contradictory media messages about eating fish?

Pilot Study

- Women recognized inconsistencies in media reporting about the safety of fish consumption
- Women believed the advisories & media about fish safety to be vague
- Women's involvement varied according to their motherhood and pregnancy status

Methods

- Exploratory study → qualitative methods
- Method: Focus groups
- Six focus groups, consisting of between 8 and 12 women in each group
- Locations:
  - Calverton, Maryland
  - Rohobeth Beach, Delaware
  - Richmond, Virginia
- Trained moderators similar to participants
- Semi-structured interview guide
- Data analysis: Grounded theory & constant comparison

Sample

- **Participants**: 59 women of childbearing age, pregnant women, nursing women, or women with children for whom they feed and care for
  - Self-identified race & ethnicity: 31 White, 25 Black/African American, 2 Latina, 1 Asian American
  - Income: median $50,001 to $75,000
  - Education: 23 with bachelor's degree, 11 with HS diploma or G.E.D.
  - Fish consumption: varied
- Participants received $40 for their time, help

Sample articles

- Purpose: To elicit real-time reactions to conflicting news about risk
- Asked participants to pretend they are fish eaters
- Provided real stories about fish safety
- After determining whether women perceived conflicting information in the stories themselves, we explained that:
  - "These news stories present conflicting information to you about the safety of eating fish. One says it is perfectly fine to eat fish. Another says fish should be avoided. Another says that even though tuna is high in mercury, fish is still good for you."

Results: Problem recognition

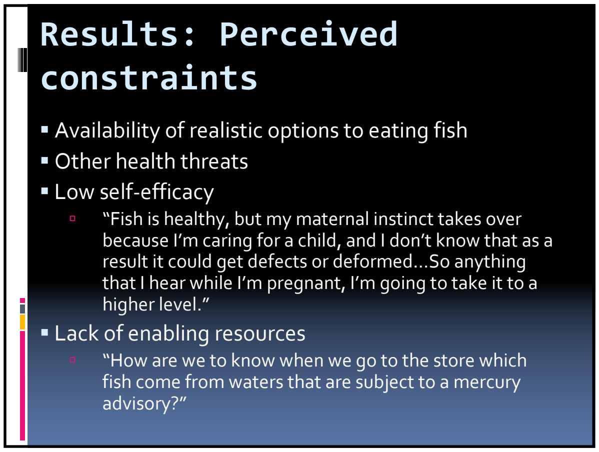
- **Confusion**: "Why is it so controversial? Either mercury is okay for you or it's not. It should be fairly black and white."
- **Skepticism**: "Everything is bad for you these days."
- **Cognitive negotiations**
  - Some information is better than no information
  - Confirmatory information
  - Comparisons to experiences: "My grandmother ate fish her whole life and there isn't anything wrong with her."

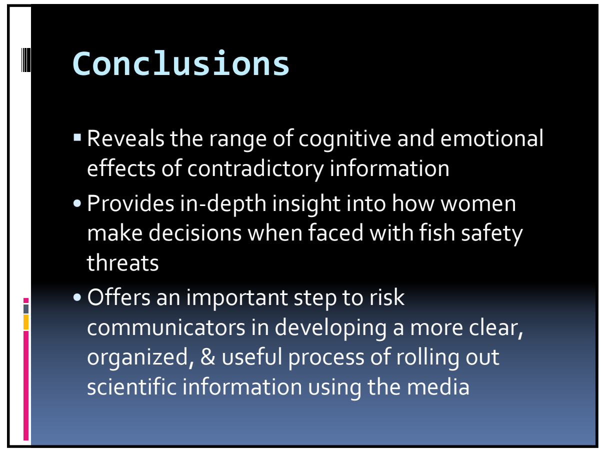
Results: Level of involvement

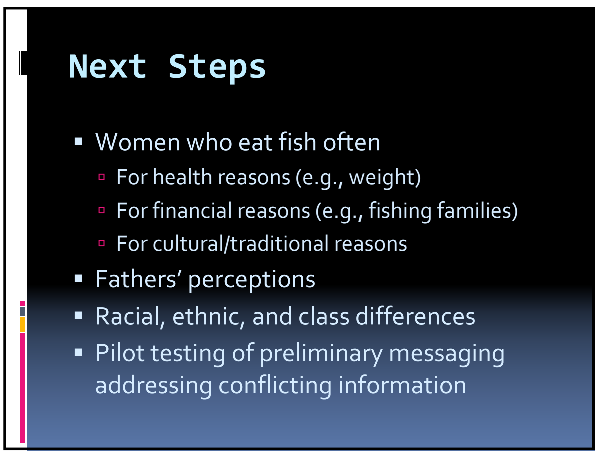
- **Geographical proximity**
- **Maternal identity**
  - "I'm more protective of my kids since they're so young, you know, they're still developing…I try to limit or protect them as much as possible. So, if somebody tells me something might hurt them, I'm definitely not going to use it or buy it or wear it or eat it."
- **Fish consumption habits**

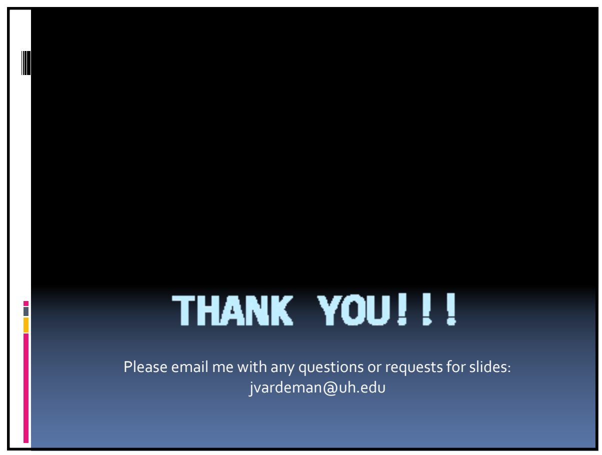
Results: Level of involvement, cont'd

- ↑ LOI, ↑ emotions: anger, fear, confusion, anxiety, guilt
  - **Anger**: "I get angry because I want to do what's best and you don't know what's driving the [news] article."
  - **Fear**: "It really has me scared, you know, what if something happens to my sons and it's because I ate food that I wasn't aware—I should have been more aware of what was going on…so I'm probably not going to buy any fish any more ever."


Results: Perceived constraints
Availability of realistic options to eating fish
Other health threats
Low self-efficacy
"Fish is healthy, but my maternal instinct takes over because I'm caring for a child, and I don't know that as a result it could get defects or deformed…So anything that I hear while I'm pregnant, I'm going to take it to a higher level."
Lack of enabling resources
"How are we to know when we go to the store which fish come from waters that are subject to a mercury advisory?"


Conclusions
Reveals the range of cognitive and emotional effects of contradictory information
Provides in-depth insight into how women make decisions when faced with fish safety threats
Offers an important step to risk communicators in developing a more clear, organized, & useful process of rolling out scientific information using the media


Next Steps
Women who eat fish often
For health reasons (e.g., weight)
For financial reasons (e.g., fishing families)
For cultural/traditional reasons
Fathers' perceptions
Racial, ethnic, and class differences
Pilot testing of preliminary messaging addressing conflicting information


THANK YOU!!!
Please email me with any questions or requests for slides:
jvardeman@uh.edu

Questions and Answers

Q. Between the three variables you mentioned in your presentation, do you know which theory has a more significant behavioral effect?

A. "Level of involvement" and "constraint recognition" tend to produce the more opinionated effects, but all of them are important. None are more indicative than others— this is mostly a range of responses. Quantitative investigations would give us more information.

Q. Did you try to vary the content in focus groups for more responses?

A. No, we wanted to let them guide the study to find out what they found important.

Q. How were the women in your study recruited?

A. We were able to hire a recruiting firm with the Joint Institute for Food Safety and Applied Nutrition (JifSAN) grant. The women were required to have a child at home that they were feeding, and the child was required to be less than 17 years old. The recruited individuals tended to be white, lower- to middle-class women.

Q. Participants seemed distrustful of everyone and it seemed that the most trusted source was interpersonal connections. Were there any other trusted sources?

A. We did not have much of an opportunity to get more information on their trusted sources, but some women said churches or other groups were important. Many said they didn't trust their doctors, but many seemed to trust nurses. Some had visited health fairs. This warrants a more ethnographic study to find more info on location on the trusted sources.

Q. It would be interesting to find out why doctors ranked low. We found that anglers trust the doctors.

A. We weren't really looking at the trusted sources but we heard it over and over.

Fishers Weigh In: Benefits and Risks of Eating Great Lakes Fish from the Consumer's Perspective

Judy Sheeshka, Department of Family Relations and Applied Nutrition, University of Guelph, Guelph, Canada

Biosketch

Dr. Judy Sheeshka is an associate professor in applied human nutrition in the Department of Family Relations & Applied Nutrition at the University of Guelph. She has been a registered dietitian for 20 years, with a special interest in food security and the health benefits and potential risks of eating fish, especially among vulnerable populations. Dr. Sheeshka is currently an Associate Editor of *the Journal of Nutrition Education and Behavior* and is a past Associate Editor-in-Chief for the *American Journal of Health Promotion.* She sits on the International Joint Commission of the Great Lakes Health Professionals Task Force and the Working Group on Fish Consumption.

Abstract

Three decades of concern over consumption of potentially-contaminated Great Lakes fish has led government agencies and public health professionals to implement risk assessment and management programs as a means of protecting the health of fishers and their families. These programs—and much of the research conducted to support and evaluate them— may not be designed to accommodate the understandings and concerns of the fish consumer. Results from a qualitative component of a multi-disciplinary, multi-year research project on frequent (e.g., average 108 meals per year) consumers of Great Lakes fish tell the fishers' side of the story. Data from 87 tape recorded interviews conducted with Vietnamese, Chinese, and English-speaking participants are presented that underscore the quality of freshly caught Great Lakes fish and the important social and cultural benefits of fish and fishing to the consumer. Participants' understandings of the potential risk from eating Great Lakes fish and the way in which fishers and their families manage this risk are outlined. Participants' understandings of the benefits of eating fish, and the way that participants weigh the benefits and the risks in choosing to eat fish from potentially-contaminated Great Lakes locations are also discussed.

Fishers weigh in: Benefits and risks of eating Great Lakes fish from the consumer's perspective

Jennifer Dawson
Judy Sheeshka
Donald C. Cole
David Kraft
Amy Waugh

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Background

- Shoreline survey of people fishing in 5 AOC on Canadian side of GL
  - Toronto Harbor
  - Hamilton Harbor
  - Niagara River
  - Detroit River
  - St. Clair River

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Background

- Results led to more in-depth study of dietary intakes and body burden of chemical contaminants
- 91 adults recruited from Hamilton and Metro Toronto areas
  - priority given to women of child-bearing age, Asian-Canadians and 'high consumers' (>26 meals/yr)

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Methods

- Qualitative design
  - Explored benefits, risk, understanding, and meaning from the perspective of the fishers themselves, in their own words
  - 87 tape-recorded interviews with 90 of 91 study participants
  - Interviews conducted in Vietnamese (37), Cantonese (4), Mandarin (1) and English (48); translated & back-translated

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Methods

- RD and interpreters given training in semi-structured interview techniques, a training manual, and early feedback
- Field trips to learn 'shoreline lingo' to build rapport
- Comprehensive interview guides with general themes, topics to explore, sample questions, etc.

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Methods

- Audio-recorded, semi-structured interviews
  - 45-75 min.; own homes
  - 23 topics across 5 areas:
    - benefits
    - risks
    - personal protection
    - management of fishery
    - food practices

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Interpretation & Coding

- Triangulation = use of multi-methods
  - Investigator triangulation – several investigators coded selected transcripts
  - Data triangulation = long interviews, field notes, fish consumption data, observations, etc.
  - Interdisciplinary triangulation = incorporating perspectives of different disciplines
- Thematic analysis; Asian-born Canadians + Euro-Canadians coded separately

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Perceived Benefits

1. Superiority of Freshly-caught Fish
   - Incomparably good taste
   - "The quicker you get it from water to stomach, the better"
   - Quality control
   - Concern over quality of store-bought fish:

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Perceived Benefits

- Superiority of freshly-caught fish, cont'd.
  - "In the market I don't know how old it is, I don't know how fresh it is, I don't know where it was caught. They don't even know where it was caught. I don't know who handled it; I don't know how it's been cleaned. I'd rather catch it myself and so I know. From its swimming to being in my stomach, I know exactly what's happened to that fish."

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Perceived Benefits

2. Sharing with Extended Family & Friends
   - Pooling and redistributing catch
   - Sharing prepared fish at home or on shoreline:

   "Back when the Jumbos [Jumbo Perch] were running a month and a half ago, me and a friend and his brother were fishing the Hydro every day and we were feeding just about everybody down at Hydro that come down. With fish crisps. …. Everybody really enjoyed it…people we didn't even know."

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Perceived Benefits

3. Identity
   - "being Asian" a way to distinguish "self" from "other", and "Asian" from "Canadian"
     - "You may notice that those who say 'don't eat' are, like, the Canadians or Whites. Catch and release, we don't believe that, no."
   - Love of fishing and eating fish not part of cultural identity for Euro-Canadians
     - role fulfillment – self-sufficiency, productivity, skill

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Perceived Benefits

4. Economic Benefits
   - Tabulated cost of gas, lures, food, smokes, coffee, line and equipment → cheaper to buy!
   - To admit to fishing "for food" may imply short-sightedness, irresponsibility and poverty, but the social, cultural value of fish was appreciated

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Perceived Benefits

5. Health Benefits
   - Fish was superior to red meat, described in dichotomies:
     - Fish has no fat and meat is fatty
     - Fish is easy to digest and meat is difficult to digest
   - "brain food"; prevents goiter
   - "I think eating fish is good for you but with all the toxins, I don't think it's 100%"

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Perceived Risks

1. Ignoring Risk

- Reactions from others were disturbing ("You eat the fish? How could you eat it?)
- "If they don't want to eat 'em, that leaves more for me."
- "I just don't let that bother me."
- "If I'm going to die, I'm going to die, and if I'm going to live, I'm going to live."

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Perceived Risks

2. Lack of Evidence for Concern

- "I haven't started glowing in the dark or anything."
- Perception that health effects would be acute and short-term (e.g., "rash", "pox", "skin outbreak"); resembling food poisoning
- Euro-Canadians all said pregnant women should be cautious

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Perceived Risks

3. Risk in Context

- Participants who have experienced pollution

  "If you say the fish here is unsafe to eat, then the fish in Taiwan should be completely inedible."

  "I cannot say that it's not polluted in Canada, but we cannot compare this pollution with pollution in Poland. Or Russia, or Czech area or another country."

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Perceived Risks

3. Risk in Context, cont'd

- Canadian-born: comparative risks
  - "I do smoke, I drink beer, I don't take vitamins, I don't follow a diet."
  - "Everything can kill you, so it's just basically a chance that I'm taking."

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Perceived Risks

4. Belief in Environmental Improvement

- Locals have noticed improvements

  "We've come a long way since I was young …back in those days, the Niagara River was so full of junk that you could smell the chemicals from the top of the gorge. It was that strong. And now, I guess there's still stuff getting in there, that's leaching in from the dump sites that you read about. But, the water, at least it looks clean and it smells clean and it's a thousand percent better than it was."

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Perceived Risks

5. A Desire for More Information on Risk
   - Inconsistent messages → uncertainty → desire for more information on risk
   - Participants felt they lacked the expertise to make judgments and decisions, esp. Vietnamese

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Managing Risk

1. Choosing a Location to Fish
   - Avoiding hydro or nuclear power plants; locations with murky, cloudy or stagnant water; places where others wouldn't eat fish
   - Choose fish from "moving waters"
   - Euro-Canadians looked for indicator species, known to be vulnerable to pollution

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Managing Risk

2. Species Eaten
   - Euro-Canadians: Walleye, Yellow Perch
   - Asian-Canadians: Rock Bass, other Bass
   - Euro-Canadians condemned "bottom feeders" as "dirty"

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Managing Risk

3. Identifying Contaminated Fish
   - Many were confident they could visually distinguish between a "healthy" and "unhealthy" fish
     - Some acknowledged that chemical contamination was different: "It could look like the cleanest fish and there could actually be something wrong with it. You just don't even know."

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Managing Risk

4. Keeping the Small Ones
   - Almost all were Euro-Canadians:
     - Concern over contaminants
     - Better taste, texture
     - Protect breeding stocks
   - Understood size-contaminant connection

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Managing Risk

5. Cleaning Fish
   - Euro-Canadians removed fat, "mud-line"
   - Asian-Canadians removed scales, used vinegar, Chinese tea, or lemon juice to get rid of smells

6. Limiting Consumption
   - Euro-Canadians ate more fish at a meal → some Asian-born felt they didn't need to limit their consumption
   - Some Asian-Canadians ate fewer fish in Canada

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Conclusions

- "Who is at risk?" → "Who defines risk?"
- "How do fishers perceive risk?" → "How do fishers and risk assessors alike balance risk and benefit?"
- "Why don't fishers follow fish advisories?" → "How can fish advisories better respond to the needs of fishers?"

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Conclusions

- Participants saw life as full of risks, and understood that there were no definitive answers re: risks and alternatives
- Cultural identity, sense of self-worth, place in family/community were defined to some extent by fishing, eating + sharing fish
  - Purchased fish doesn't fill same social/cultural role

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Conclusions

- Scientists and health professionals don't share the same values, understandings
  - Eating GL fish not a mainstream cultural norm
- Definition and management of risk must be a negotiated, collaborative process that begins and ends with those who have the most to lose – the fish consumers.

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Acknowledgements

- Funding from the Great Lakes Health Effects Program in Health Canada
- Publication: Dawson J, Sheeshka J, Cole D, Kraft D, Waugh A. Agriculture & Human Values (2008) 25:349-364

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Questions and Answers

Q. Did the fishers say whether they perceived if the stocks were in danger?

A. People who were new to the country were confused by the messages. They didn't observe the size limits for fish catches. However, Euro-Canadians seemed to observe the limits.

Q. Were the results of the study communicated with the communities?

A. Yes. We worked with local remedial action plans and wrote monographs. The people who were tested had the option of sending the results to their doctors, and we met with participants to give them their levels.

Q. How would you reach a broad spectrum of fish consumers?

A. Participatory actions where you go back to key informants in the communities. Use the language newspapers, inviting people to a forum and finding people interested in working with scientists. More remedial action plans.

Communicating Advisories on the Risk of Mercury in Fish to the Chinese-Canadian Community

Maxine Ming-Sum Fung, University of Guelph, Guelph, Ontario, Canada

Biosketch

Ms. Maxine Fung is a recent M.S. graduate in Applied Human Nutrition from the University of Guelph. Under the guidance of Dr. Judy Sheeshka, her thesis explored the area of fish advisory communication to an at-risk group of pregnant Chinese-Canadian women. Ms. Fung is currently a dietetic intern at The Ottawa Hospital.

Abstract

Thirty-four pregnant Chinese-Canadian women who self-reported eating a minimum of one meal of fish per week were recruited from four Canada Prenatal Nutrition Program classes across Metro Toronto to take part in five focus groups conducted in Cantonese or Mandarin. Groups were asked 15 semistructured questions on the participants' fish consumption habits, awareness of advisories, knowledge of mercury, and response to messages about mercury in fish. Few participants were aware of or had knowledge of advisory messages, and most were generally shocked to hear consumption recommendations. Information issued by public health organizations was well received and trusted. Motivation for behavioral change often stemmed from concern for their children. Resources targeting Chinese-Canadians must focus on creating culturally sensitive materials that are offered in Chinese with visual elements to keep the text brief. Using the Internet to post information may be a possibility for future investigation.


Communicating Fish Advisories to the Chinese-Canadian Community
Maxine Fung, M.Sc.
Tuesday November 3rd, 2009
2009 EPA Fish Forum
Portland, Oregon


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Principle Investigator
– Maxine Fung
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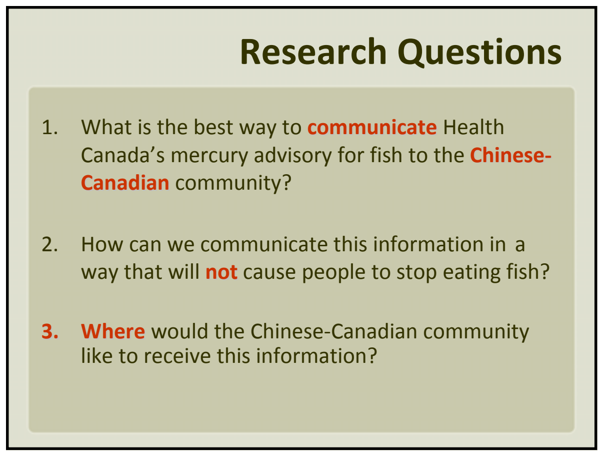
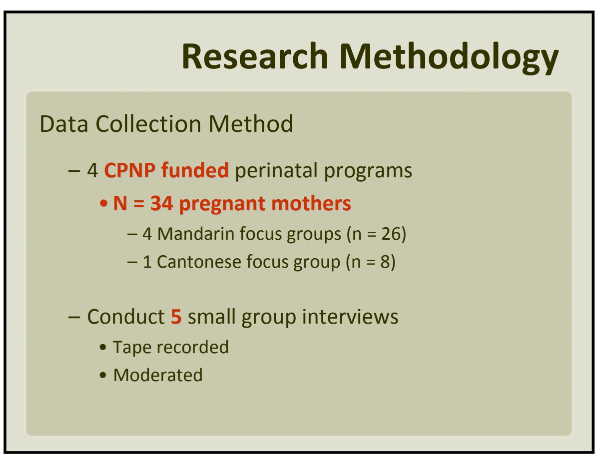
Co-Investigators
– Dr. Loren Vanderlinden
• Toronto Public Health
– Dr. Barbara Knuth
• Cornell University


Rationale
Fish Advisory Research
– Need for correct & positive message
• Conflicting literature leads to confusion
• Message may lead to decreased consumption
– Research targeting minorities is needed
• Asian community is at risk


Research Questions
1. What is the best way to communicate Health Canada's mercury advisory for fish to the Chinese-Canadian community?
2. How can we communicate this information in a way that will not cause people to stop eating fish?
3. Where would the Chinese-Canadian community like to receive this information?


Research Methodology
Data Collection Method
– 4 CPNP funded perinatal programs
• N = 34 pregnant mothers
– 4 Mandarin focus groups (n = 26)
– 1 Cantonese focus group (n = 8)
– Conduct 5 small group interviews
• Tape recorded
• Moderated


Research Methodology
Data Collection Method
– 15 questions
• Consumption habits
• Advisory knowledge
• Opinions
– Feedback on resources
– Impact of advisories

Research Methodology

Data Management and Analysis

1. Transcribed verbatim
   - Mandarin or Cantonese **to Chinese text**
2. Translated
   - Cantonese or Mandarin **to English**
3. Back translated
   - English **to Chinese text**

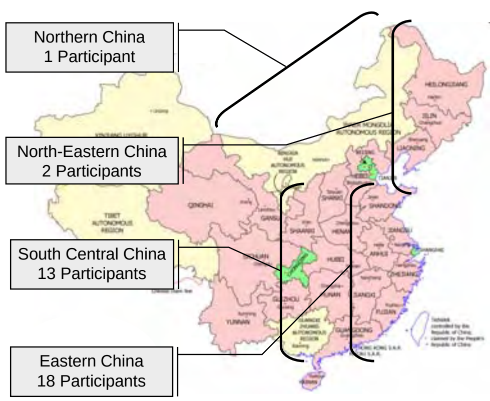
Research Methodology

Thematic Analysis (Braun & Clarke, 2006)

- Method to identify, analyze and report patterns
  - **Semantic** approach
    - Interprets patterns to answer questions

Accurate Description (Strauss & Corbin, 1990)

- Aim to give **sense of real life** observations



Participants

Cultural Habits

"…I grew up in Fujian province of China…which is close to the sea. I watched my relatives and friends go fishing at sea. I picked up the habit from my parents and believed in eating fresh fish."

Participants

Language Barriers

"…Our English is poor. Looking at all these brochures, I can barely understand with so few pictures. Pictures help us to figure out the fish names so please add some more pictures."

Participants

Internet Savvy

"I would use the computer to search Google or Baidu. …The internet provides the most up to date and has extensive information."

Participants

Time Constraints

"...I have brought some flyers home to read but never could find the time. Short and simple is the key. It would be nice if we could bring it home, hang it up and take a quick look at it before going to buy fish."

Thematic Results

Feeling Vulnerable

- Participants **knew little** about advisories
  - Very few were aware
  - **Low knowledge** of risks of eating fish
    - Species and size differences
    - Consumption recommendations
- **Surprised** they did not know
  - Message did not reach them

Thematic Results

"This was the first time I've heard it. It was quite a surprise to me because I never knew about it before."

"When I was in the hospital for my last pregnancy [in the US], a detailed warning about the risks of eating fish was explained to me ... and a dietitian was coaching us daily. We don't have these in Canada."

Thematic Results

Being Overwhelmed

- Fish a large part of life and is familiar
  - Part of **cultural identity**
- Recommendations suggest **large changes**
  - Responses: fear to indifference
  - Most **continue** to eat fish with mercury in mind

Thematic Results

Being Overwhelmed

"...It is impossible to uproot a long time habit overnight. I still like to eat fish, but I will pick the smaller fish and eat it less frequently."

Thematic Results

Placing Trust

- Question and scrutinize information
- Trust the Canadian government
  - Public health agencies

Thematic Results

Acting for the Future

- Peer and elder influence
  - Choosing fish for believed benefits
  - Improved appearance and intelligence
- Most will change habits for **their children**
  - Follow advisories to some extent

Thematic Results

Acting for the Future

"I think this information was provided just for us. I should trust it very much. Now I am pregnant. For the sake of my baby, I will follow it."

Thematic Results

Thematic Relationship

- Experiences of being **new immigrants**

1. Heeding peer/elder advice
2. Immigrating for the future
3. High expectations for Canada
4. New environment increases vulnerability
5. Adjusting to Canada is overwhelming
6. Making changes for the future

Implications

Limitations of Research

- **Small sample** size
- **Non-random** sampling
- Limitation to **print** material

Research Contributions

- **Unique** focus
  1. Women
  2. Pregnancy
  3. Chinese-Canadians
  4. Qualitative nature

Summary

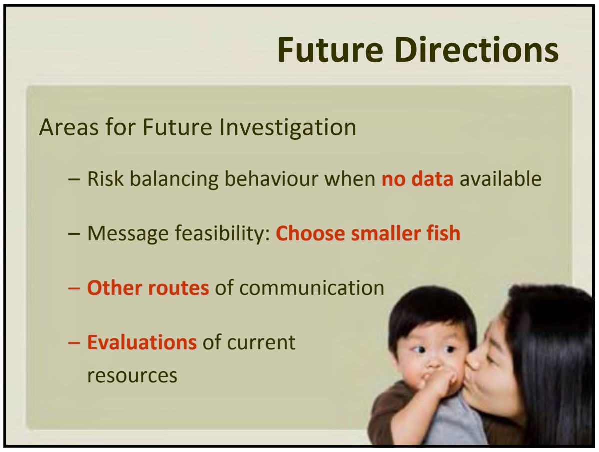
Recommendations for Printed Resources

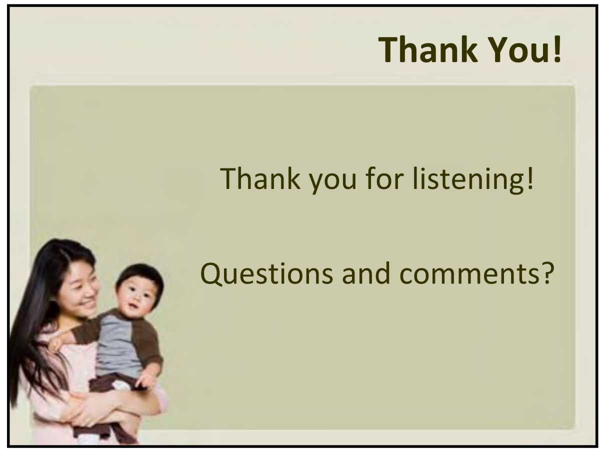
1. **Translate** resources to Chinese
2. List fish **commonly consumed** by Chinese-Canadians
3. Label fish in **English** and **Chinese**

Summary

Recommendations for Printed Resources

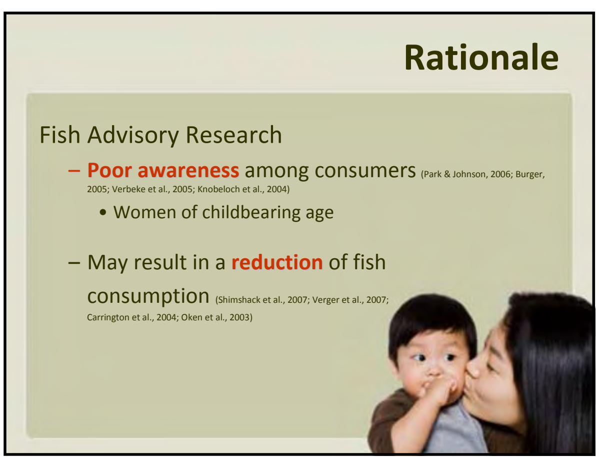
4. Simplify resources
   - Short and **concise**
   - Use **visuals**
5. Establish **accessibility**
   - Internet
   - Supermarkets, physician's office


Future Directions
Areas for Future Investigation
– Risk balancing behaviour when no data available
– Message feasibility: Choose smaller fish
– Other routes of communication
– Evaluations of current resources


Thank You!
Thank you for listening!
Questions and comments?


Outline
1. Rationale
2. Research Questions
3. Research Methodology
4. Participants
5. Thematic Results
6. Implications
7. Future Directions


Introduction
Current Research
– Lacks focus on various areas:
1. At-risk pregnant women
2. Fish consumers
3. At-risk ethnic minorities
4. Canadian perspective


Rationale
Fish Advisory Research
– Poor awareness among consumers (Park & Johnson, 2006; Burger, 2005; Verbeke et al., 2005; Knobeloch et al., 2004)
• Women of childbearing age
– May result in a reduction of fish consumption (Shimshack et al., 2007; Verger et al., 2007; Carrington et al., 2004; Oken et al., 2003)

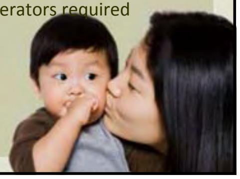

Methods
Preparation
– 6 telephone interviews to TPH staff
• Health professionals
• Worked closely with pregnant Chinese-Canadian women
– Main objectives
• Group vs. individual interviews
• Comfort with written consent

Methods

Preparation

– **Focus groups** suggested
  - Small groups of 5 to 8

– Clients generally **Mandarin** speaking
  - Mandarin translators and moderators required



Introduction

Mercury Fish Advisories

– Consumption advice for fish **high** in mercury (Health Canada, 2007)

Group	Recommendation	Meal size
General Population	4 meals / month	150 g
Specified Women	1 meal / month	150 g
Children (5-11)	1 meal / month	125 g
Children (1-4)	1 meal / month	75 g

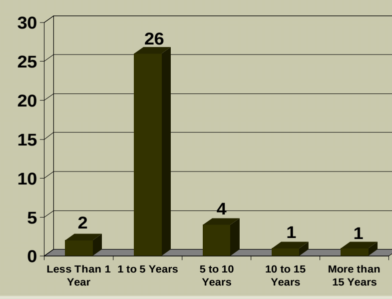
Methods

Thematic Analysis

1. Transcribe data
   – Familiarize with interview data
2. Generate initial codes
   – Ordering materials
3. Establish and refine themes
   – Reducing materials
4. Select extracts
   – Reporting with excerpts as support

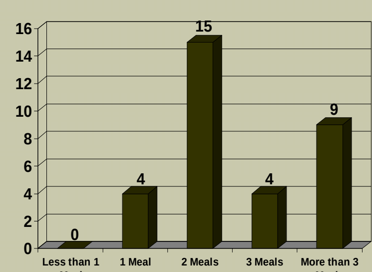
Participants

Participants: Years in Canada



Participants

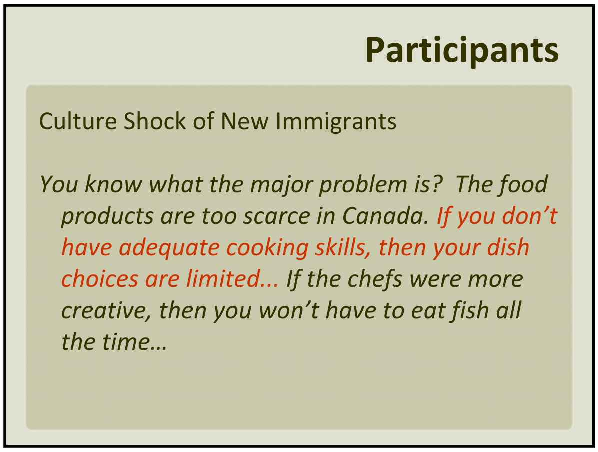
Participants: Typical Weekly Fish Consumption



Participants

Language Barriers

"… It doesn't matter if it doesn't have pictures or diagrams, but it is essential to have Chinese descriptions of fish names. … We need the Chinese translation to tell us the mercury level of those common kinds of fish we normally eat…"


Participants
Culture Shock of New Immigrants
You know what the major problem is? The food products are too scarce in Canada. If you don't have adequate cooking skills, then your dish choices are limited… If the chefs were more creative, then you won't have to eat fish all the time…


Implications
Recommendations
1. Improve accessibility
• Internet
2. Improve readability
• Language, picture and diagram use
3. Improve cultural sensitivity
• Culturally applicable fish

Questions and Answers

Q. Risk is being communicated through health care providers and government agencies. Have you considered targeting school children? Children are more likely to be bilingual and are making lifelong diet choices.

A. One mother said she would be more willing to trust something that came from her children's school because it came from school.

I think these studies make us question whether we are communicating through the right channels Also, we should consider whether we should be targeting different audiences (i.e., those who are still willing to change).

We developed some coloring books and targeted every 3rd grader in the state. We felt it was very well-received. Many other age groups requested them as well.

Q. Did you run into any other barriers in your interviews with Asian populations? Is it better to approach the most senior member of the household?

A. We were concerned about whether Asian groups would share in focus groups and asked key informants for suggestions. They suggested focus groups with fewer than 8 individuals to minimize the chance of individuals feeling intimidated.

It was very important to find key informants to gain an understanding of types of sensitivities. We found that many of the questions we asked around food security did not make sense when translated, because traditionally there are stigmas around admitting that someone does not have enough food. It was also very difficult to collect hair from Asian participants.

Qualitative Evaluation of Sport Fish Consumption Advisories in California and Strategies for Effective Communication

Alyce Ujihara, California Department of Public Health, Environmental Health Investigations Branch

Biosketch

Ms. Alyce Ujihara is a research scientist in the Environmental Health Investigations Branch of the California Department of Public Health (CDPH). In her 15 years at CDPH, she has conducted studies of fish consumption practices, chemical exposure, and advisory awareness in anglers and low-income women. She has also developed outreach, education, and training activities on fish contamination issues for diverse audiences. Ms. Ujihara holds a B.A. in Environmental Science and an M.A. in Energy and Resources from the University of California, Berkeley.

Abstract

The California Department of Public Health conducted an evaluation study to explore ways to improve communication of sport fish advisories to California's diverse populations. We chose a qualitative approach using key informant interviews and focus groups to explore how sport fish consumers perceive consumption advisories and identify factors that influence their comprehension and compliance. We identified some barriers to communication, including the use of poorly understood terminology, misleading category headings, and ineffective visual tools. Communication approaches that were found to be more effective included portion sizes that reflect commonly consumed amounts, round meters to convey contaminant levels, three advice categories with color coding, and population definitions that identify specific age ranges. These findings were used to develop an advisory brochure format to communicate sport fish advisories to diverse audiences.

Qualitative Evaluation of Sport Fish Consumption Advisories in California and Strategies for Effective Communication

Alyce Ujihara
California Department of Public Health

National Forum on Contaminants in Fish
Nov. 3, 2009

CDPH

Fish Mercury Project (FMP) 2004-2008

- Monitor sport fish for mercury
- CDPH role: stakeholder involvement and risk communication
- Diverse fishing populations
- Stakeholder feedback: advisories not always understood or accepted

Advisory Evaluation Objectives

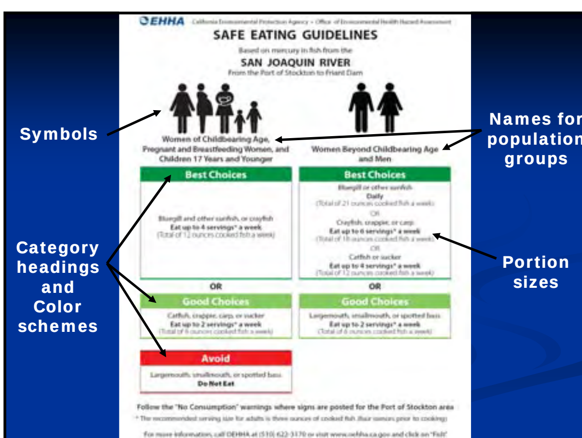
- Explore how target audiences perceive and understand sport fish consumption advisories
- Identify barriers to communication
- Explore portion sizes
- Identify more effective communication methods
- Create a brochure to communicate advisories to diverse populations

Methods

- Qualitative approach
  - Perceptions, attitudes, underlying beliefs
  - Level of comprehension
  - Acceptance of information/intention to change
- Tools
  - Key informant interviews (N=46)
  - Focus groups (9 focus groups, N=77)
- Written interview guide with open-ended questions and probing

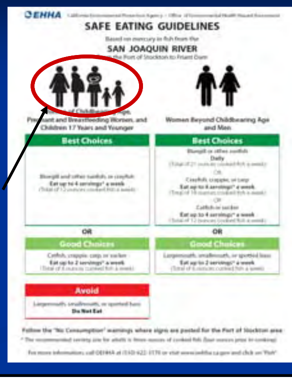
Methods

- Participant recruitment
  - Ate sport fish at least one times/month
  - Represented diverse ethnicities, income and age ranges, men and women
  - Stipends provided
- Many interviews/focus groups recorded and transcribed, along with detailed field notes
- Data Analysis
  - Data coded independently by two staff
  - Categorized codes to generate broader themes
  - Saturation—range of responses exhausted



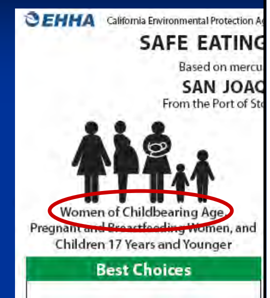
Barriers to Communication: Symbols

- Very influential, noticed first
- Silhouette images were misunderstood
- This image represented a family



Barriers to Communication: Terminology

- "Women of childbearing age"
  - Poorly understood
  - Active desire or current efforts to become pregnant
  - Not well accepted
  - Preferred term: "women 18-45"

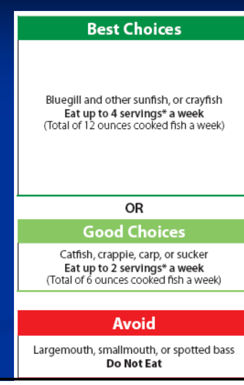


Barriers to Communication: Terminology

- "Anglers" vs. "fishermen"
  - "Anglers" are elite fishermen who use fancy gear and boats, fish in tournaments, or do not eat their catch
- "Uncooked" vs. "cooked"
  - "Uncooked" interpreted as raw fish, so information not applicable if they don't eat raw fish
- "Omega-3 fatty acids"
  - Poorly understood
  - "fatty acids" had negative connotation
  - Preferred: "High in Omega-3s" along with use of pink heart graphic

Barriers to Communication: Category Headings

- "avoid" is understood
- "best" or "good" choice are not clear



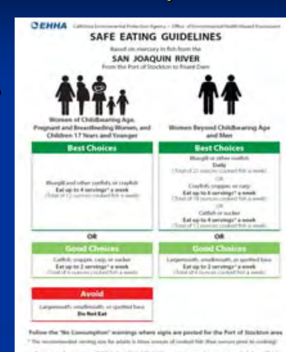
Barriers to Communication: Category Headings

- Recommendations in heading not well understood
- Some respondents choose category that matched current consumption—did not understand that higher limits means safer fish

2 meals a week
Bluegill and Trout
1 meal a week
Catfish and Carp
1 meal a month
Largemouth bass

Barriers to Communication: Different advice for two populations presented side by side

- Difficult to figure out which advice column to follow
- Same fish in different categories was inconsistent and lacked credibility

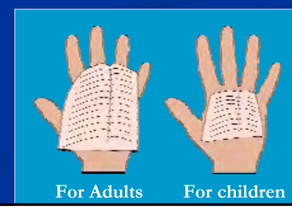


Portion Sizes

- How are portion decisions made?
- Are advisories likely to influence portion sizes?
- Findings:
  - Decisions on portion sizes based on hunger/appetite/availability
  - Most participants do not understand ounces or could not estimate their consumption in ounces
  - Portion descriptions in advisories not likely to be heeded

Portion Sizes: Recommendations

- Avoid unrealistic portion sizes (e.g., 3 ounces)
- Base advice on typical consumer portion sizes (e.g., 6-8 ounces)
- Regulate intake through frequency of consumption (e.g., servings/week)
- Provide a visual reference
- Convey concept of smaller portions for children

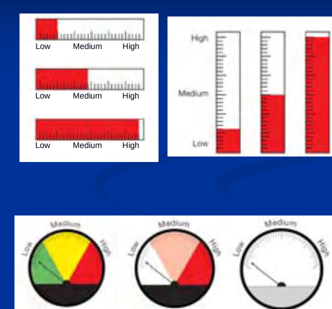


Influence of Personal Beliefs

- Personal beliefs strongly influence fishing and fish consumption
- Beliefs based on past experience, trusted sources, but generally not advisories
- Participants skeptical of advice that contradicts their beliefs
- Examples:
  - Bottom feeders like catfish are most contaminated
  - Striped bass swim fast, near the surface so they are cleaner
- Recommendation:
  - Don't give advice without explanation
  - Information about contamination levels in fish provided a basis for advice

Effective Methods

- Convey mercury levels with round meters
- Three categories
  - High, medium, low
- Color schemes
  - Red, yellow, green



Effective Methods

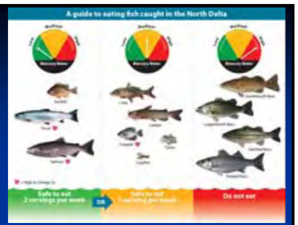
- Fish pictures
  - Very influential, noticed first
  - Participants are strongly connected to their preferred fish
  - Non-English speakers could identify fish they ate even if they didn't know the names

Effective Methods

- Vertical format preferred over horizontal format

Effective Methods

- Directly linking mercury level to advice using layout and color
- Don't use a key



How Participants Intend to Use Advisory

- Eat less fish or avoid contaminated species
  - *Well, if I can't eat the bass anymore, because it literally says 'do not eat' …at least I can still eat catfish and, uh, carp, because I, I'm not going to eat that anymore.*
- Eat more "good" fish
  - *I guess I would try the salmon or the trout…because for one, it's high in omega-3s, low in mercury*
- Concern for others
  - *The first thing that I'm going to do is I'm going to go home and tell my husband, you know, what's ok to eat and what not to eat.*
- Recognizing options/choice
  - *Some people choose to run red lights, some people don't. You give the information out, they read it, it's their choice what they're going to do with it*

How Participants Intend to Use Advisory

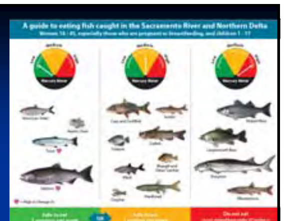
- Reject advice/created distance from information
  - *I ain't gonna stop fishing. I ain't gonna stop eating striper bass.*
  - *This is good for the young crowd, because people will change, but I don't think it will do very much for us, because we're already set in our ways, you know, pretty much, as far as eating.*
  - *It's not like we eat fish every day.*
- Comprehension does not always result in compliance
- Need other communications approaches to change behavior

Topics Needing Further Investigation

- Comprehension of the term "Or"
- Conveying advice based on fish length
- Conveying advice for 2 populations
- Comprehension of sport fish advice alongside commercial fish advice
- Describing geographic areas

Conclusions

- Qualitative approach helped to gain deeper understanding of target audiences and improved how advisory information is presented
- Findings used to create an advisory brochure format
- New format used in 6 locations in California




Acknowledgements

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- Local Stakeholder Advisory Group
- EcoVillage Farm Learning Center
- Vietnamese Voluntary Organization (VIVO)
- United Cambodian Families
- Food Stamp Nutrition Education Program
- Expanded Food and Nutrition Education Program
- Delta Health Care WIC Program
- the office of Dr. James Brode
- California Striped Bass Association
- Oroville Hatchery

Exploring the Potential of a Point System for Communicating Fish Consumption Guidance

Chung Nim Ha, Alaska Department of Health and Social Services, Division of Public Health

Biosketch

Ms. Chung Nim Ha is a health educator with the Environmental Public Health Program at the Alaska Department of Health and Social Services, Division of Public Health. She received her B.A. from Stanford University and her M.P.H. in Health Behavior and Health Education from the University of Michigan. In her current position, Ms. Ha addresses community concerns about exposure to environmental contaminants and is developing educational materials for the state's fish consumption guidelines. Prior to her current position, Ms. Ha worked with the Minnesota Department of Health for 10 years as a research scientist. She also owned an ice cream shop for a few years. Ms. Ha grew up in Fairbanks, Alaska, and after a 20-year hiatus in the Lower 48, now lives in Anchorage.

Abstract

To inform consumers on local fish consumption guidance, most states develop and distribute educational materials in a variety of formats to diverse target audiences, including women of childbearing age, sport anglers, subsistence consumers, and the general population. These materials are typically designed to be as simple and as understandable as possible to the lay reader. Finding effective ways to communicate what is often complex information can be a challenge for public health. A state's fish advisory may include multiple consumption categories, numerous fish species, differing consumption categories of a single fish species based on weight or length, and self-caught versus store-bought sources. Most states use tables or charts to graphically communicate much of this information. However, little is known whether target audiences are able to interpret these tables or charts correctly so that they know how much of what fish to eat to avoid excessive mercury (or other contaminant) exposure.

In developing Alaska's fish consumption guidance, anecdotal evidence suggested that seemingly straightforward consumption tables or charts could be misinterpreted and confusing. The main concern was that some target audiences may not understand that the five consumption categories are mutually exclusive (not additive), yet consumers could "mix and match" among several categories, but only within certain parameters. To address this concern, Alaska developed a "point system," modeled after familiar weight loss diet programs. This point system assumes a mixed species diet of fish and aims to clarify the relationship among the different consumption categories so that consumers are confident that they are following the recommended eating guidelines. To evaluate this point system, several focus groups were conducted with urban-area women. Preliminary findings will be shared and future evaluation efforts for developing educational materials for Alaska's fish consumption guidelines will be discussed.

Exploring the Potential of a Point System for Communicating Fish Consumption Guidance

Chung Nim Ha, MPH
Environmental Public Health Program

2009 National Fish Forum
Portland, Oregon

Guidelines for AK Women & Children
5 Consumption Categories (# meals/week)

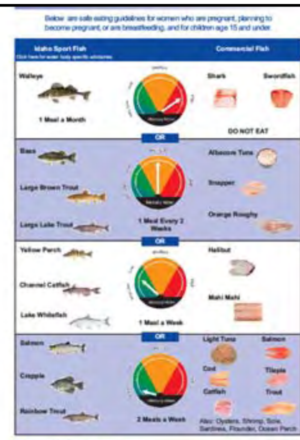
Unlimited	4	3	2	1
Pacific cod Walleye pollock Black rockfish Pacific ocean perch King salmon Chum salmon Pink salmon Red salmon Silver salmon Halibut < 20 lb. Lingcod < 30 in.	Sablefish Rougheye rockfish Halibut 20 - 39 lb. Lingcod 30 - 39 in. **Includes: any halibut from stores and restaurants**	Halibut 40 - 49 lb.	Yelloweye rockfish Halibut 50 - 89 lb. Lingcod 40 - 44 in.	Salmon shark Spiny dogfish Halibut ≥ 90 lb. Lingcod ≥ 45 in.

↑ Canned chunk light tuna
↑ Canned albacore tuna

Federal advice: avoid shark, tilefish, king makerel, swordfish

Answer these questions:

- *How should we present our 5 consumption categories?*
- *Do women know how to interpret consumption categories (in tables/charts) correctly?*
- *How can you optimize a mixed species diet?*



SAFE EATING GUIDELINES for women who are pregnant, planning to be pregnant, or are breastfeeding and for children under age 15.

For most of Wisconsin's Inland (non-Great Lakes) waters.*

WEEKLY	2 meals per WEEK	Atlantic or Pacific Salmon (not Great Lakes), farm-raised catfish, shrimp, pollock, and other purchased fish low in mercury.
	OR	
	1 meal per WEEK	Canned "light" tuna. Wisconsin panfish including bluegill, sunfish, crappies, and yellow perch. Also, bullheads, and inland trout*.
MONTHLY	1 meal per MONTH	Canned "white" tuna (6 oz.), tuna steaks, and halibut. Wisconsin gamefish including walleye, pike, bass, catfish, and any other Wisconsin species*.
DO NOT	DO NOT EAT	ANY SWORDFISH, SHARK, KING MACKEREL, TILEFISH, OR WISCONSIN MUSKIE

SAFE EATING GUIDELINES for men and women beyond their childbearing years.

Unrestricted* – Wisconsin panfish, bullheads, and inland trout. Also, farm-raised catfish, shrimp, pollock, canned "light" tuna, Pacific or Atlantic salmon (not Great Lakes), and other purchased fish low in mercury.
1 meal per week* – Wisconsin gamefish and any other Wisconsin species. Also, canned "white" tuna, tuna steaks, and halibut.
1 meal per month – Shark, swordfish, king mackerel, tilefish, and Wisconsin muskie.

*On certain waters, where data indicate higher mercury levels, more restrictive advice is needed. Please visit our website at: **dnr.wi.gov/fish/consumption** or call your local health department.

Fish is good for you. Eat fish low in mercury!

For more information about purchasing fish, visit the FDA website at fda.gov.

Fish not on the list?
Call Oregon Public Health Division at 1-877-290-6767 or visit our Web site at www.healthoregon.org/fishadv

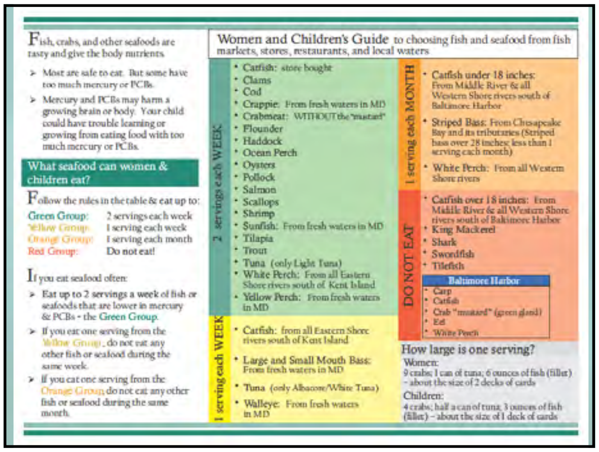
WHAT KINDS AND HOW MUCH FISH SHOULD I EAT?
Safe eating guidelines for women who are pregnant, planning to be pregnant, or are breastfeeding and for children under age 6.

Below are general guidelines based on mercury levels measured in fish throughout Oregon and levels of mercury found in commercial fish. Please check for and follow specific advisories for fish caught in local lakes and rivers before using the general advice in the table below (see back of brochure).

EAT UP TO TWO MEALS A WEEK	EAT UP TO ONE MEAL A WEEK	AVOID OR EAT RARELY (up to 1 meal per month)
Bluegill Crappie Perch Salmon & Steelhead Trout Anchovies Cod Flounder Haddock Mackerel, canned Ocean Perch Salmon & Steelhead Sardines Shellfish (shrimp, crabs, clams, oysters, mussels) Sole Tilapia Trout Tuna, canned light	Carp Catfish Sturgeon Sucker Halibut Mahi mahi Sea bass Tuna, canned white Albacore	Bass Brown trout Northern pikeminnow Walleye Mackerel, King (DO NOT EAT!) Shark (DO NOT EAT!) Swordfish (DO NOT EAT!) Tilefish (DO NOT EAT!) Tuna, steaks

UNCOOKED MEAL SIZE:
Adult = 8 oz. Child = 4 oz.

SPORT CAUGHT FISH ARE DESIGNATED BY THIS SYMBOL.



Urban Focus Groups

- 3 focus groups conducted Sept. 2009
  - Held 5:30 – 7:00pm Tuesday – Thursday
- Recruited via flyers posted at:
  - WIC clinics
  - Head Start centers
  - Fred Meyer stores
  - Public libraries
  - Neighborhood recreation and health centers
- Callers screened over the phone
- Participants received $40 gift card

Focus Group Participation Eligibility Criteria

- Between age 21 to 45
- Live in Alaska
- Eat fish (at least occasionally)
- Either:
  - Pregnant
  - Planning to get pregnant
  - Nursing
  - Have kid(s) under age 12

Discussion Outline

- Introductory warm-up questions
- 2 quizzes (done individually):
  - 1st Reverse Pyramid
  - 2nd Point System (aka. mix & match)
- Go through quiz answers
- Compare and evaluate two designs
  - Content
  - Design
- Rate importance, potential impact of info.

Sample Quiz Questions

- *How many meals of halibut that you bought at the store can you eat in a week?*
- *You'd like to have tuna (albacore) sandwiches for lunch and salmon for dinner this week. How many meals of each can you eat?*
- *You had a meal of yelloweye rockfish on Monday. How many meals of black cod could you have for the rest of the week?*

Focus Group Participant Characteristics (n=14)

- **Age:**
  - 21 to 30: 9
  - 31 to 45: 5
- **Residency in AK:**
  - entire life 9
  - 1.5 - 15 yrs 5
- **All Anchorage residents**
- **Schooling:**
  - High school 8
  - College 3
  - Master's 1
- **Motherhood status:**
  - 1+ child <12 10
  - Nursing 1
  - Pregnant 2
  - Plan to have kids 3

Focus Group Findings: Point System

- 13 of 14 preferred Point System:
  - Clearer, easier to understand
  - Much easier to answer questions when point values were assigned
  - You can mix and match
  - Similar to Weight Watchers: *"a lot of people are on diets"*
  - Would take and put on fridge if convenient size
- Criticisms/concerns:
  - More time-consuming than Reverse Pyramid
  - Some people might think it's too much work
  - Could be confusing for some who aren't good at math, so give examples!
  - Confusion about relationship between 6-oz. meal size and points

Focus Group Findings: Reverse Pyramid

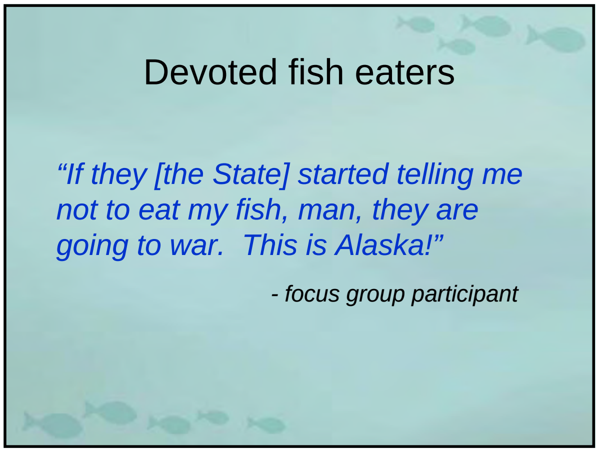
- Criticisms:
  - "ORs" are confusing, can't combine with "ORs", really hard to think about the "ORs" and what that means
  - Didn't notice the "ORs" (2 people)
  - Hard to mix and match: *"I like the way this one looks better, but it was hard to answer the questions"*
- Strengths:
  - Less time-consuming: *"At first I didn't like it, but I like it better than mix and match; people don't have time for the point system"*
  - More streamlined, familiar shape: *"we're used to looking at pyramids in terms of eating"*

Limitations

- Evaluation based on a small number of self-selected urban women
- Untested with rural or subsistence populations
- May not be a big deal for most people:
  - Don't eat most of the listed species
  - Eat only 1 – 3 fish meals per week

Bottom Line

- Point system has potential to reduce confusion and misinterpretation of fish consumption categories → ↑ consumption, ↓ risks of over-exposure to contaminants
- Conventional approaches for presenting consumption advice may not communicate intended advice, and may limit "mix and match"
- Very important to test materials with target audience; don't assume something is simple or straightforward


Devoted fish eaters
"If they [the State] started telling me not to eat my fish, man, they are going to war. This is Alaska!"
- focus group participant

Questions and Answers

Q. *Will you continue testing and improving the point system?*

A. We will. This is only suggestive feedback, because only 14 people were interviewed. One person suggested combining the pyramid and the point system. I'd like to encourage all states to think outside of the box and really consider whether their systems (sometimes full of confusing ands and ors) are communicating the right message.

Q. *In the Midwest halibut is already pre-packaged. How do you know if the fish came from a large or small fish?*

A. The guidance I have presented is for self-caught fish. Store-bought halibut generally weigh around 35 pounds. Unlike a self-caught fish, however, you do not usually buy and eat an entire store-bought fish. Therefore, consumers of the self-caught fish will eat a consistent contaminant level (whether it is high, low, or average), whereas consumers of store-bought fish will generally eat fish of varying levels of contaminants.

Q. *Based on Alyce's work, would you consider testing meal size information?*

A. Each state seems to have a different meal size, so we think it is very important to communicate the meal size information effectively. We decided to put ounces on the card and give a reference. The card is for commercial fish but we plan to take it further and work with other states. We would like opinions on what reference doses to use.

Q. *I recently read an article in Science about the collapse of the world fisheries. Are you considering sustainability issues in your work?*

A. We decided not to incorporate sustainability issues because it is very contentious. We decided solely on the safety of infants. We don't want to overlook the sustainability, but right now it can work against public health.

Q. *Do omega-3 levels in fish vary within regions or the farmed-raising process?*

A. Omega-3 levels are primarily based on what the fish eats. It is suspected that fish oil may be reduced in feeds to farmed salmon after PCB controversies. We would like to look into omega-3 levels in farmed fish further.

Development, Validation, and Dissemination of a Seafood Safety Wallet Card

Charles R. Santerre, Department of Foods and Nutrition, Purdue University

Biosketch

Dr. Charles R. Santerre (Ph.D.) is a professor of food toxicology in the Department of Foods and Nutrition at Purdue University. Previously, he served as an Operations Manager of Chemistry at a private food testing laboratory in Columbus, OH, Adjunct Associate Professor in the Environmental Sciences Program at Ohio State University, and Assistant Professor in the Environmental Health Science Program and the Institute of Ecology at the University of Georgia. His research involves food toxicology and nutrition, and he has served as the National Spokesperson for the Institute of Food Technologists, Chairperson for the Institute's Toxicology and Safety Evaluation Division, and Director of the Food Toxicology Center of the National Alliance for Food Safety. Dr. Santerre is currently a scientific advisor for the American Council on Science and Health, a scientific expert for the International Food Information Council, and a full member of the Society of Toxicology. He received a B.S. in Human Nutrition and a Ph.D. in Environmental Toxicology and Food Science, both from Michigan State University.

Abstract

Based on the hypothesis, "When provided with effective educational materials, childbearing-aged women will consume seafood that provides nutrients that support a healthy pregnancy while lowering the risks from exposure to pollutants and foodborne pathogens in seafood," a seafood safety wallet card was developed. The information on this wallet card recommends women who will become pregnant, are pregnant, or are nursing to consume 8–12 ounces of fish weekly. Based on the mercury (Hg) and polychlorinated biphenyl (PCB) concentrations and using the U.S. Environmental Protection Agency's health-based guidelines, commercial fish are categorized into three groups. These groups are low Hg (eat up to 12 ounces per week), moderate Hg (eat up to 4 ounces per week), and high Hg (do not eat). An additional category highlights fish that are both lower in Hg and PCBs and higher in omega-3 fatty acids (based on the U.S. Department of Agriculture's Nutrients Database values). In addition, sensitive populations are advised to eat only fish that have been properly cooked based upon a U.S. Food and Drug Administration guideline. Finally, a Web site is provided on the wallet card that directs women to a clickable U.S. map. From this map, women can obtain consumption advisories for recreationally caught fish from each state.

The wallet card, which has been reviewed by many scientists from across the country and has been validated by focus groups, is currently being distributed to women of child-bearing age at many different locations. These locations include a maternity ward, an aquarium, two state health departments, three Sea Grant Programs, and by Cooperative Extension Programs in many states (i.e., Massachusetts, Florida, Rhode Island, Illinois, Indiana, California, Texas, and Connecticut). Circulation for the first version of the wallet card was one-third of a million copies.

Development, Validation and Dissemination of a Seafood Safety Wallet Card

Charles R. Santerre, Purdue University
Jim Stahl, IN Dept. Environmental Mgmt.
LaNetta Alexander, IN Dept. of Health

Harvard Center for Risk Analysis

- "…if pregnant women were to … replace fish high in mercury with fish low in mercury [and high in omega-3 fatty acids], cognitive development benefits [for babies]…could be achieved with virtually no nutritional losses."

Harvard School of Public Health Press Release,10/19/05

Overview

- Evolution of IN Advisory
- Wallet card
  - Creation
  - Validation
  - Dissemination

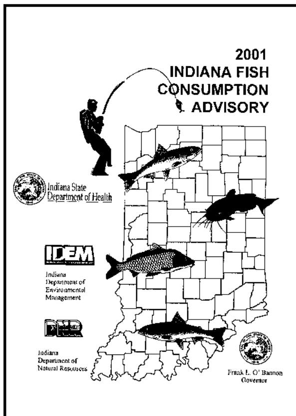
Evolution of IN Advisory – from 1998

ISDH, IDEM, IDNR cooperate to collect and analyze recreationally-caught fish for contaminants

- 10,000 copies (~60 page booklet) printed annually – 6 million Indiana residents
- Advice for commercial fish not provided
- Nutritional advice not provided

Evolution of IN Advisory – from 1998

- Advisory rather complex
- Advisory primarily distributed to anglers (~80% male)
- Advsiory only published in English
- 38% of anglers were not using the Advisory because they were either unaware of the Advisory or they were aware but chose not to follow
- Impact of the Advisory was never measured



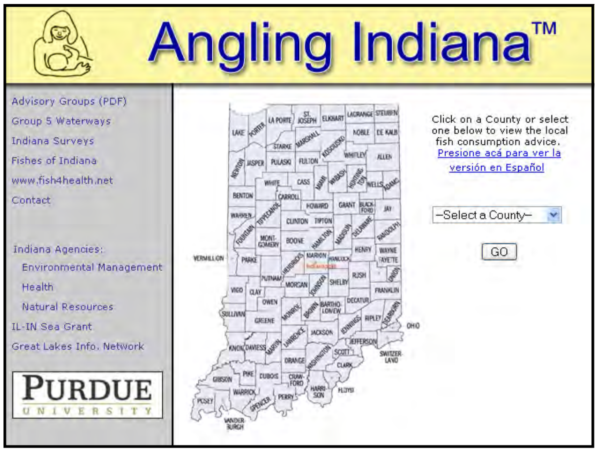
1998 STREAMS AND RIVERS ADVISORY

Location	Species	Fish Size (inches)	Contaminant	Group
St. Joseph River (Maumee River Basin)				
Allen County	Rock Bass	7-9	■	3
(Cont.)		9+	■	4
St. Joseph River (St. Joseph River Basin)				
Elkhart County	Black Redhorse	13-17	○	2
		17+	○	3
	Channel Catfish	20-24	■	3
		25-26	■	4
		26+	■	**5**
	Golden Redhorse	13-25	■	3
		25+	■	4
	Largemouth Bass	11-12	○	2
		12+	○	3
	Rock Bass	7-9	■	3
		9+	■	4
	Shorthead Redhorse	14-17	■○	3
		17+	■○	4
	Smallmouth Bass	9-13	○	2
		13+	○	3
	Walleye	16-17	○	3
		17+	○	4
St. Joseph County	Black Redhorse	14-17	■○	3
		17+	■○	4
	Carp	**20+**	■○	**5**
	Channel Catfish	22+	■○	4
	Golden Redhorse	13-22	■	3
		22+	■	4
	Largemouth Bass	15-16	■○	3
		16-18	■○	4
		18+	■○	**5**
	Shorthead Redhorse	15-19	■○	3
		19+	■○	4
	Smallmouth Bass	7-9	■○	2
		9+	■○	3
	Quillback	18+	■	3
	White Sucker	14-16	■	3
		16+	■	4

○ = Mercury Group 2 = 1 meal/week Group 4 = 1 meal/2 months
■ = PCBs Group 3 = 1 meal/month Group 5 = DO NOT EAT
(Women and children see advisory groups on page10)

Evolution of IN Advisory – from 1998

- Organized advisories by county (previously by waterbody)
- Reduced length of each County Advisory to single page (front & back) for sensitive populations only
- Provided for Spanish and for Kosher consumers
- Increased distribution to consumers and healthcare professionals (10k booklets to 160k wallet cards for same cost)
- Determined the impact of the FCA on sensitive populations



Angling Indiana - 2009 FISH CONSUMPTION ADVISORY

Tippecanoe County - advice for sensitive populations*

Waterbody	Fish Species	Fish Length (inches)	Maximum Amount for Adults to Eat** (Meals)
All Indiana Rivers and Streams (unless specified)	Carp	ALL	0
Elliot Ditch	ALL SPECIES	ALL	0
Middle Fork Wildcat Creek	Black Redhorse	Up to 10	8 ounces per week (1 meal/week)
	Carp	Up to 22 22+	2 ounces per week (1 meal/month) 0
	Golden Redhorse	Up to 10	8 ounces per week (1 meal/week)
South Fork Wildcat Creek	Black Redhorse	13+	0
	Carp	Up to 18 18+	2 ounces per week (1 meal/month) 0
	Channel Catfish	19+	0
	Creek Chub	7+	0
	Golden Redhorse	11+	0
	Longear Sunfish	4+	0
	Rock Bass	7+	0
	Smallmouth Bass	10+	0
	White Sucker	12+	0
Wabash River (upstream of Lafayette)	Blue Sucker	21+	0
	Black Redhorse	19+	0
	Channel Catfish	15+	0
	Sauger	13+	0
	Shorthead Redhorse	15+	0
	Smallmouth Buffalo	ALL	0
Wabash River (downstream	Bigmouth Buffalo	18+	0

Fish for Your Health™

Advice for pregnant or nursing women, women that will become pregnant, and children under 6 years of age

1. **Eat fish** – Health experts recommend that women eat 8-12 ounces/week (weight before cooking) of fish. Children, ages 2-6, should eat at least 2 ounces/week. As a reference, 3 ounces of fish is about the size of a deck of cards. Women that eat fish which contains omega-3 fatty acids (EPA & DHA) will pass these nutrients to their babies and suoport healthy brain and eye development.

   Best Choices: Eating six ounces/week of the following fish provides the recommended amounts of healthy fats and will minimize your baby's exposure to pollutants: salmon (wild or farm-raised), rainbow trout (farm-raised), herring, mackerel (Atlantic, Jack, chub), sardine, shad (American), whitefish.

2. **Before eating recreationally-caught fish**, check our *Fish4Health* website below for your State's fish consumption advisory and avoid eating fish that is heavily contaminated with pollutants. If a fish that you caught is not listed in the advisory, then eat no more than 1 meal per month. If you are unsure about the safety of the fish that you caught, be safe - '*catch-and-release*'.

3. **Minimize your exposure to pollutants in commercial fish** - follow the advice given below. (Ex. If you eat 4 ounces of albacore tuna, then don't eat any other fish from this category until the following week.)

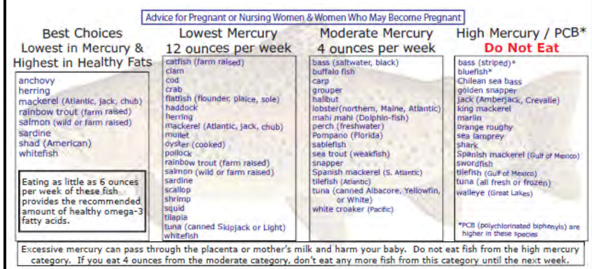
Level of Mercury or PCBs**	Maximum Amount for Adults to Eat	Commercial Fish Species
Lowest	12 ounces per week (2 meals /week)	**anchovy**, butterfish, catfish (farm-raised), clam, cod, crab (Blue, King and Snow), crayfish (also called crawfish), croaker (Atlantic), flatfish (Flounder, Plaice, Sole), haddock, hake, **herring**, jacksmelt, lobster (spiny), **mackerel (Atlantic, Jack, chub)**, mullet, oyster (cooked), perch (ocean), pickerel, pollock, **rainbow trout (farm-raised)**, **shad (American)**, **salmon (wild or farm-raised)**, **sardine**, scallop, shrimp, squid, tilapia, tuna (Skipjack, Light, canned), **whitefish**, whiting (bolded fish contain more of the healthy omega-3 fats)
Moderate	4 ounces per week (1 meal/2 weeks)	bass (black), buffalo fish, carp, perch (freshwater), grouper, halibut, lobster (northern, Maine, Atlantic), mahi mahi (Dolphin-fish), Pompano (Florida), sablefish, sea trout (weakfish), scorpion fish, snapper, Spanish mackerel (S. Atlantic), tilefish (Atlantic), tuna (Albacore, Yellowfin, White, canned), white croaker (Pacific)
High	Do not eat	bass (striped)**, bluefish**, Chilean sea bass, jack (Amber, Crevalle), king mackerel, marlin, orange roughy, shark, Spanish mackerel (Gulf of Mexico), swordfish, tilefish (also called golden bass or golden snapper - Gulf of Mexico), tuna (all fresh or frozen), walleye (Great Lakes, Canada)

Evaluation of Impact

- Expanded Food & Nutrition Education Program (EFNEP)
- 721 women of limited-resources (ages 18-49; 35% pregnant; 5% nursing) completed a pre/post-tests around a 30-50 minute one-on-one training
- 39% had not eaten fish in the past month
- 10% had eaten fish that is higher in mercury
- Only 7% had previously used the Indiana Advisory
- 79% planned to use the Advisory (after training)
- Participants understood the importance of: eating fish as part of a healthy diet; avoiding fish that are higher in pollutants; and selecting fish that are high in omega-3 fats

Key Messages - Sensitive Population

- Why is fish important to eat
- How much fish to consume
- Commercial seafood to avoid
- Commercial seafood high in nutrients
- Pathogen safety
- Recreationally-caught fish safety advice
- Omega-3 fatty acid consumption advice



Wallet Card Creation

- Seafood consumption recommendation - FDA/CFSAN, AHA, Dietary Guidelines Advisory Committee, NAS/FNB
- Hg limits - EPA's RfD
- Hg data – FDA/CFSAN, Purdue studies
- PCB limits - EPA's non-cancer endpoint
- PCB data - striped bass and bluefish from East Coast study
- Cooking recommendation - FDA/CFSAN
- Omega-3 fa's – USDA/ARS Nutrient Database

Scientific Review

- Indiana State Agencies (IDEM, ISDH, CES)
- Sustainable Seafood Forum Advisors
- Great Lakes Cooperators
- Florida State Agency Cooperators (DEP, DoH, DoA)

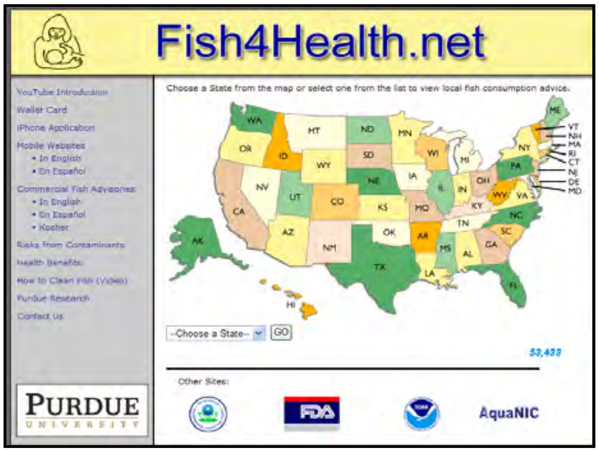
Safe Limits – Sensitive Population

Rate* (oz/wk)	Mercury£ (ppb)	PCBs§ (ppb)
12	<120	<50
4	120-377	50-148
0	>378	>149

*Fresh weight
£Hg intakes based upon: 60 Kg body weight (132 lb); RfD = 0.1 µg/kg bw-d
§PCBs intakes based upon: 60 Kg body weight (132 lb); 50% cooking loss; non-cancer endpoint = 0.02 µg/kg bw-d

Dietary Recommendations

- National Academy of Sciences (NAS) - 2002
  - EPA + DHA = 140 mg/d (nursing/pregnant)
- Dietary Guidelines Advisory Committee Report - 2004
  - 8 oz fish/wk (EPA + DHA = 500 mg/d)
- American Heart Association (AHA)
  - 2 servings (2-3 oz per serving) of fatty fish/week



Validation - Focus Group

Group included 9 women (18-37 yrs. of age)

From wallet card, women learned:

- that they should eat 8 oz of fish per wk (2 meals)
- that they should be cautious when eating recreationally-caught fish when pregnant/nursing
- that they should avoid raw fish when pregnant
- which fish are higher in n-3 fats
- which fish are higher in pollutants

Most women would use the wallet card

Seafood Restaurant Survey (n=78)

1. From the wallet card, if you were pregnant, which would you be more likely to do?
   - 36% - decrease your overall fish consumption
   - 15% - increase your overall fish consumption
   - 39% - not change your overall consumption of fish
   - 8% - not sure
2. From the wallet card, if you were pregnant, which would you be more likely to do?
   - 92% - decrease your consumption of fish that is higher in mercury
   - 1% - increase your consumption of fish that is higher in mercury
   - 6% - not change your overall fish consumption
   - 0% - not sure
3. From the wallet card, if you were pregnant, which would you be more likely to do?
   - 3% - decrease your consumption of fish that is higher in omega-3 "healthy" fats
   - 77% - increase your consumption of fish that is higher in omega-3 "healthy" fats
   - 18% - not change your overall consumption of fish
   - 3% - not sure

Dissemination Techniques

- Web sites
  - Fish4Health.net & AnglingIndiana
- iPhone & Mobile phone apps
- Handouts (1-page)
  - English, Spanish, Kosher
- Wallet cards
- YouTube and Podcast videos
- X-Train™
  - dietitians, nurses, teachers

Dissemination Targets

- State Agencies/Functions
  - WIC Clinics
  - Sea Grant Programs (RI, TX, IL-IN)
  - Health Departments (IN, FL)
  - County Cooperative Extension Offices
- Ob/Gyn's, Pediatricians, RDs, Nurses
- Grocers, Seafood Restaurants and Vendors
- Aquarium (AoP)

New Media Risk Messaging: From Brochures to Blogs

Lars Ullberg, Director, Applied Creative Training

Biosketch

Emmy Award winner Lars Ullberg has been a consultant and producer television, film, and new media for over twenty years. He has presented before the U.S. Senate Subcommittee on Homeland Security and at national symposia on a whole range of media projects from documentaries to virtual reality training simulations and games. As supervising producer, he launched several television projects involving health issues, including *Untold Stories of the ER* (Discovery) and *Interventions* (A&E). Prior to launching Applied Creative Training, a nationally recognized production services company, he was Executive Producer and Director of Development at the University of Illinois, School of Public Health, Center for the Advancement of Distance Education (CADE). Supervising a staff of over 60 people, he lead developments in broadcasting, webcasting, games, and virtual reality for clients ranging from The Department of Homeland Security, the CDC, US Health Services Administration, California Distance Learning Health Network, British Petroleum (BP), and the City of Chicago. He most recently collaborated with the California Department of Public Health Immunization Branch in creating the online documentary: *From Brochure2Blog: Public Health Communication for a New Age* (viewable at www.brochure2blog.org) and the virtual town hall discussion *Public Health Cafe: Vaccines Wading through the Confusion* (viewable at www.brochure2blog.org/PublicHealthCafe/home.aspx).

Abstract

This presentation will provide an overview of new media tools and their uses in government messaging - particularly relating to health. Technology and the internet have changed the world. With 50% of consumers seeking health information online, new strategies are needed to meet this demand in how people seek and receive health-related information. This presentation will address trends like Web 2.0, Blogs, Wikis, and Social Networks like Facebook and Twitter. Specific examples created for the California Dept. of Public Health Immunization Branch will be discussed, including: webcasts, viral documentaries, online games/training exercises, and virtual town hall meetings.


New Media
Risk Messaging:
From Brochures to
Blogs
2009 FISH FORUM


Vocabulary Test:
Tweet
Avatar
Griefer
Mashup
Vog
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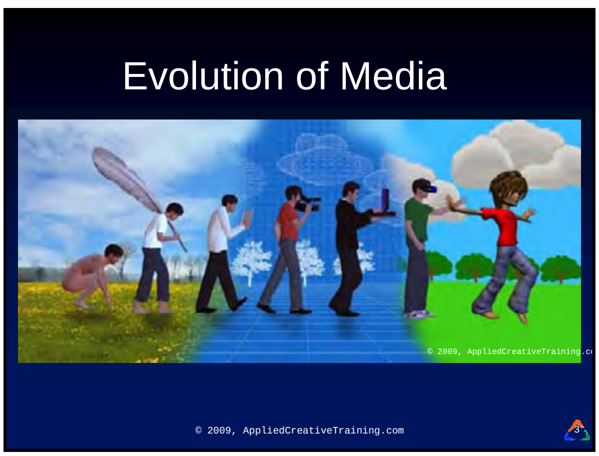
2


Evolution of Media
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3


Lars Ullberg
Applied Creative Training


New Media, New Thinking
THE INCREDIBLE
SHRINKING
ATTENTION!
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What Are Others Doing?
California Department of Public Health
Brochure to Blog Documentary - Web/YouTube
Virtual Town Hall Discussion - Live/Web/TV
Online Scavenger Hunt Game - Web
"Izzy" Immunization Bear - Facebook/Twitter
H1N1 Updates - Web/Twitter
California Kids IZ Game - Web
Tahoe New Media Training - Web/Virtual Reality
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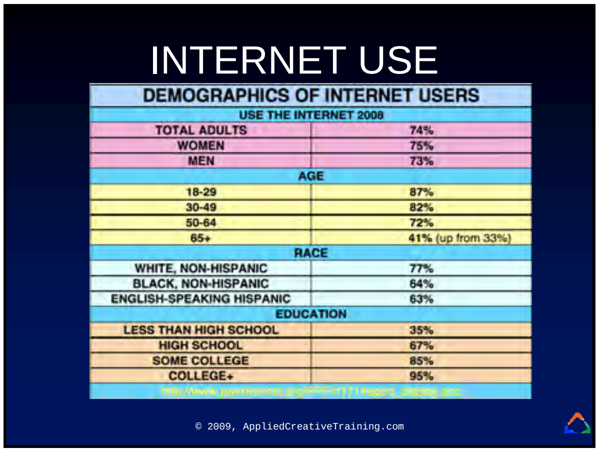
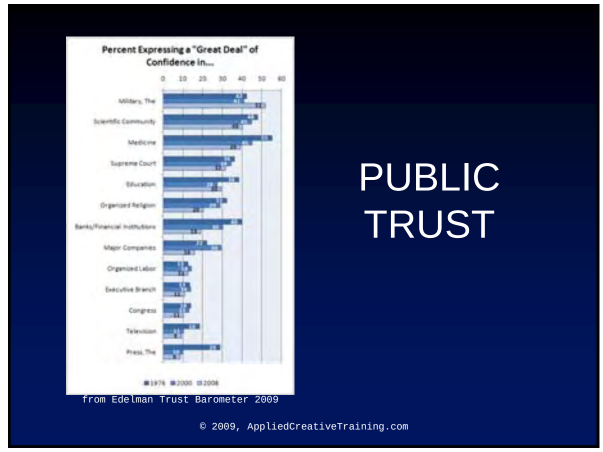
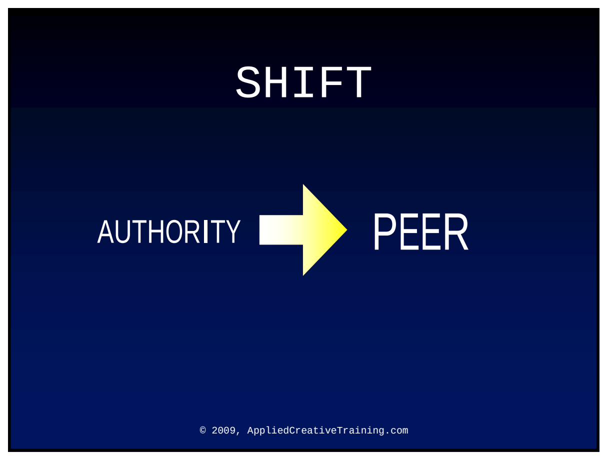
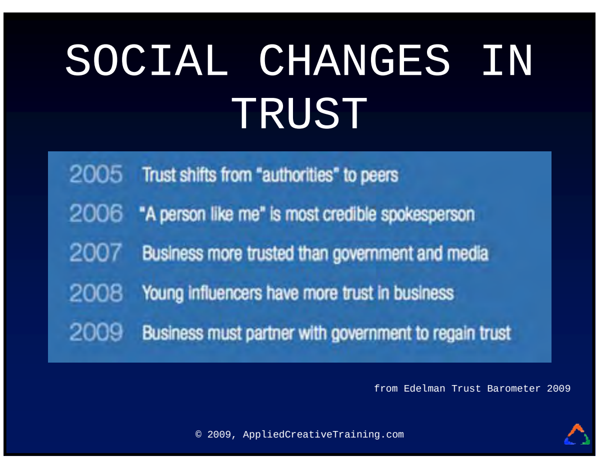
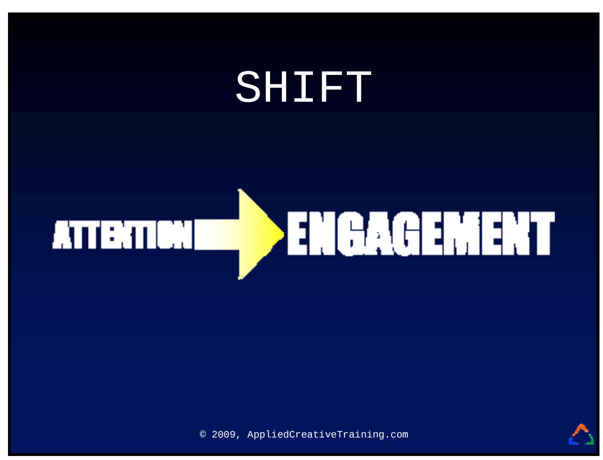


DEMOGRAPHICS OF INTERNET USERS	
USE THE INTERNET 2008	
TOTAL ADULTS	74%
WOMEN	75%
MEN	73%
AGE	
18-29	87%
30-49	82%
50-64	72%
65+	41% (up from 33%)
RACE	
WHITE, NON-HISPANIC	77%
BLACK, NON-HISPANIC	64%
ENGLISH-SPEAKING HISPANIC	63%
EDUCATION	
LESS THAN HIGH SCHOOL	35%
HIGH SCHOOL	67%
SOME COLLEGE	85%
COLLEGE+	95%
http://www.pewinternet.org/PPF/r/171/report_display.asp	









Social Marketing

- Interruptive Marketing is in decline
- Consumers are not listening any more
- The audience controls the environment:

Creating, Selecting, Changing, and Communicating

PUBLIC HEALTH = PUBLIC PARTICIPATION

Family 2.0

Public Health 2.0

Health 2.0 is Patient Empowered

61% of American adults look online for health information.

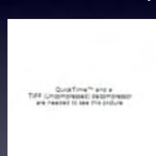
SHIFT

SCIENCE → IDENTITY

WHO AM I?

Healthy? Rugged? Traditional?

Hungry? Sportsman?



Conservationist? Individualist?

SHIFT

AUDIENCE → PARTICIPANT

Technology to Technique

Internet is Collective Storytelling

JOIN THE CONVERSATION!

Losing control of the public conversation is frightening.

FISH FORUM 2.0

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

INTERACTIVE FISH

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

YOUTUBE


FACEBOOK
Mercury in Fish
Eat healthy fish.
Track your mecury level.
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TWITTER
twitter
Hey there! toxicsoup is using Twitter.
Join today!
toxicsoup
RT @vegtv #Mercury found in every fish tested amid 30% increase among humans http://bit.ly/20KoAe
© 2009, AppliedCreativeTraining.com


Google Maps - Fishing
Google maps fishing
© 2009, AppliedCreativeTraining.com


WIKI
Mercury in fish
From Wikipedia, the free encyclopedia
Background
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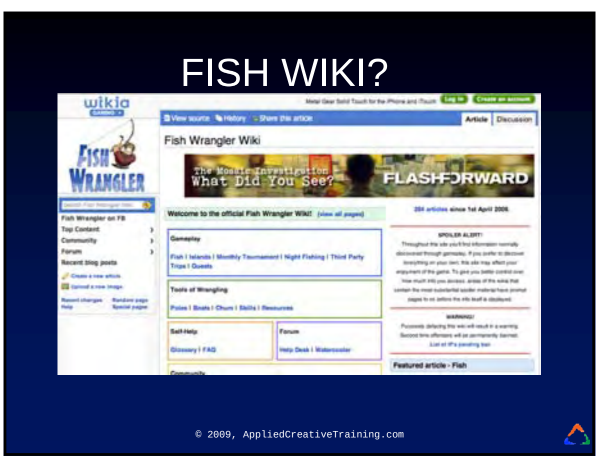
FISH WIKI?
wikia
Fish Wrangler
Fish Wrangler Wiki
What Did You See?
FLASHFORWARD
Welcome to the official Fish Wrangler Wiki!
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GEOCACHE
LOCATE
CACHE
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CONNECTIONS
digg labs
Pregnant women should get flu shot as winter bites: WHO
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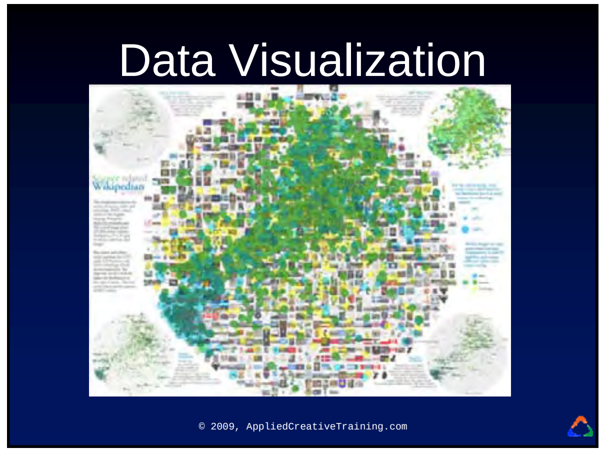
Data Visualization
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Dashboards
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Info Ring
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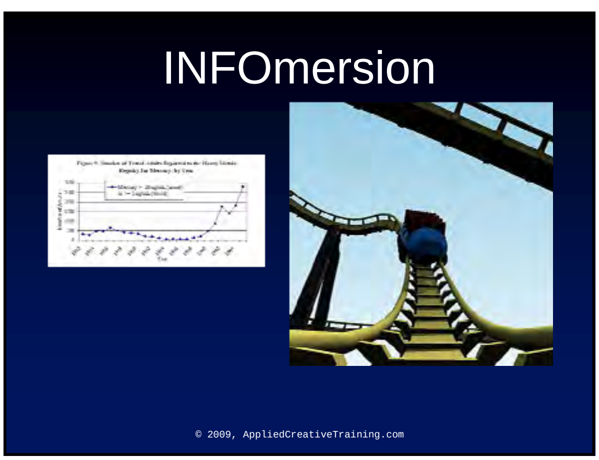
INFOmersion
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VIRTUAL TRAINING
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Prescription for New Media
PHASE 0

General

- **Assess Need/Identify Improvement Goals**
- **Review/Debrief Incidents and Exercises**
- **Plan/Execute Next Generation Follow-up Exercises**
- **Identify Strategic Partners**
- **Generate Evidence-base along the way**

Digital

- **Find Topical Centers of Gravity**
- **Identify Pre-Existing Online Community Partnering Organizations**
- **Identify Blog Opinion Leaders and eVangelists**

Prescription for New Media
PHASE 1

- **Spring Strategy**
- **Create "PULL" Applications/Websites -** Interactive/High Value Downloads
- **Digitize All Assets** - convert all video and print materials into digital archives
- **Share Digitized Assets -** with partners across jurisdictions
- **Identify Existing/Establish Local Social Network Site** - based around unique/key issues
- **Online Registration for "PUSH" Messaging**
- **Pre-Visualize/Evaluate Plans and Exercises - think visually**
- **Mixed Media Training -** with partners


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Questions and Answers

Q. We have gradually moved to more virtual meetings because of budget restrictions. Have you considered moving to Twitter and Facebook

A. Social media can ebb and flow, but having the tools to respond as it ebbs is critical. Twitter has been useful for H1N1.

Q. Is the information posted on the website live, and do you have to keep responding?

A. Juicy and interesting content is read and re-read by others. If it's on the Internet, someone almost always hears it. We don't focus on small discussions but rather create intensive events such as a week of blogging. We are learning that people have been looking at the blog posts over time.

Q. Can you explain the degree of interaction you use in communication materials?

A. We have a call center for H1N1, but we don't want the line to be overloaded, so we've also created videos of the line's Frequently Asked Questions. This method is more effective than text because the audience feels like people are talking to them.

Q. We all know we need more consistent messaging; do you have any suggestions on how we can get there?

A. How do you currently pull together the collective wisdom on PCBs? You come to this meeting. Imagine having virtual forums that everyone could attend and contribute to on a more than biannual basis. I think that if everyone in this room was more networked together, you would see more change, but it has to start with change to the bureaucracy. "The rules have changed and the rulers haven't realized it." I know that many of you aren't able to access Twitter and Facebook, but the federal government is realizing that there are virtual worlds that can be very effective in reaching different groups. Start a technology working group and talk to your IT group.

Q. In general, government wants control over what goes out there, which is incompatible with most social media platforms. Do you have any suggestions to rectify this incompatibility?

A. The number-one way people are going to look up a topic is online, so websites are critical. In general, information cannot be accessed easily on many government websites. If you are relying on the media sound bites to get your message out, it's not going to be relayed exactly as you wanted it, and you run the risk of letting the counterargument get more media coverage. It would be better to produce documentaries and discussions on your website to discuss all of the different viewpoints and then go to media. This way, people can go to your website and read responses to the counterpoints. For example, the anti-vaccination community has been working together with an online message that convinced over 200 mothers not to vaccinate. To keep low measles numbers, you have to have 90% of the population vaccinated, so losing 5% of vaccination can cause measles outbreaks. The vaccination community then had to react to the anti-vaccination movement because they did not have existing counterarguments readily available to the public.

Q. Sierra Club is working on social media, but peer-reviewed information is often copyrighted and not in a layperson format. How do get around that?

A. It has to be translated into English. The more complex, the more collaborative help is needed to reach the public. The Internet is unraveling our old notions of academia, and there is a push to get the research out there.

Q. *Do you have any advice for advisory managers?*

A. (1) Use repetition: You have to put information out more than once and in many ways. There are others out there with tons of opinions that will overshadow just one method of communication. (2) Try to understand the identity of the audience, because they generally won't identify with a scientist. (3) People in an audience want to be participants: they don't want to hear the answer; they want to hear how they can figure it out themselves.

Plenary Presentation

Can We Maximize Nutritional Intake While Minimizing Toxic Risk from Fish Consumption? An Update of Our Knowledge on Mercury and Omega-3 Fatty Acids from Marine and Freshwater Fish Consumption

Donna Mergler, University of Quebec

Dr. Donna Mergler (Ph.D.) was named Professor Emerita in June 2006 by the Faculty of Science at the Université du Québec à Montréal (UQAM), where she had been a professor in the Department of Biological Sciences since 1970. She is a member of the research group CINBIOSE, a PAHO/WHO collaborating center for the prevention of work and environment-related illnesses. She received her doctorate in Neurophysiology from McGill University in the early 1970s, and since then, her research has focused on early neurotoxic effects of exposure to workplace and environmental pollutants. Her major studies in occupational health examined nervous system deficits associated with manganese exposure among industrial workers and the long-term effects of exposure to organic solvents and pesticides. In the area of environmental health, she performed the first population study demonstrating nervous system changes associated with environmental exposures to manganese, which in Canada had replaced lead as a gasoline additive. Dr. Mergler is currently involved in studies examining the effects of manganese exposure on children in Canada, Mexico, and Brazil. In the early 1990s, she began the CARUSO project on the source, transmission, and effects of mercury in the Brazilian Amazon. Her more recent research in the Amazon focuses on dietary factors that influence mercury absorption, metabolism, and toxicity, with a view to providing Amazon communities with the means to maintain fish consumption and reduce mercury exposure and its effects. In Canada, she was the team leader of the health studies within the Collaborative Mercury Research Network, a multi-million dollar Canadian National Science and Engineering Research Council network, the objective of which was to examine mercury and its impact in the Canadian environment using an interdisciplinary, ecosystem approach. She was the first Academic Scholar of the International Development Research Centre Ecosystem and Health program from 1999–2002 and served as Director of UQAM's Institute for Environmental Sciences from 2002–2004. From 2005–2006, she chaired an international panel on the health effects of mercury exposure for the conference, "Mercury as a Global Pollutant," and in 2009, she was part of the International Joint Commission on the Great Lakes Scientific Advisory Board Working Group on Risks and Benefits of Consumption of Great Lakes Fish. Dr. Mergler is currently the Canadian principal of the Community of Practice on Ecosystem Approaches to Human Health to Reduce Toxic Exposures in Latin America and the Caribbean, a successful network that links centers of excellence, researchers, policy-makers, and non-governmental organizations in Mexico, Central America and the Caribbean, the Andes, Cono Sur, and Brazil. Dr. Mergler currently heads a Canadian Institutes of Health Research team on women, environment, and health. With her research group, she has developed innovative approaches to examine women's health and participatory methodologies for studies in occupational and environmental health. She has contributed to the development of an ecosystem approach to human health. These studies focus on preventive intervention and combine quantitative and qualitative methods to bring about concrete and lasting solutions to problems of environmental degradation. A prize-winning film, *Sur les rives du Tapajós*, is based on her work in the Amazon. Dr. Mergler has published over 130 articles in scientific journals, given many conference keynote addresses, and won several awards for her work.

Abstract

At the Mercury as a Global Pollutant meeting in Madison, WI, in 2006, an international panel analyzed current knowledge on the health effects of mercury (Hg) exposure from fish consumption and produced a

consensus document, which was subsequently published in the journal *Ambio*.[1] Since that time, studies have further confirmed Hg toxicity in human populations, particularly its effects on children's neurodevelopment and adults' cardiovascular systems. The international panel also noted that fish can contain both methylmercury and beneficial omega-3 fatty acids, stressing that, as with Hg, there are large variations in the levels of omega-3 fatty acids in fish. This panel recommended that selection of fish species for consumption should seek to maximize the intake of beneficial fatty acids while limiting exposure to methylmercury. Although many marine fish may be good sources of fatty acids, less is known about fresh-water fish.

In this presentation, we will examine the research advances on the effects of Hg on human health over the past 3 years, with an emphasis on dietary factors that influence Hg toxicity and its effects. We will analyze the recent findings and distinguish, where possible, between the consumption of marine and fresh-water fish.

---

[1] Mergler, D., H.A. Anderson, L.H. Chan, K.R. Mahaffey, M. Murray, M. Sakamoto, and A.H. Stern. 2007. Panel on health risks and toxicological effects of methylmercury. Methylmercury exposure and health effects in humans: A worldwide concern. *Ambio 36*(1):3–11.

Can we maximize nutritional intake while minimizing toxic risk from fish consumption?

An update of our knowledge on mercury and omega-3 fatty acids from marine and fresh-water fish consumption

Donna Mergler PhD
Professor Emerita
Center for Interdisciplinary Research on Biology, Health, Society and Environment (CINBIOSE)
University of Quebec at Montreal

cinbiose —PAHO-WHO Collaborating Center— PAHO/WHO

The Madison Declaration on Mercury Pollution

Henry Anderson, USA
Laurie Chan, Canada
Kathryn Mahaffey, USA
Donna Mergler, Canada
Michael Meyer, USA
Michael Murray, USA
Mineshi Sakamoto, Japan
Mark Sandheinrich, USA
Anton Scheuhammer, Canada
Alan Stern, USA

Eighth International Conference on Mercury as a Global Pollutant
Madison Wisconsin August 6–11, 2006

cinbiose

The Panel on Health Risks and Toxicological Effects of Methylmercury: Donna Mergler, Henry A. Anderson, Laurie Hing Man Chan, Kathryn R. Mahaffey, Michael Murray, Mineshi Sakamoto and Alan H. Stern

Methylmercury Exposure and Health Effects in Humans: A Worldwide Concern

- "Methylmercury is a highly toxic compound that biomagnifies through the aquatic food web, placing at risk humans who consume significant quantities of predatory fish … or who rely heavily on fish as a food source."
- "..there is growing evidence that current exposures are sufficient to alter normal function of several physiological and developmental systems.. Long-lasting effects of fetal methylmercury exposure have been described in children throughout the world."
- "Current studies suggest that exposure to methylmercury could increase the risk of adverse cardiovascular effects in a significant fraction of the human population."

Ambio 36: 3-11 (2007)

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The Panel on Health Risks and Toxicological Effects of Methylmercury: Donna Mergler, Henry A. Anderson, Laurie Hing Man Chan, Kathryn R. Mahaffey, Michael Murray, Mineshi Sakamoto and Alan H. Stern

Methylmercury Exposure and Health Effects in Humans: A Worldwide Concern

- "Fish can contain both methylmercury and beneficial omega-3 fatty acids. Methylmercury exerts toxicity and can also diminish the beneficial health effects of omega-3 fatty acids…."
- "There is some evidence from animal studies showing that selenite protects against inorganic mercury toxicity. However, there is almost no evidence showing protection against methylmercury toxicity by organo-selenium compounds… found in the human diet."

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Nervous system effects in children

The Panel on Health Risks and Toxicological Effects of Methylmercury: Donna Mergler, Henry A. Anderson, Laurie Hing Man Chan, Kathryn R. Mahaffey, Michael Murray, Mineshi Sakamoto and Alan H. Stern

Methylmercury Exposure and Health Effects in Humans: A Worldwide Concern

- The panel discussed at length the different findings from the 2 major birth cohort studies in the Faroes and the Seychelles Islands studies:
  - The Faroes study has consistently shown associations between cord blood Hg and neurobehavioral deficits and electrophysiological changes up to 14y
  - The Seychelles study only showed delayed development in their study among the most highly exposed (mothers' hair Hg) at 9 years old.

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Recent findings from the Seychelles study

- Re-analysis of the data from the Seychelles study of the 9 year olds suggests that susceptibility may not be homogeneous:
  - Motor proficiency and activity level improved significantly with increasing MeHg for children who had an average home environment.
  - However, motor proficiency significantly decreased with increasing prenatal MeHg exposure in children whose home environment was below average.

(Huang et al, 2008)

inbiose

A new Seychelles cohort

- In a new cohort study the Seychelles, extensive data was obtained on dietary factors that may positively influence neurobehavioral development.
- An adverse association between MeHg and the mean Psychomotor Developmental Index (PDI) score at 30 months, when nutritional factors were included in the multiple regression model.

(Davidson et al, 2008)

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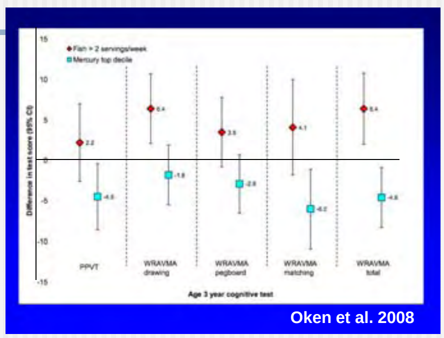
Opposing effects of Hg and fish consumption on neurobehavioral performance in 3 year olds

N = 341 mother/child pairs (Massachusetts)

Mean maternal total fish intake :1.5 ± 1.4 servings/week

40 (12%) mothers consumed >2 servings/week

Mean maternal hair mercury level: 3.8 ng/g. Top decile >1.2µg/g



Oken et al. 2008

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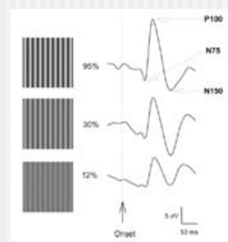
A study with Inuit children reported Hg-induced electrophysiological changes

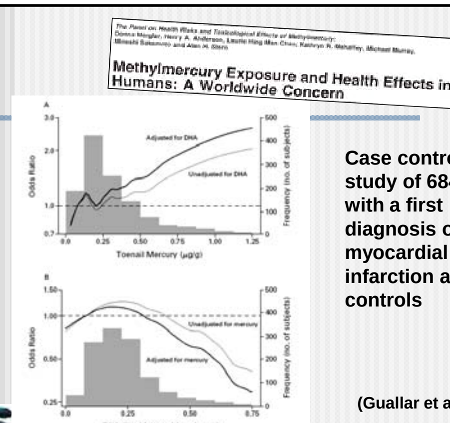
- In Canadian Inuit children, prenatal and current Hg exposure were associated with changes in latencies for Visual Evoked Potentials



(St-Amour et al, 2006)

inbiose

Cardiovascular system in adults



Case control study of 684 men with a first diagnosis of myocardial infarction and 724 controls

(Guallar et al, 2002)

Recent studies on myocardial infarction

- At the Mercury as a Global Pollutant Meeting in June 2009:
  - Jykri Virtanen presented data showing an increased incidence of myocardial infarction in a Finnish longitudinal cohort study in relation to mercury exposure,
  - Bengt Vessby presented data from Sweden showing decreased risk with Hg exposure in Swedish study; the authors consider that at these lower exposures, Hg is a proxy for fish consumption

Cardiovascular function

- Blood Hg was associated with changes in heart rate variability (HRV) and increased systolic pressure in Canadian Inuit men and women (Valera et al, 2008)
- In Faroese whalers, Hg exposure was associated with increased blood pressure and common carotid intima-media thickness, but HRV was equivocal (Choi et al, 2009)

Systolic Blood Pressure in a Canadian Inuit Population (n =731)

	Beta estimate	p
Blood Hg (log)	+1.27	0.05
Serum %EPA	- 1.75	0.05
Blood Se	- 2.80	0.03
Blood Hg (log)	+2.14	0.0004

- EPA and Hg did NOT modify the relation between blood Hg and blood pressure (interaction term not significant)
- Not adjusting for these elements could underestimate effect size

Valera et al . 2009

Since the Madison Declaration in 2006

- Mercury developmental neurotoxicity has been confirmed at very low doses
- There is more evidence for mercury-induced cardiovascular alterations and illness
- There is growing evidence that omega-3 Fatty Acids (FA) and possibly Selenium (Se) can offset some of the toxic effects of mercury
- BUT, is increased fish consumption synonymous with increased omega-3 FA and Se?

Nutrients from fish consumption

- There is a lot of information on omega-3 and Se from marine fish
- What about freshwater fish eaters?

Omega-3 Fatty Acids in serum of freshwater fisheaters

- **Great Lake fish-eaters** (Cole et al, 2002)
  - No relation between GL fish consumption and serum omega-3 FA for Euro-Canadians (n = 45)
  - Significant relation between GL fish meals and serum DHA for Asian Canadians (n = 41), but not EPA
  - Significant relation between consumption of "other" fish meals and serum omega-3 FA.
- **Sportfishers (n=112) in the fluvial lakes of the St. Lawrence** (Godin et al, 2003)
  - No relation between St. Lawrence fish consumption and serum omega-3 FA

Fishermen at James Bay, Quebec (n= 31)

	Prior to fishing season (june)	Post fishing season (November)	difference
Blood Hg (nmol/L)	21.9 ± 3.7	35.6 ± 5.2	+ 63%***
Hair Hg (µg/g)	1.4 ± 0.3	2.8 ± 0.4	+100%***
Blood Se (µg/L)	242.9 ± 6.2	247.7 ± 5.6	-
EPA + DHA (%)	4.92 ± 0.20	5.30 ± 0.60 %	-

Bélanger et al, 2008

Omega-3 Fatty Acids in serum of freshwater fisheaters

- A study of 259 persons who eat fish from lakes of the St. Lawrence and Abitibi
- Extensive food frequency questionnaire on fish species from local lakes, other lakes and market (frequency and portion = g/day)
- Measures of multiple contaminants, fatty acids and selenium (Se)
- Using published data, omega-3 FA from each species was estimated

(Philibert et al. 2006)

Results

- Highly significant (p<0.0001) relation between fatty fish intake and serum omega-3 F
- Highly significant (p<0.0001) relation between estimated omega-3 FA intake from fatty fish and serum omega-3 FA
- No relation between local catch consumption and serum omega-3 FA
- No relation between estimated omega-3 FA intake from local catch consumption and serum omega-3 FA

(Philibert et al. 2006)

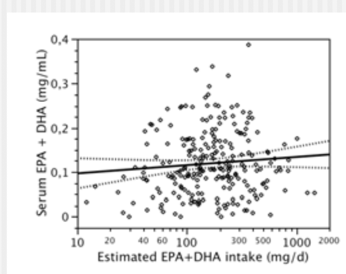
Fish consumption and biomarkers

	mean intake (g/day)	% EPA + DHA	Blood Se (µg/L)	Hair Hg (µg/g)
Total fish	57.1 ± 64.9 (3.26 - 641)	ns	ns	↑ **
Local catch	26.7 ± 59.9	ns	ns	↑ ***
Lean marine	18.2 ± 18.4	ns	ns	ns
Fatty marine	6.09 ± 8.70	↑ *	↑ **	ns
Trout	1.63 ± 3.77	↑ *	ns	↑ **

A conundrum

- This group ate, on average, 57 g/day of fish (median: 40 g/day)
- Based on published estimates of EPA and DHA in fish species, mean EPA + DHA intake would be 225 mg/d ± 202 (median: 171 mg/day)
- But: EPA+ DHA levels were low: 0.12 mg/mL ± 0.07
- The % EPA + DHA in fatty acids were : 2.1% ± 1
- Overall, for total fish consumption, there was no relation between estimated intake and serum EPA+DHA

No overall relation between estimated EPA + DHA intake and serum EPA + DHA



$R^2 = 0.002$; p = 0.45

Conclusions from these studies

- The results from these studies confirm the relation between estimated omega-3 FA in fish and serum omega-3 FA for fatty fish
- For lean fish, this relation does not appear to hold,
  - Animal studies suggest that fatty fish oils may be necessary for the assimilation of EPA and/or DHA in plasma
  - Seasonal and fish size variations in EPA and DHA may be more important in lean fish
  - Cooking differences? Frying fish reduces omega-3
- Marine fatty fish appear to be the only fish contributor to blood Se.

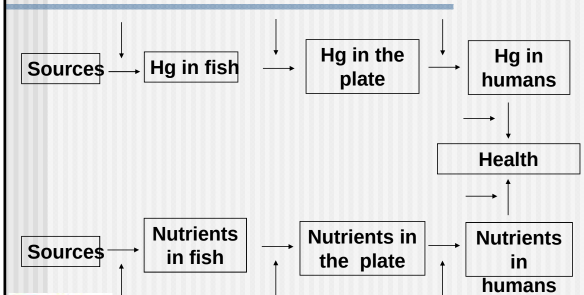
- **Why is this important?**
  - Because according to current estimates and guidelines, many people who are eating primarily lean fish (which includes many freshwater fish) think that they are getting adequate nutrient intake…
  - Because when regulators estimate benefits, they may overestimate for lean fish consumption
- **What to do?**

Fishermen at James Bay, Quebec (n= 31)

	Prior to fishing season (june)	Post fishing season (November)	difference
Cholesterol VLDL (mmol/L plasma)	0.60 ± 0.04	0.55 ± 0.04	- 8%*
Cholesterol HDL (mmol/L plasma)	0.77 ± 0.04	0.81 ± 0..05	+5%*
GPx (U/g Hb)	75.1 ± 2.3	82.4 ± 2.8	+ 9.7%**
Beta-carotene (µmol/L)	0.37 ± 0.04	0.54 ± 0.07	+ 46%*

Bélanger et al, 2008

Maximize nutrition, minimize risk



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- Guallar et al, N England J Med 347: 1747-1754; 2002
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- Bélanger et al, Metabolism Clinical and Experimental 57: 630-636; 200
- Philibert et al, Am J Clin Nutr. 84:1299 –1307; 2006

Questions and Answers

Q. Blood selenium is readily excreted due to homeostasis; therefore, selenium levels remain constant in blood. Could this explain the lack of relationship between freshwater fish consumption and selenium levels?

A. The relationship with the marine fatty fish is very clear; therefore, I would expect to see the same relationship with freshwater fish if there were increased selenium.

Q. It's not a surprise that a relationship isn't seen between EPA+DHA in blood and EPA+DHA in fish because it's so variable. Are you suggesting that unless we can get the serum levels, we should not make estimates for fish consumption purposes?

A. We are only beginning to measure EPA+DHA in fish. I would like to see studies of varying fish consumption types and frequencies measuring the EPA+DHA relationship: lean fish, fresh fish, consumption during different seasons, etc. Even if there's less EPA+DHA in walleye, for instance, we should see some relationship when we measure levels in fish and in people. The guidelines are very good for marine fish but not for freshwater fish. After two years of looking at Great Lakes data, we don't have enough info at this time to give good information on the nutritional info on these fish.

Section II-F
Risks and Benefits

Moderator:

Henry Anderson, Wisconsin Department of Health and Family Services

Dr. Henry A. Anderson (M.D.) received his M.D. from the University of Wisconsin Medical School in 1972. He is certified by the American Board of Preventive Medicine, with a subspecialty in occupational and environmental medicine, and is a fellow of the American College of Epidemiology. He is Chief Medical Officer and State Environmental and Occupational Disease Epidemiologist with the Wisconsin Department of Health and Family Services. He has adjunct professor appointments in Population Health in the Wisconsin School of Medicine and Public Health and the Gaylord Nelson Institute for Environmental Studies. Over the past 25 years, he has conducted multiple research projects investigating human health hazards of consumption of Great Lakes fish and other sport fish and developed and evaluated the effectiveness of public health advisories. He is co-chair of the Great Lakes Fish Advisory Consortium.

Presentations

Risk-Benefit Synthesis for Fish Consumption Advisories

Gary Ginsberg, Connecticut Department of Public Health

A Quantitative Approach to Methylmercury-Omega-3 Risk-Benefit Analysis Based on Joint Regression in Population-Based Studies

Alan Stern, New Jersey Department of Environmental Protection

Composite Risk Benefit Curve Approach to Fish Consumption: Dispelling Some Myths

Michael Gochfeld, CRESP-Environmental and Occupational Health Sciences Institute, New Jersey

Recent Advances in Our Knowledge of Mercury and Selenium on Human Health

Melanie Lemire, University of Quebec

Omega-3 Levels in Fish: Data Quality, Quantity, and Future

Bruce Holub, University of Guelph

Risk-Benefit Synthesis for Fish Consumption Advisories

Gary L. Ginsberg, Toxicologist, Connecticut Department of Public Health,
Division of Environmental and Occupational Health Assessment, Hartford, CT

Biosketch

Dr. Gary L. Ginsberg (Ph.D.) is a toxicologist at the Connecticut Department of Public Health within the Division of Environmental and Occupational Health Assessment. He also serves as adjunct faculty at the Yale School of Public Health and is an Assistant Clinical Professor at the University of Connecticut School of Community Medicine. Dr. Ginsberg has served on two National Academy of Science panels (Biomonitoring, EPA risk methods), and is a member of EPA's Science Advisory Board. 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 (currently) working in public health. He has published in the areas of toxicology, carcinogenesis, physiologically based pharmacokinetic modeling, inter-individual variability, and children's risk assessment. Dr. Ginsberg is also co-author of *What's Toxic, What's Not,* a book on toxics for the lay public.

Abstract

There is reasonable rationale to provide the public with species-specific fish consumption advice because species differ widely in their methyl mercury (meHg) and omega-3 (O-3) fatty acid (FA) content. However, a tool is needed to weigh the relative risks and benefits of these counteracting constituents. We have developed algorithms based upon published dose-response relationships for the adverse effects of meHg and the beneficial effects of O-3 on common endpoints: coronary heart disease and neurodevelopment. The meHg and O-3 content of 16 commonly consumed species were used to estimate the net risk/benefit for each species on these endpoints. O-3 benefits are estimated to outweigh meHg risks for some species (e.g., farmed salmon, herring, trout) but the opposite was found for others (e.g., swordfish, shark). Species that are in between can be broken into once per week (e.g., canned white tuna, tuna steak, halibut) or twice per week (e.g., cod, canned light tuna) consumption. These are tentative assignments based upon limited dose-response information, but exemplify the manner in which risk/benefit calculations may be used to fine tune species-specific advice. Separate advice appears warranted for the neurodevelopmental risk group versus the cardiovascular risk group because a greater net benefit from fish consumption was found for the latter endpoint. More research on the adverse effects of meHg on cardiovascular endpoints would be particularly useful in this regard.

Risk-Benefit Synthesis for Fish Consumption Advisories

Gary Ginsberg, Brian Toal
Connecticut Dept of Public Health

National Forum on Contaminants in Fish
Portland OR Nov 2009

Fish Consumption Advisories Traditionally Focus on Risk

- Mercury, PCBs, Chlordane, Dioxin
- High risk group – WC-BA, young children
- Consumption limits based upon RfD
- Benefits of fish consumption not quantitatively considered
  - FCA encourages consumption while also give warning msg and setting limits

Dueling Epi Studies 1990's to 2000s

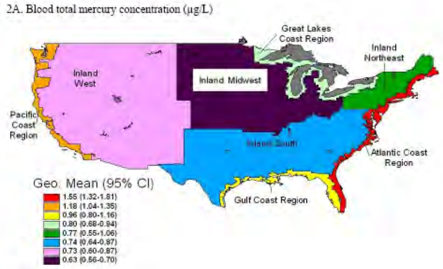
Seychelles Island

NAS Resolved Debate in 2000 – showed how to set RfD

Mahaffey, et al. EHP, 2008

(http://www.ehponline.org/members/2008/11674/11674.pdf)

2A. Blood total mercury concentration (μg/L)



Fish Consumption Debate Not Over

- With RfD, set limits on fish consumption
  - One to two meals/week of commercial seafood
  - No swordfish, shark, tilefish, king mackerel
  - Statewide freshwater advisory – 1 meal/month
- But – lose omega-3 benefits??
  - Brain development
  - Cardiovascular mortality – acute MI
    - Miscellaneous other benefits – eyes, anti-inflamm
  - Benefits really lost if msg too scary
- To eat fish or not to eat fish – Is that the Question?

Possible Risk Benefit Approaches for FCA

- Retain current advisory but improve risk communication – only balance the msg?
- Refocus advisory on individual fish?
- Separate risk-benefit assessment for diff endpoints and types of receptors?

Qualitative Assessment: IOM, 2006

- Qualitative review of fish consumption patterns, benefits,risks, uncertainties
- Recommendations
  - Include seafood in diet
  - Keep consumption w/in federal advice for high risk group for mercury in seafood
  - Increase monitoring
  - Gen pop – eat 2 3oz meals/wk – CV benefit
    - If eat more, choose from a variety of species

Qualitative Evaluation: Mozaffarian and Rimm, 2006

- Reviewed D/R for CV benefits and Hg risks
- Table of nutrients & contams in fish species
- Reviewed costs, supplements, n6:n3 ratio
- Evidence synthesis
  - Benefits outweigh risks – but …..
  - Women of CBA/nursing moms - follow federal advice
  - All others, no limits; if > 5 mls/wk, no high Hg species
  - Don't worry about cancer risks from organoCl's

Mozaffarian and Rimm, 2006

Figure 2. Relationship Between Intake of Fish or Fish Oil and Relative Risks of CHD Death in Prospective Cohort Studies and Randomized Clinical Trials

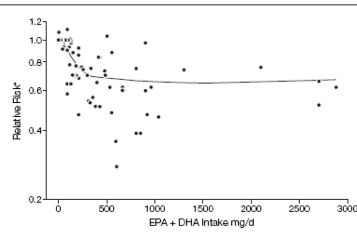
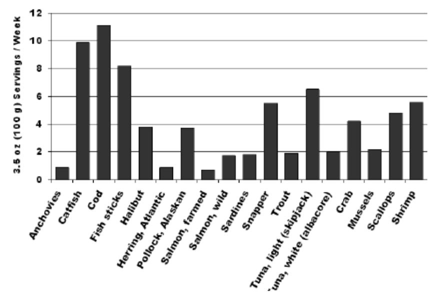


Figure 2. The number of 3.5 oz (100 g) fish servings per week needed to provide an average of 250 mg/day of the marine n-3 polyunsaturated fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Based on data from Mozaffarian and Rimm [1].

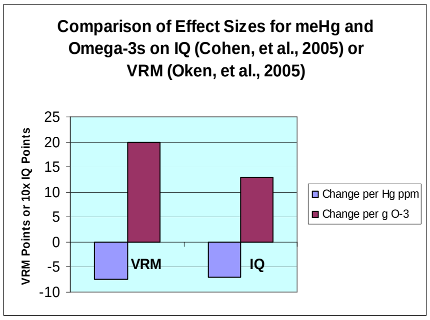


Quantitative Analyses

- Ponce, et al., 2000
  - MI prevention benefits of fish vs
  - meHg neurodevelopmental effects
    - delayed speech - Iraq - maternal hair
  - weighted by QALYs
  - evaluated net effect of fish consumption
    - Risk - benefit of MI vs CNS development
    - Across range of fish concs (0-2 ppm)
    - Endpoints differ, key receptors differ, not species specific

More Quantitative Analysis

- Cohen et al, 2005
  - Regression slopes for
    - meHg on IQ
    - DHA on IQ
    - fish consumption on stroke and CHD
  - Evaluated ↓ed consumption from advisories and over-reaction
  - Standardized fish consumption patterns and federal databases for meHg and omega-3
    - no individual fish analyzed
  - Converted health endpoints to QALYs



Conclusions – Cohen et al.

- Fish consumption advisories can yield developmental benefits if followed
- Can lead to increased risks if advisory → worry → fish avoidance

•Are fish advisories that focus on good species less likely to cause avoidance?

EHP, E Article:
http://www.ehponline.org/docs/2008/11368/abstract.html

Quantitative Approach for Incorporating Methyl MercuryRisks and Omega-3 Fatty Acid Benefits in Developing Species-Specific Fish Consumption Advice

Gary L. Ginsberg* and Brian F. Toal

Connecticut Dept of Public Health, Hartford, CT

Table 1
Dose Response Relationships for Key MeHg and Omega-3 FA Endpoints

Endpoint	Agent	Dose-Response	Comments	Reference
Adult CHD Mortality	Omega 3 FA	14.6% decreased relative risk per 100mg/d	Combined data across 20 studies for EPA+DHA intake vs CHD mortality; possible saturation of benefit above 250 mg/d	Mozaffarian and Rimm 2006
Adult MI Risk	MeHg	23% increased relative risk per ppm hair Hg	Slope adjusted for DHA content of lipid as index of fish oil intake; Risk not apparent < 0.51 ppm hair Hg; Toenail Hg measured but converted to ppm in hair	Guallar et al. 2002 Ohno et al. 2007 for toenail to hair Hg conversion; Zhang and Yu 1998 for odds ratio conversion to relative risk
Infant VRM Score	Omega 3 FA	2.0 point increase per 100 mg/d	VRM measured at 6 months in 135 mother-infant pairs; fish oil intake estimated from dietary survey	Oken et al. 2005
Infant VRM Score	MeHg	7.5 point decrease per ppm hair Hg	VRM measured at 6 months in 135 mother-infant pairs; Direct measurement of maternal hair Hg	Oken et al. 2005

Abbreviations: CHD: coronary heart disease; MI: myocardial infarction; VRM: visual

Risk-Benefit Analysis of Oken et al., 2005

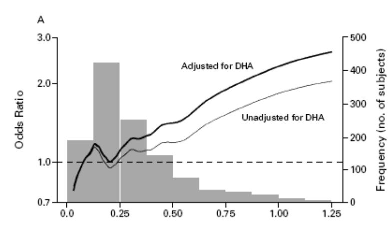
Table 2. Associations of maternal second-trimester fish consumption and maternal hair mercury at delivery with infant cognition at 6 months (VRM score): results from six linear regression models among 135 mother–infant pairs in Project Viva.

	Change in VRM score [% novelty preference (95% CI)]	
Model	Effect per weekly fish serving	Effect per ppm maternal hair mercury
Fish only	2.5 (–0.01 to 5.0)	—
Fish and participant characteristics[a]	2.8 (0.2 to 5.4)	—
Mercury only	—	–4.6 (–10.3 to 1.1)
Mercury and participant characteristics[a]	—	–4.0 (–10.0 to 2.0)
Fish and mercury	3.9 (1.2 to 6.5)	–8.1 (–14.1 to –2.0)
Fish, mercury, and participant characteristics[a]	4.0 (1.3 to 6.7)	–7.5 (–13.7 to –1.2)

[a]Participant characteristics adjusted for include maternal age (continuous), race/ethnicity (white vs. nonwhite), education (college graduate vs. not), marital status (married or cohabiting vs. not), and infant sex, gestational age at birth (continuous), birth weight for gestational age (continuous), breast-feeding duration (continuous), and age at cognitive testing (continuous).

Guallar, et al. 2002

Risk of MI in 684 men in Eastern Finland

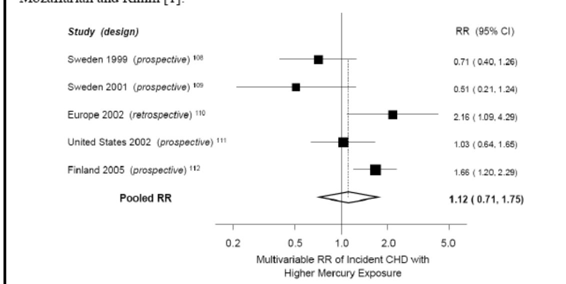


Mercury and CVD

- **Salonen 1995**
  - 1833 Finnish men
  - 2x ↑ed MI > 2 ppm
- **Salonen 2000**
  - 1014 Finnish men
  - ↑ed athero > 2.83 ppm
- **Guallar 2002**
  - 684 European men
  - Linear D-R for MI
- **Virtanen 2005**
  - 66 Finnish cases
  - OR 1.66 for high Hg
- **Ahlqwist 1999**
  - 1462 Swedish women
  - Amalgam exposure
    - Serum Hg not assoc with MI or stroke
- **Hallgren 2001**
  - 78 Swedish men/wom
  - Poss assoc in low O-3 and high RBC Hg grp
- **Yoshizawa 2002**
  - 33,737 US men
  - Mostly dentists

Mozaffarian (2009) Int J Environ Res Pub Health 6: 1894-1916

Figure 3. Meta-analysis of studies of mercury exposure and risk of coronary heart disease (CHD). Relative risk (■) and 95% CIs (–) are shown comparing the highest to the lowest quantile of mercury exposure after adjustment for other risk factors. Adapted from Mozaffarian and Rimm [1].



Components of Quantitative Risk/Benefit Analysis

- Dose response relationships
- Fish Hg & O-3 data from FDA, USDA, etc
- One compartment PK model to convert fish meal (3oz) to hair Hg concentration

Fish Conc → Daily O-3 intake → Neurodev Benefit; CardioV Benefit

Fish Conc → (PK Model) Hair mercury → Neurodev Risk; CardioV Risk

Table 2. Omega 3 FA and MeHg Levels in Commonly Eaten Fish

Fish Species	Omega-3[a] (mg/ 6oz)	MeHg[b] (ug/g)
Cod, Atlantic	269	0.11
Flounder/Sole	852	0.05
Halibut	1398	0.26
Herring, Atlantic	3424	0.04
Lobster	1129	0.24
Pollack	922	0.06
Salmon, Atlantic, farmed	3658	0.014
Sea Bass	1295	0.27
Shark	1170	0.99
Shrimp	536	0.01
Swordfish	1392	0.97
Tilapia	240	0.01
Trout	1744	0.03
Tuna, canned, light	425	0.12
Tuna, canned, white	1462	0.35
Tuna, fresh, yellowfin	474	0.325

[a]Omega-3 FA represents the sum of EPA and DHA. Data from USDA, 2005 although shark data from Mozaffarian and Rimm, 2006.
[b]MeHg data from USFDA 2006; data for salmon reported as fresh/frozen and not distinguished according to source.

Risk/Benefit Equations for Coronary Heart Disease and Neurodevelopment

Net Risk/Benefit for Adult CHD =

((Omega-3 FA mg/meal) (#meal/wk)(1 wk/7d)*(14.6% ↓edrisk/100mg Omega-3 FA)) – (([(Hair Hg change/fish meal) (# meals/wk)] - (0.51 ppm hair Hg)) * (23% ↑ed risk/1 ppm Hair Hg))

Net Risk/Benefit for Infant VRM =

((Omega-3 FA mg/meal) (#meal/wk)(1 wk/7d)*(2 VRM pts/100mg Omega-3 FA)) – ((Hair Hg change per fish meal) (# meals/wk) (7.5 VRM pts/1 ppm Hair Hg))

Figure 1
Net Effect of meHg and Fish Oils on Neurodevelopment at 6 months of Age: 1 Fish Meal/Week

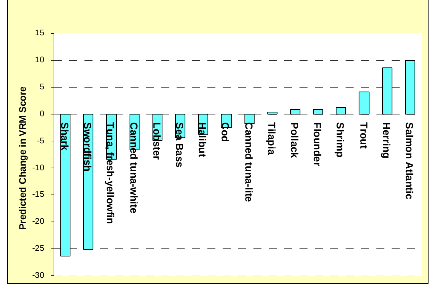


Figure 2
Net Effect of meHg and Fish Oils on Cardiovascular Risk: One Fish Meal per Week

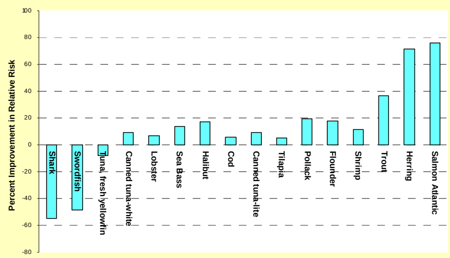


Figure 3
Net Effect of meHg and Fish Oils on Cardiovascular Risk: Two 6 oz Fish Meals per Week

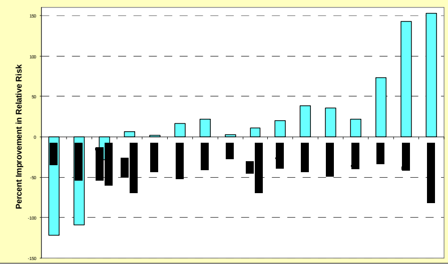


Table 3
Tentative Fish Consumption Categories for the 16 Species
Analyzed in the Current Risk/Benefit Assessment
(Based upon 6 oz meal size)

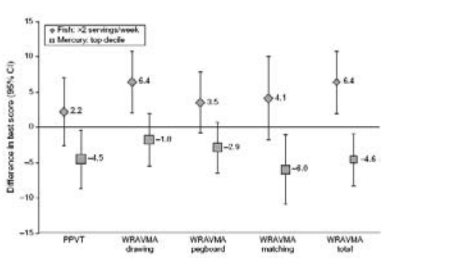
Consumption Category	Receptors	Fish Species
Unlimited (pending evaluation of other contaminants)[a]	Neurodevelopment Risk Group[b]	Tilapia, Pollack, Flounder, Shrimp, Trout, Herring, Salmon
Twice per week		Canned light tuna, Cod
Once per week		Canned white tuna, Tuna steak, Halibut, Sea bass, Lobster
Do not eat		Swordfish, Shark
Unlimited (pending other contaminants)	Cardiovascular Risk Group[c]	Tilapia, Pollack, Flounder, Shrimp, Trout, Herring, Salmon, Canned light tuna, Cod
Twice per week		Canned white tuna, Halibut, Sea bass, Lobster
Once per week		Tuna steak
Do not eat		Swordfish, Shark

[a]Unlimited taken to mean daily consumption.
[b]Pregnant women, women of child-bearing age, nursing mothers, young children
[c]General adult population.

If Some Fish Risky Why Do Various Studies Show Fish Benefit

- Population eats a variety of fish
  - Some provide major benefit – salmon, shrimp
  - Net benefit in general pop – more salmon than swordfish
    - FDA approach – evaluate overall fish consumption patterns
  - In subgroups – e.g., frequent sushi – meHg excess and symptoms
  - In Finland – where fish low in omega-3 – CV morbidity

Oken et al. Amer J Epidemiol 167: 1171-1181, 2008



IGURE 1. Associations of maternal second-trimester fish intake (>2 weekly servings vs. never) and erythrocyte mercury levels (top decile vs. elow) with child cognitive test results at age 3 years, Project Viva, Massachusetts, 1999–2002. Effect estimates were adjusted for each other as ell as for parent and child characteristics. CI, confidence interval; PPVT, Peabody Picture Vocabulary Test; WRAVMA, Wide Range Assessment f Visual Motor Abilities.

Oken et al. Amer J Epidemiol 167: 1171-1181, 2008

TABLE 5. WRAVMA* total score for children aged 3 years according to maternal prenatal fish intake and mercury levels, Project Viva, Massachusetts, 1999–2002

Fish intake	Mercury ≤90th percentile			Mercury top decile		
	No.	Estimate†	95% CI*	No.	Estimate†	95% CI
>2 weekly servings	31	5.9	1.0, 10.9	9	4.1	−3.4, 11.7
≤2 weekly servings	229	1.8	−1.8, 5.3	25	−4.2	−9.6, 1.2
Never	47	0	Referent			

* WRAVMA, Wide Range Assessment of Visual Motor Abilities; CI, confidence interval.
† Adjusted for child sex, age at testing, fetal growth, gestation length, breastfeeding duration, birth order, and primary language; maternal Peabody Picture Vocabulary Test score, age, prepregnancy body mass index, race/ethnicity, education, marital status, and alcohol consumption and smoking during pregnancy; and paternal education.

Limitations in Current Data

- Multiple contaminants and nutrients
  - Hg, PCBs, dioxin, pesticides, PBDEs
  - O-3s, iodine, selenium, iron, protein
- Multiple endpoints – cancer separate issue?
- Dose response – should equal wt be given to mercury CV risk as omega-3 CV benefit?
- Data inputs – need more omega-3 and Hg fish data

Summary

- Quantitative Risk-Benefit FCA approach demonstrated
- Species-specific advice should be focus
- Net benefit for certain fish – unlimited consumption if no PCB/POPs issues
- Net risk for certain fish – no or very low consumption even if not in “hi risk” group
- Risk/benefit tilted more towards risk for neurodevelopmental vs CV outcomes

Questions and Answers

Q. *In your opinion, how much should we be looking at selenium when developing advisories?*

A. I think we need to consider the effects of mercury and selenium separately until we have more information on the selenium interaction with mercury (e.g., selenium in freshwater fish).

Q. *It may be useful to look at the outcome and statistics when the effects of selenium and mercury are combined.*

A. We did look at the outcome, but I think more information is needed. For example, mercury affects multiple systems in the body, and selenium may not be able to compensate for all of the effects. Conversely, selenium may have multiple effects as well.

Q. *What implications may selenium have on reference doses? Do you think only looking at mercury in fish advisories is short-sighted?*

A. I think the effects of selenium, mercury, polyunsaturated fatty acids, and other compounds need to be evaluated with respect to the reference dose and the application of it, but I think more information is needed.

A Quantitative Approach to Methylmercury-Omega-3 Risk-Benefit Analysis Based on Joint Regression in Population-Based Studies

Alan H. Stern, Office of Science, New Jersey Department of Environmental Protection

Biosketch

Dr. Alan H. Stern (Ph.D.) is lead for toxicology and human health risk assessment in the Office of Science of the New Jersey Department of Environmental Protection. He received a B.S. in Biology from the State University of New York at Stony Brook, an M.S. in cellular and molecular biology from Brandeis University, and a doctorate in public health from the Columbia University School of Public Health. He is a Diplomate of the American Board of Toxicology and served as a member of the National Research Council/National Academy of Sciences Committee on the Toxicology of Methylmercury. Dr. Stern's areas of expertise include human health risk assessment and exposure assessment, including probabilistic approaches. He has pursued an abiding interest in the risk assessment for mercury in general and methylmercury in particular, having published several papers relating to the derivation and interpretation of the methylmercury reference dose. He is also very involved in the consumption advisory process in the State of New Jersey.

Abstract

In contemplating fish consumption advisories that attempt to balance the risk from methylmercury (MeHg) against the benefit from omega-3 fatty acids, the advice for both the high omega-3 fatty acids–low MeHg case (good) and the low omega-3 fatty acids–high MeHg case (bad) is relatively clear cut. However, there is a problem when we attempt to find the appropriate balance for the intermediate cases. Studies that simply assess health endpoints as a function of the fish consumption of a given population without characterizing both the MeHg and omega-3 fatty acids intake represented by that fish consumption provide little guidance for other populations that may consume very different fish diets. Similarly, studies that assess health outcomes based on characterizing either MeHg alone or omega-3 fatty acids alone also provide little guidance beyond the study population because they cannot determine to what extent the risk is confounded by benefit or the benefit is confounded by risk in the average fish diet of the study population. To apply epidemiologic data in a way that allows them to be generalized to individuals consuming a variety of fish diets, it is necessary to evaluate "naked" MeHg risk and "naked" omega-3 fatty acids benefit. This evaluation can be accomplished in studies in which the outcome (e.g., neurodevelopment) is described by a model that simultaneously controls for the effects of both MeHg and omega-3 fatty acids. This evaluation allows for approaches in which the summation of risk and benefit can be compared for varying intakes of MeHg and omega-3 fatty acids from diets of different fish containing variable amounts of each. To date, there is only one study (Strain et al., 2008) that provides such data and addresses only one developmental endpoint. As illustrated by studies that have modeled multiple developmental endpoints controlling for MeHg and fish consumption (rather than omega-3 fatty acids intake), the application of this approach is likely to be complex because some endpoints appear to be susceptible to MeHg risk but do not offer a fish consumption benefit and vice versa. This means that some combinations of MeHg and omega-3 fatty acids may be net-positive for some endpoints, but net-negative for other endpoints. Clearly, for such an approach to provide data that can be translated into useful fish consumption advice additional, targeted research is needed.

A Quantitative Approach to Methylmercury-Omega-3 Risk-Benefit Analysis Based on Joint Regression in Population-Based Studies

Alan H. Stern
Leo R. Korn
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The Problem

- How can we derive fish consumption advice that balances the risk from methylmercury (MeHg) against the benefit from omega-3s?
  - MeHg and omega-3 operate on many (some?) of the same endpoints
  - Therefore, data on risk from consumption of fish is likely to be confounded by benefit from omega-3s in the same fish
  - Vice-versa for data on benefit from fish consumption

- Some advice is easy
  - High omega-3, low MeHg - **GOOD**
    - anchovy
    - sardines
    - herring
    - salmon
  - High MeHg, low omega-3 **BAD**
    - swordfish
    - shark

- The difficulty comes when we think about advice for fish with medium levels of both MeHg and omega-3s
  - tuna
  - snapper
  - bluefish
  - sea bass
  - freshwater bass, pike, walleye????

Why not use studies that evaluate outcomes against fish consumption

- For example, Daniels et al.(2004) (ALSPAC study data)
- This was largely the approach taken by FDA in its recent proposal
- There are two arguments against using such an approach

- 1. In almost any population there will be a variety of patterns of fish consumption, but regression analyses of fish consumption vs. outcome assume that all consumers are eating the same mean diet
- 2. Data from such a study only apply to a different population if it is assumed that the second population has the same fish diet
    - i.e., that both populations eat fish with the same balance of MeHg and omega-3s

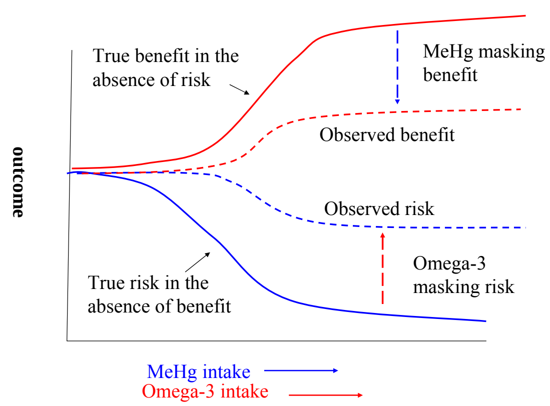
What about studies that quantify MeHg or omega-3s?

- If we at least have MeHg vs. outcome data or omega-3s vs. outcome data, can't we get risk information from one study and benefit information from another?
  - The original Faroes and Seychelles results supplied MeHg risk-only data
  - Other studies (e.g., ALSPAC) supply fish benefit-only data

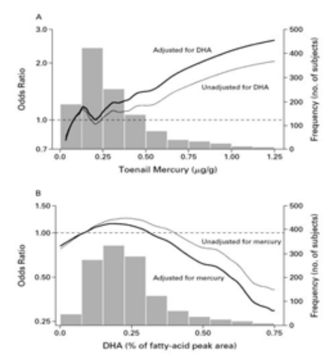
- **No.**
  - remember that MeHg and omega-3s largely operate on the same endpoints
  - therefore, if we look at each separately, the risk from MeHg is likely to be partially obscured by the benefit from the omega-3s

  and

  - the benefit from the omega-3s is likely to be partially obscured by the risk from the MeHg



An example from Guallar et al. (2002)



The naked truth

- What are needed are "naked" risk and benefit data
  - that is, data on MeHg risk not obscured by omega-3 benefit

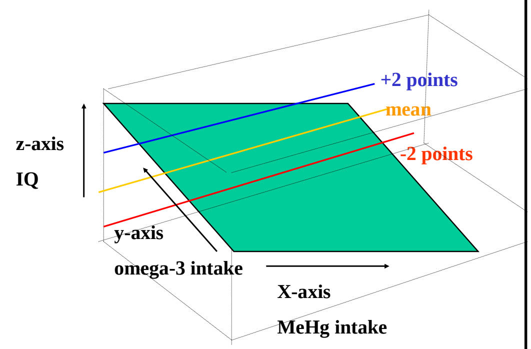
  and

  - data on omega-3 benefit not obscured by MeHg risk

So, how do we get this information?

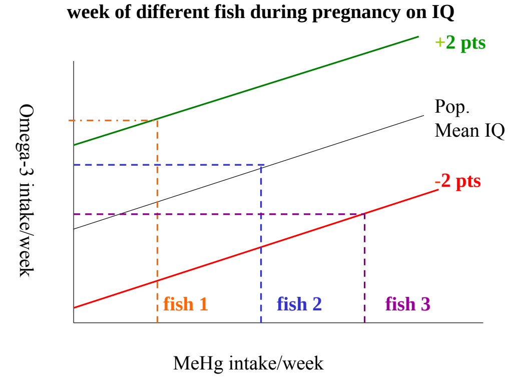
- By creating multiple regression (or structural equation) models that contain both omega-3 and MeHg exposure information
  - recall that in multiple regression, the coefficient (β) of each independent variable reflects the "slope" of that variable when the slopes of the other variables are held constant
    - this is what is meant be "controlling" for a variable

- So, if we have a regression model (for e.g., IQ) with both omega-3 and MeHg in the model, the β for each reflects the "naked" effect of each
  - the same reasoning applies to cardiovascular endpoints
- The relationship among the three variables (outcome, MeHg and omega-3) is described by a plane in three-dimensions
  - Things become more complicated if there is interaction



- We can then derive the value for that particular endpoint that would result from independent values of MeHg and omega-3 intake
  - each independent combination of MeHg and omega-3 intake can represent (e.g.) 1- 8 oz portion of a particular fish per week
- For example

Hypothetical relationship of the effect of one 8 oz meal per week of different fish during pregnancy on IQ

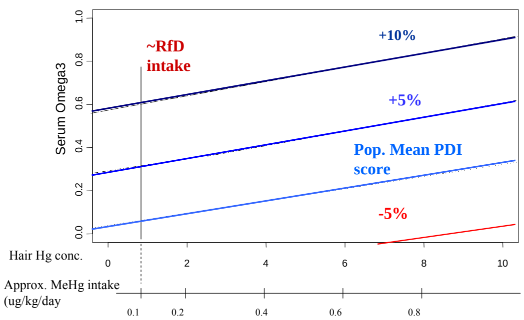


- In theory, these data can be combined in any combination to reflect the combination of MeHg and omega-3s from different fish and different fish diets to arrive at an overall beneficial outcome.

A real-world example

- Unfortunately, there is currently only one developmental study that provides data that is somewhat appropriate for such an analysis.
- Strain et al. (2008) - Seychelles data for MDI and PDI at 9 and 30 months of age.
  - MeHg is only significant for PDI-30 months
  - omega-3 is not significant for any endpoint
    - intake may be saturated
- Therefore, just an example and not a basis for advisories

Strain et al. (2008) - PDI at 30 months



Many endpoints, many possible combinations of MeHg and omega-3 influences

- Even if we confine ourselves to developmental endpoints, many endpoints have been identified that are sensitive to MeHg risk
- Will the MeHg-risk, omega-3 benefit derived for one endpoint hold for other endpoints?

- We can get an idea of the answer from looking at studies in which MeHg intake and **fish consumption** (not omega-3 intake) were both controlled in a regression model

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- Choi et al (2008); Budtz-Jorgensen et al. (2007)
- For motor endpoints both fish consumption and MeHg exposure are significant in the structural equation model.
- e.g.,
  - motor performance at 7 yrs

	Fish intake	Hg biomarker
coefficient	25.1 (p - 0.0 1)	-12.2 (p - 0.009)

- However, for some endpoints there was MeHg risk, but no significant evidence of benefit for fish consumption
- e.g.,

	Fish intake	Hg biomarker
verbal performance at 7 yrs		
coefficient	3.62 **(p = 0.61)**	-10.8 (p = 0.002)
attention at 14 yrs		
coefficient	12.2 **(p = 0.13)**	-9.54 (p = 0.016)

- Lederman et al. (2008) - NYC
- both fish consumption during pregnancy (yes/no) and ln cord blood Hg were significant in some of the models

.	Fish intake	ln cord blood Hg
PDI-36 months		
coefficient	8.73 (p = 0.006)	- 4.16 (p = 0.007)
Full IQ		
coefficient	5.64 (p = 0.015)	- 3.76 (p = 0.002)

- But, for some endpoints MeHg, but not fish consumption was significant

	Fish intake	ln cord blood Hg
performance IQ		
coefficient	4.26 **(p = 0.138)**	- 4.16 (p = 0.007)
MDI-24 months		
coefficient	2.44 **(p = 0.325)**	- 2.76 (p = 0.035)

- Thus, it appears that different endpoints have different responses to fish consumption/omega-3 (and MeHg)
- Some may be susceptible to MeHg risk, but not omega-3 benefit.
- This means that MeHg risk and omega-3 benefit need to be defined for a wide variety of endpoints
  - otherwise advice could result in significant benefit for some outcomes, but significant risk for others.

Conclusion

- There is a conceptual way forward for providing fish consumption advice that balances risk and benefit
- BUT, we are not there yet
  - except for the all-benefit and all-risk cases
  - need to consider:
    - risk and benefit data not confounded by each other
    - variable response to MeHg and omega-3 across the various sensitive outcomes

Questions and Answers

Comment: Supplements can vary widely. Supplements from higher trophic levels can exceed what you might get from most fish. With respect to fish farming, supplements can increase the omega-3 levels in fish but aquaculture is already using 90% of the available omega-3s already and increasing the levels would not leave much for any other omega-3 demands.

Q. Can you identify the most sensitive period during pregnancy for exposure to mercury and omega-3s?

A. The sensitivity periods have not been carefully looked at, but mercury might impair the development during the third to fourth month when neurons are forming cortical centers. We are able to look at the length of the hair to determine the temporal periods of mercury intake. Rochester wanted to look at temporal sensitivities in the Iraqi sea poisoning but I'm not sure where he is on that.

Cord blood from the Faroe Islands data was a good predictor in most of the end points. The end of second trimester and beginning of the third appears to be critical.

In general, the last trimester until 2 years of age is critical. EPA + DHA are elevated in the brain during this period.

Comnent: In a recent study published by EPA, individuals with the highest levels of mercury have the lowest levels of selenium to protect against the effects of mercury. Methylmercury is an irreversible inhibitor of enzymes. In gestation, we are at the ragged edge of nutrient deficiency. Also, vitamin D has a very important role in development too.

Q. Chronic exposure is different than poisoning in general, correct? How prevalent is true poisoning in the U.S.?

A. The subtle changes in intellectual function with low levels are just as important as poisoning When you decrease IQ by 5 points in children, there is a doubling of kids in special education and a reduction in super-bright kids. We are looking at the risk and benefits of nutrient and toxics. Oken's study shows that mercury moves the neurodevelopmental curve to the left, with more kids with learning problems. Omega-3s move the curve the other way.

How do we define mercury poisoning? There is poor surveillance because physicians tend not to think of mercury but are increasingly ordering screens for neurologic disorders. Since states have requirements to report the test, we can follow up with the physicians. The state health departments look into these tests, but you don't always get the results in time, and sometimes even if you do get the results in time, it doesn't always get into the literature. We need to work directly with the clinicians to find the cases. We need to decide what set of clinical tests should be run. We have a real problem capturing the data to represent all the exposure levels and use those data as a teaching tool to impress on the medical community.

There are clinically apparent outcomes out there and believe it or not, you can get mercury poisoning from sushi. The shift in IQ can change our society incredibly.

We now understand that the effects of mercury happen on a range of exposures through neurological, toxicological, and cardiovascular pathways.

There is also inorganic mercury to consider. For example, light bulb crushing workers have high levels and toxicity. Clinically, there is a broad spectrum, and here we need to specifically refer to methylmercury.

Q. *Can the panel speak to the fact that there may be more than one separate mechanism that creates the benefits and risk endpoints for mercury?*

A. There may be some fluxes in various organs that we haven't studied yet. Hair and blood may not be the only endpoints for different systems such as neurological, toxicological, and cardiovascular.

Anything like mercury that can potentially interfere with enzymatic processes needs to be considered at many levels. For example, sulfur amino acids are what give every enzyme its tertiary structure, and can be altered by mercury.

Omega-3s work on a lipid level so mercury and omega-3s are very different mechanistically and may explain why there are different counterbalancing effects and risk factors.

Q. *I have a lot of questions on amount of samples needed for an advisory, how to treat subsistence fishers, etc. There is a lot of resistance to discussing the risks and benefits of fish consumption. Can the panel offer any ideas of how to explain the benefits in press releases in a way that risk management folks can accept it when we tell people one meal a month or no consumption?*

A. If we don't think the public understands compromises, we're wrong. The Amazon region has some of the highest levels of mercury reported. The first advisory campaign was to eat more fish that don't eat other fish. It was a positive campaign to emphasize cultural input and at the same time, acknowledge the risk. After five years, we looked at mercury levels and fish consumption and health outputs, and found that people continued to eat just as many fish but inversed the proportion of piscivorous and nonpiscivorous fish. This was associated with a 40% decrease in mercury levels and improved motor function. Judy Sheeshka said that it's important to manage, but to work with the people. Analyze the nutritional and risk factors but don't be rigid about it. Look at it in context of risk-benefit and social value.

The high risk groups are young kids, so we need to deliver the education to kids in grade school. For others, you have to market it. Think about Larry King, Beckham, etc.

Consider a fish-specific approach. There are some fish that you may want to steer people towards and others which you may want to steer away from.

Q. *Reference doses are largely comprised from the Faroes Island studies. Implicitly, we are modeling from a population that is at the high end of mercury but reflects omega-3 levels of the U.S. population. Is this a possible motivation to move forward to achieve a "reference balance"?*

A. Reference doses are for methylmercury and not for fish consumption. We need to know all of the risks and benefits of fish consumption and factor those in. Many factors will determine how much methylmercury or omega-3s are in the fish, so we need to keep these things separate until we know more about the risks and benefits of fish consumption.

If you strip out the omega-3s in the Faroe experiment, you might get a different dose response. The reference doses might be lower. Now that we are correcting for benefit, you might see a different risk profile. It may be that we use reference doses as a back check.

Q. *Why do we have the same reference doses for children and adults?*

A. At the time of the reference dose determinate, there wasn't enough information to differentiate reference doses. Philosophically, we should have more reference doses.

Q. *In the Seychelles studies, levels of mercury in cord blood do not rise to the reference doses because there is a 1:1 molar ratio between mercury and selenium. In the Faroes study, however, they are eating much higher mercury to selenium ratios. Seychelles isn't having the same issues. In beluga whales, all of the mercury in the pituitary and brain was associated with selenium. Shouldn't selenium ratios affect reference doses?*

A. Just knowing that there is a binding between selenium and mercury is not enough to influence a quantitative reference doses. All of the endpoints in the neurodevelopmental, cardiovascular, and other systems need to be considered, as well as the effect of the bound complex.

Q. *What should be done in isolated regions where people are constrained to rely on government monies for food acquisitions and there is no availability of farmed foods? Are you going to identify a specific omega-3 level and how do you propose to get it into diets?*

A. Quebec tribes are similar in this way to the Amazon populations. We need to know where the real risks and real benefits are coming from. I don't think the only fish consumption benefits are from omega-3s, and there may be even more sorts of benefits from omega-3s. In taking a holistic approach of looking at sources and the pathways, you can come up with way to respect both health and environment.

We cannot eliminate all risk and have to more try to maximize the benefit. And if we shift food, we also shift risk.

Providing supplements could be cost effective.

Q. *Mercury is cheap to analyze and I am worried that there are other compounds that we should be looking at. Does the panel know of any new aims to investigate PCBs and dioxins?*

A. It is another level of analysis that we need to perform.

In Quebec, PCBs weren't coming from the fish but were more associated with neurodevelopmental effects than mercury. It needs more attention.

Q. *How far away are we from doing quantitative risk benefits for fish advisories? How long do we have to wait for the gaps to close? Should we keep waiting and just keep using risk?*

A. There are concrete omega-3 benefits that you can glean from the cardiovascular and neurodevelopmental data, but we need more data to refine the quantitative estimates. Omega-3s may be acting as a surrogate for other things in fish. We found that we're not that far from the national advice with the risk-benefit information. Donna's studies about leaner fish throws the benefits for a loop and may need to investigate that more, but cod and tuna are more concrete. We don't have omega-3 estimates for freshwater fish, but Connecticut will be using omega-3s for our marine advisories.

Public health departments need to act in the presence of uncertainty. If we cherry-pick our endpoints, we may be putting people at risk for other endpoints. Prudent advice is always the way I'd like to go.

Q. *Should we use the PCB data from Asian markets which were more restrictive than mercury in terms of advice? Do we have enough? How do you feel about its relative importance on public health outcomes?*

A. We need to look at reference doses for mercury and for PCBs and decide whether they are both exceeding and decide interactively. We need to think about the point of departure risk.

You have to consider all of the data available. Another aspect is that we accumulate PCBs over time. The length of time of spent breastfeeding will predict PCB levels until an individual is 20 years old. Should we also be looking at the level of PCBs coming from other areas?

Q. *The public needs a simple message but it has to take into account multiple contaminants and nutrients. Can we come up with something similar to "eat more real food – mostly plants"? Something which encourages diversification out of the basket?*

A. Congrats to the people developing the advisories in Washington State.

Q. *One of the major players is not here: FDA. We need to keep reminding ourselves that state advisories are incredibly important, but 80% of all fish consumed are commercial fish. We need to have joint meetings again.*

A. I almost feel like it is criminal to sell fish with over 1 ppm of methylmercury. People have the ability to poison themselves with a few commercial fish purchases and these should not be in the marketplace. This is a first cut of how FDA should be interacting with us.

FDA used to be 0.5. There are other ways we should be interacting with FDA.

Q. *If selenium is present at a high enough level in fish, would you still not expect to see the effects of mercury? Is it or is it not a 1:1 ratio?*

A. We don't have the whole selenium picture. I think it's the same for omega-3s. We need to find how to calculate the balance. There are definitely deleterious endpoints of selenium. We know that it causes a redistribution of selenium to the brain.

Q. *Would you suggest that states start to include analysis on EPA+DHA in sampling?*

A. Yes, but it tends to be measured in a different lab.

Composite Risk Benefit Curve Approach to Fish Consumption: Dispelling Some Myths

Michael Gochfeld, Department of Environmental and Occupational Medicine, UMDNJ-Robert Wood Johnson Medical School, Piscataway, NJ

Joanna Burger and Christian Jeitner, Division of Life Sciences, Rutgers University, and Environmental and Occupational Health Sciences Institute and Consortium for Risk Evaluation with Stakeholder Participation, Piscataway, NJ

Tina Goodwin, Department of Environmental and Occupational Medicine, UMDNJ-Robert Wood Johnson Medical School, Piscataway, NJ

Biosketch

Dr. Michael Gochfeld is an environmental toxicologist and occupational physician whose research and clinical work emphasizes heavy metals. He teaches the first-year medical school course in Epidemiology, Biostatistics and Prevention, lectures in Public Health courses on toxicology and risk assessment, and is the Director of the Occupational/Environmental Medicine residency at Robert Wood Johnson Medical School. He served as Director of Environmental and Occupational Health at the New Jersey Department of Health and later chaired New Jersey's Mercury Task Force. He has chaired international committees on cadmium and gender effects in toxicology. As a member of the multi-university Consortium for Risk Evaluation with Stakeholder Participation, Dr. Gochfeld advises the U.S. Department of Energy on the safe management of nuclear wastes. He collaborates with Dr. Joanna Burger on studying the distribution of metals in a variety of biota and the corresponding ecologic and human health consequences.

Abstract

In 2005, we published a model composite benefit-risk by dose curve for fish consumption and development, emphasizing mercury (Hg) (*NeuroToxicology 26*:511). Based on the scant data on fish consumption frequency that was available at the time, it appeared that most of the benefits for pregnancy and development accrued to those who ate fish about once a week (8–45 g/d), with little added benefit from more frequent fish consumption. Conversely, the threshold for risk, based on epidemiological studies, occurred at a higher level, allowing the composite curve to point to fish consumption rates that were overall beneficial while not downplaying the potential for toxicity. Adults consuming high-Hg fish daily manifest signs of mercury toxicity. Neither the benefit nor harm mechanisms are fully understood. Benefits probably accrue only in part from omega-3 fatty acids; selenium appears important as well, perhaps through direct protection against mercury. Other nutrients, other diet choices, or life styles associated with fish consumption may contribute to benefit, whereas polychlorinated biphenyls (PCBs) contribute to harm. The threshold for harm depends on criterion chosen (e.g., EPA RfD of 0.1 µg/kg/day) and fish species eaten. New data allow us to refine the curves and to take into account the variability in meal size (g/day) and mercury content (0.05 to > 1 ppm) of mercury. Data on fish consumption frequency, meal size, species, and source should still be gathered, but there need be no conflict between benefit and risk if people choose wisely and moderately.

Composite Risk Benefit Curve Approach to Fish Consumption: Dispelling some myths

Michael Gochfeld
Joanna Burger
CRESP & EOHSI
November 4, 2009

Public Health is Controversial

- Always has been
- John Snow vs prevailing miasma theory
- Public good vs individual autonomy
  - Quarantine vs freedom
  - Mandatory Vaccination (flu, thimerosal)
- Nutritional supplements
- Genetically modified organisms
- **Eat more or less or different fish**

Fish consumption Balancing risks & benefits

- Good things in fish
  - Protein
  - Low cholesterol
  - High PUFA (EPA and DHA)
  - Selenium
- Bad things in fish
  - MeHg (methylmercury)
  - PCB (polychlorinated biphenyls)
  - Other organics

Fish consumption Balancing risks & benefits

- Good things in fish
  - Protein
  - Low cholesterol
  - High PUFA (EPA and DHA)
  - Selenium
- Bad things in fish
  - MeHg (methylmercury)
  - PCB (polychlorinated biphenyls)
  - Other organics
- Eating fish as a surrogate for health conscious people
  - Healthy life styles
  - Avoiding red meat and twinkies
  - Exercise
  - Early prenatal care
  - Higher SES
  - Higher maternal education

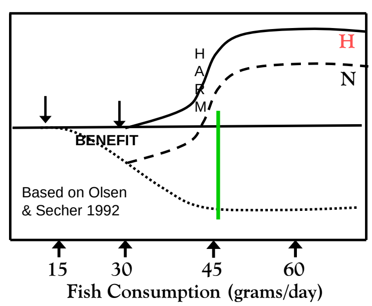
Benefit domains

- Adult cardiovascular
  - Blood pressure
  - Arrythimia
  - Non-fatal and fatal MI
- Fetal infant development
  - Including pregnancy outcomes
  - Developmental landmarks
  - IQ
- Adult cognitive (dementia, Alzheimer)
  - Is it an accident that several cultures consider fish "brain food"
  - Or is it that proximity to abundant fish sources was correlated with other demographic/SES benefits
  - Until 75 years ago the contaminants would have been negligible

COMPOSITE DOSE-RESPONSE CURVES

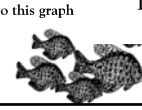
Gochfeld & Burger (2005) Neurotoxicology 26:511

IS THERE A "Sweet Spot" AT WHICH YOU GET ALL THE BENEFITS BUT NONE OF THE RISKS?



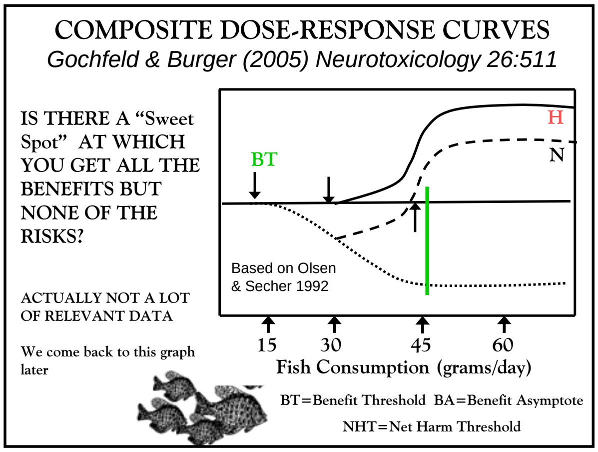
ACTUALLY NOT A LOT OF RELEVANT DATA

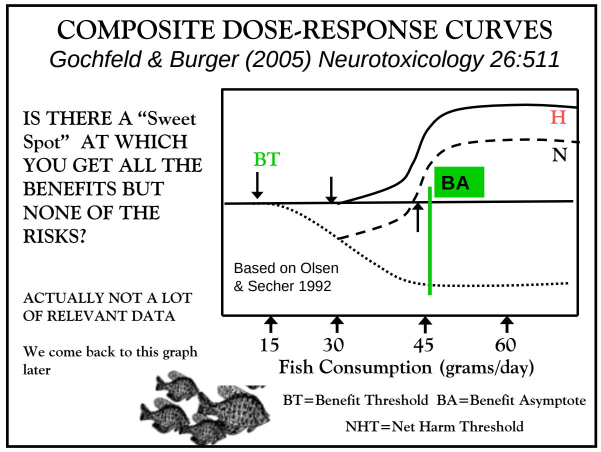
We come back to this graph later

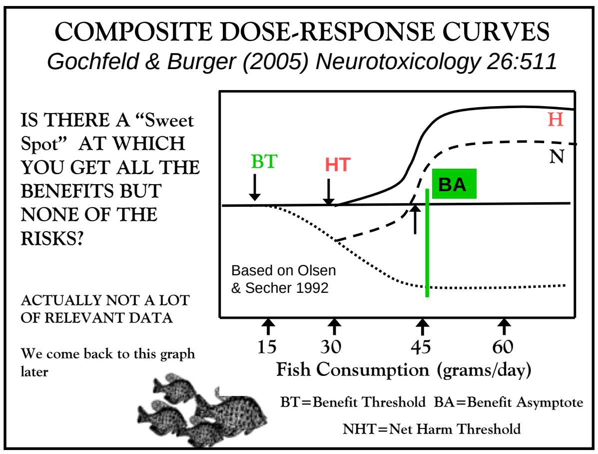


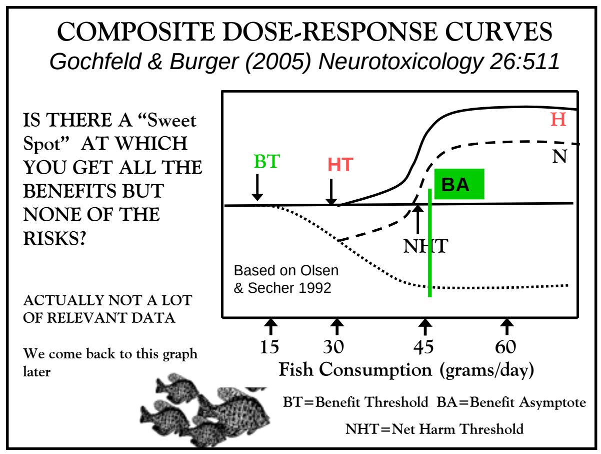
BT=Benefit Threshold BA=Benefit Asymptote

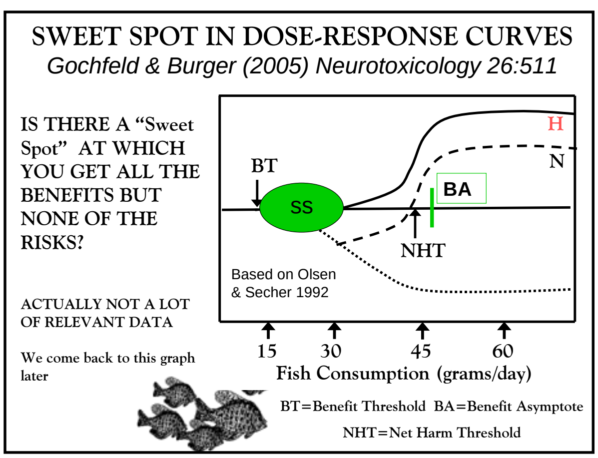
NHT=Net Harm Threshold











Do we know enough already?

- Eat more fish low in bad things and high in good things
- Eat less fish high in bad things and low in good things
- Don't ignore innumerable other important life styles and cultural issues
- Where possible provide location specific, species specific and culture specific information
- So intelligent people can make wise decisions

Do we know enough already?

- Eat more fish low in bad things and high in good things
- Eat less fish high in bad things and low in good things

But as an academic

- I'm always going to say
- "more research is needed"
- Every discovery raises additional questions
- And with individualized medicine on the horizon there are domains of genomics, proteomics etc which certainly contribute to the benefits and harms from fish (or smoking or twinkies)
- Maybe we'll there will be a blood test to see if YOU need more or less fish than your neighbor

Common currency

- Increased risk per µg/day of MeHg
- Decreased risk per mg/day of PUFA
- Decreased risk per g/day of fish or servings per week

- UNCOMMON CURRENCY
  - Fish consumption metric
  - PUFA intake metric
  - Endpoints assessed

Common currency

- Increased risk per µg/day of MeHg
- Decreased risk per mg/day of PUFA
- Decreased risk per g/day of fish or servings per week

- UNCOMMON CURRENCY
  - Fish consumption metric
    - Semi-quantitative questionnaires, often historic recall
    - Grouped results in different ways
    - Or absent completely
  - PUFA intake metric
    - Sometimes measured in blood
    - Uncertain intake multiplied by variable concentration data
  - Endpoints assessed

IDEALIZED COMPOSITE CURVES

IS THERE A "Sweet Spot" AT WHICH YOU GET ALL THE BENEFITS BUT NONE OF THE RISKS?

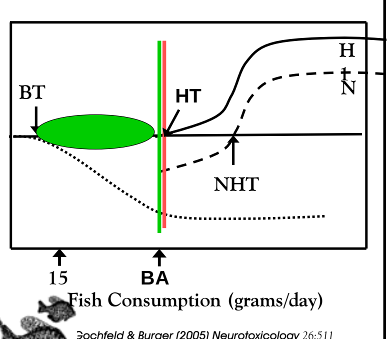
Here the Harm Threshold LIES ABOVE the Benefit Asymptote

H=Harm N=Net

BT=Benefit Threshold

NHT=Net Harm Threshold

BA=Benefit asym



Gochfeld & Burger (2005) Neurotoxicology 26:511

What Are the benefits due to?

- Good things in fish
  - High PUFA (EPA and DHA)
    - Which is what the literature seems emphasize
  - Selenium
  - Protein
  - Low cholesterol
  - All of the above

- Or to correlates of fish intake
  - Avoidance of red meat and twinkies
  - Other lifestyle correlates (particularly among those who eat fish frequently specifically for health reasons

If PUFA benefits are so clear, why not just take supplements?

- It's a lot cheaper than fish
- $1.50 to $10 PER MONTH
- BUT
- Other supplement-only studies have not been reassuring
  - CARET* CHEMOPREVENTIVE STUDY FOR LUNG CANCER
  - found NEGATIVE impact of beta-carotene and vitamin A vs controls on lung cancer
- Are there downsides to MEGA-supplementation
  - lactation supplement and ↑BP in children
  - Increased risk of diabetes mellitus (Sept 2009)
- *beta-Carotene and Retinol Efficacy Study*

EPA Oral RfD

- **_I.A. Reference Dose for Chronic Oral Exposure (RfD)**
- Substance Name — Methylmercury (MeHg)
  CASRN — 22967-92-6
  Last Revised — 07/27/2001

In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

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The National Flower of Risk Assessment -----THE HEDGE

MeHg RfD is based on

- **Critical Effect** Developmental neuropsychological impairment
- Human epidemiological studies
  - Grandjean et al., 1997;
  - Budtz-Jørgensen et al., 1999a)

Uncertainty for MeHg RfD

- Used benchmark dose
- Dose that would double the number of children below the 5th percentile
- Variation in toxicokinetics from ingested dose to blood level 3x
- Variation in toxicodynamics 3x
- Therefore overall UF 3 x 3 =10
- Variation in cord blood was ignored
  - Cord assumed = maternal but in reality
  - Cord about 1.7 to 2x higher than maternal

Myth 1

- The RfD has a 10 fold margin of safety
- So we don't really have to worry about
  – 0.1 µg/kg/day
- This is based on protecting sensitive individuals.
- So there will be some individuals, who may be susceptible AT the RfD
- And some possibly below
- And if **they** also happen to eat a lot of fish…..

Myth 2

From various historic default assumptions

- "people don't eat enough fish to get sick"
- "Oh that's just the 99th percentile"
- But that small percentage above the 99% translates into a large number of people
- 1 % of 300,000,000 is 3 million
- In public health we worry about some conditions with lower occurrence rates

So part of the controversy is an illusion based on Myth 2

- Some people believe that you can't get mercury poisoning at the levels of fish consumption reported at these meetings.
- They point to Iraq and Minamata as the totem for MeHg poisoning
- With hair levels above 50 ppm

MW 57 yo guitarist

- Health conscious. No red meat for 15 year
- Ate fish almost daily
- 6-8 ounces per meal
- Mainly Swordfish and Tuna steaks
- Estimated fish intake 1140g/wk = 163 g/day
- Estimated MeHg intake about 850 µg/week
- For a 60 kg women = **2 µg/kg/day**
- Equivalent to a hair level about 20 µg/g (ppm)
- Basal hair samples was 13.3 ppm
- She noted tingling in face and fingers, tremor
- Faulty coordination and weakness in strumming guitar
- Hair falling out, trouble sleeping, irritable
- Neuropsych testing at the time of her visit 6 months after stopping fish
- Performed badly on grooved peg test and other neurobehavioral tests
- At 1 year, hair level was 6 ppm and strumming returned

More cases of MeHg poisoning

- Ed Groth published a report "Over the Limit"
- Lists 24 cases of very high fish consumption (including MW)
  – Some with typical MeHg symptoms
  – Some with atypical presentation
  – Some with still uncertain diagnosis
- http://mercurypolicy.org/wp-content/uploads/2008/12/mppoverthelimit.pdf
- Or google Groth "over the limit" Mercury Policy Project

Rollercoaster

How much of the benefit comes from PUFAs

- And not all the benefits have the same trajectory

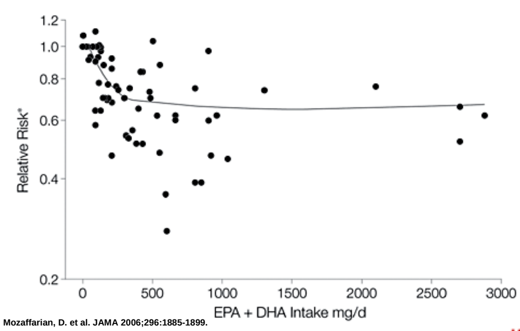
Protective effect for "Heart" is well established

Hu et al (2002) Nurses Health Study n=84,688

	<1/mo	1-3/mo	1/wk	2/wk	≥5 wk	Trend
Total CHD adj	1	.79 [.64-.97]	.71 [.51-.87]	.69 [.55-.88]	.66 [.50-.89]	P<.001
Non-fatal MI	1	.81 [.57-.15]	.66 [.47-.92]	.73 [.49-1.08]	.55 [.33-.90]	P=.01
	ESTIMATED PUFA INTAKE BY QUINTILES					
% of energy	3%	5%	8%	14%	24%	
Total CHD	1	.93	.78	.68	.67	P<.001

Mozaffarian & Rimm 2006

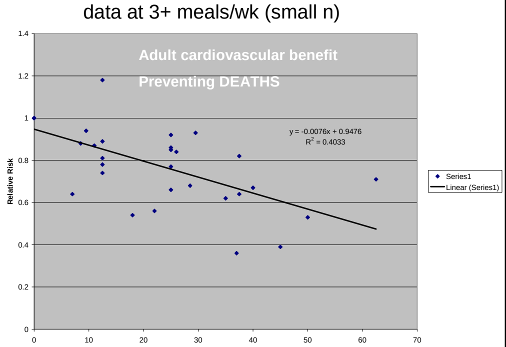
Relationship Between Intake of Fish or Fish Oil and Relative Risks of CHD Death in Prospective Cohort Studies and Randomized Clinical Trials Fig 2 in Mozaffarian & Rimm 2006)



Mozaffarian, D. et al. JAMA 2006;296:1885-1899.

Tina Goodwin analysis

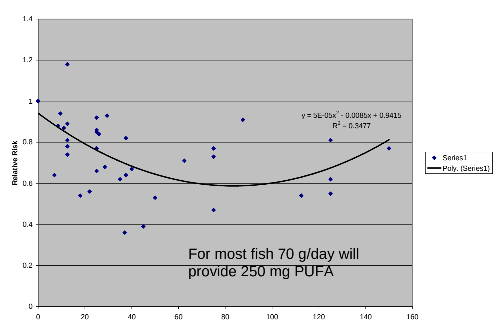
One of the problems is that many papers censor intake data at 3+ meals/wk (small n)



Analysis of 10 studies with fish-consumption estimates

Goodwin & Gochfeld (MS)

Best site obtained with quadratic regression r^2=.35



Fish Intake Studies & CHD

		Fish intake	Highest category	Benefit threshold (midpoint)	Benefit asymptote
Hu et al 2002	84,688 nurses	5 categories	≥5/week (>120 g/day)	1/wk = 25 g/d HR=.66	none
Ascherio et al. 1995	44,895 men	6 categories	≥ 6/week	12 g/day HR=.74	Unclear ~110g/d
Albert et al. 1998	20,551 men Physicians	5 categories	≥ 5/week (>120 g/day)	37.5 g/day HR=.82	2-5x/wk=85g/d HR=.91
Krumhout et al 1985	852 men Zutphen	5 categories	≥ 45 g/day	7 g/day HR=.64	c45 g/day
Yuan et al 2001	18,244 men China	5 categories	≥200 g/day	18 g/day Not significant	unclear, Possibly 25 g/d
Daviglus et al 1997	1822 men Western Elect.	4 categories	≥ 35 g/day	8.5 g/day	None
Mozaffarian et al 2003	3910 Harvard	5 categories	≥ 3/week (>73 g/day)	11 g/day HR=.78	None
Oomen et al 2000	1097 men	4 categories	≥40 g/day	9.5 g/day HR=.94	none

(Bjerregaard et al 2009) Denmark Prevention of Acute Coronary Syndrome

Lean vs Fatty Fish 57,053 men & women (Age=50 to 64 years).

	Men	Women	
Fatty Fish	**g/d >27 vs ≤6** **OR=.67** **33% decrease** CI= [.53-.85]	**g/d >23 vs ≤ 5g** **OR=.78** **22% decrease** CI=[.51-1.19]	Herring Mackerel Salmon Trout Char Caviar
Lean Fish	**g/d >39 vs ≤14g** **OR=1.02** **NO DECREASE** CI=[.81-1.28]	**g/d >33 vs ≤ 12** **OR=.78** **22% decrease** CI=[.51-1.20]	Plaice Cod Shrimp Tuna

Oomen et al 2000 Fish intake and heart disease mortality (Europe)(n=2638)

- Lean fish consumption conferred no benefit in any country.
- Fatty fish compared with non-fatty-fish consumption was associated with lower CHD mortality;
- Pooled Relative Risk 0.66 [0.49-0.90]
- Am J Epidemiol 2000 51:999-1006

Streppel et al. 2008
Netherlands
Zutphen 40 year followup

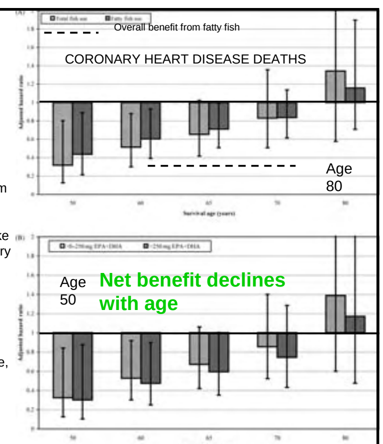


Figure 1 Hazard ratios, with 95% confidence intervals, for long-term fish consumption (*A*) and eicosapentaenoic acid+docosahexaenoic acid intake from fish (*B*) in relation to coronary heart disease death at different ages and adjusted for energy intake, alcohol intake, wine use, fruit and vegetable consumption, saturated fat, *trans* unsaturated fatty acid, *cis* monounsaturated and *cis* polyunsaturated fat intake, serum cholesterol lowering diet, smoking, body mass index, prevalence of diabetes mellitus, systolic blood pressure, and socioeconomic status.

Mozaffarian found negative effect of fried fish

For men with heart disease

Those who ate baked/broiled fish mortality decreased with intake (up to a point)

Those who ate primarily fried fish mortality increased with intake.

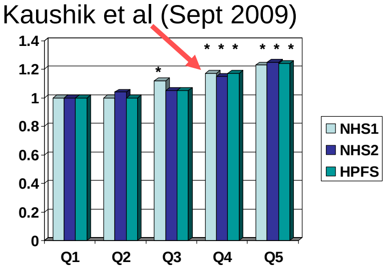
Long-chain omega-3 fatty acids, fish intake, and the risk of type 2 diabetes mellitus

Kaushik et al (Sept 2009)

Multivariate adjusted Relative Risk by Quintile of LCPUFA intake estimated from diet (mainly fish frequenc)

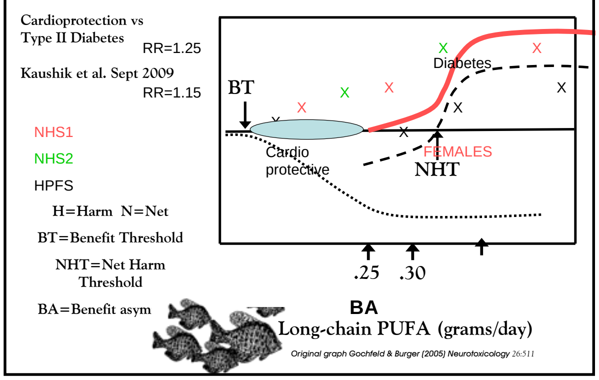
Median daily intakes

Q1 60 – 60 – 90 mg
Q2 120 – 100 – 180 mg
Q3 180 – 250 – 280 mg
Q4 270 – 320 – 390 mg
Q5 490 – 360 – 620 mg

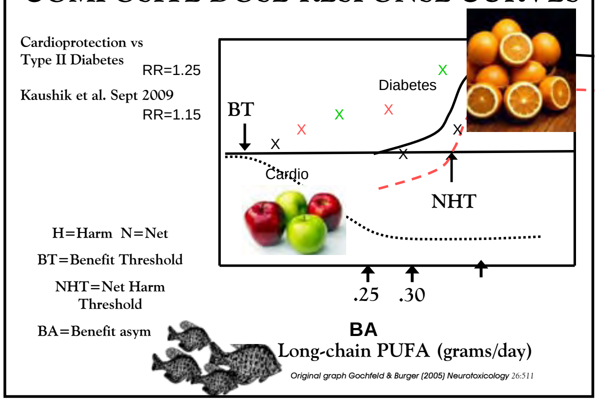


NHS1=Nurses Health Study 1976 =121,700 female RNs
NHS2=Nurses Health Study II 1989 = 116,609 female RNs
HPFS=Health Professionals Study 1986 = 51,529 male health professionals

COMPOSITE CURVES: NURSES



COMPOSITE DOSE-RESPONSE CURVES



Guallar et al 2002

MERCURY MUTES CARDIOPROTECTIVE EFFECTS

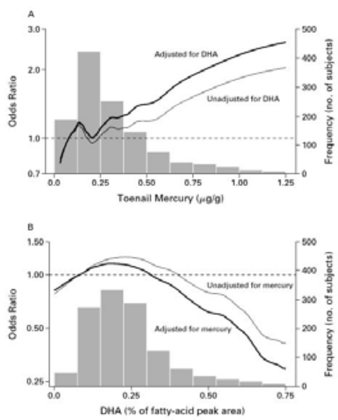


Figure 1. Nonparametric Estimates of the Risk of Myocardial Infarction According to the Levels of Mercury in the Toenails (Panel A) and of Docosahexaenoic Acid (DHA) in Adipose Tissue (Panel B).

Cohen, Bellinger & Shaywitz (2005) reviewed three prospective studies

- Faroes, Seychelles, New Zealand
- Faroes (7 yo study-Grandjean et al 1997)
  - 10x increase in MeHg delayed development by 5-8 months.
  - Some have accused Philippe Grandjean of over-analyzing
- Seychelles
  - Some have accused Philip Davidson of under-analyzing
- Cumulative estimate from Harvard analysis
  - 1 ug/g increase in maternal hair mercury
  - Loss of 0.7 [0-1.5] IQ points

Length of Gestation RCCT

- Olsen et al (1992) Denmark n=
  - Fish Oil 2.7 g/day vs olive oil and no oil
  - From week 30
  - Fish Oil → 4 days longer gestation & 107 g heavier
  - Effect greater in women with lower fish intake
- Smuts et al. (2003) US n=291
  - DHA from eggs (normal egg 33mg or high-DHA egg 133 mg) from 30 wks to delivery
  - 133mg →6 days longer (P=.009). BW increased 83 g (NS)

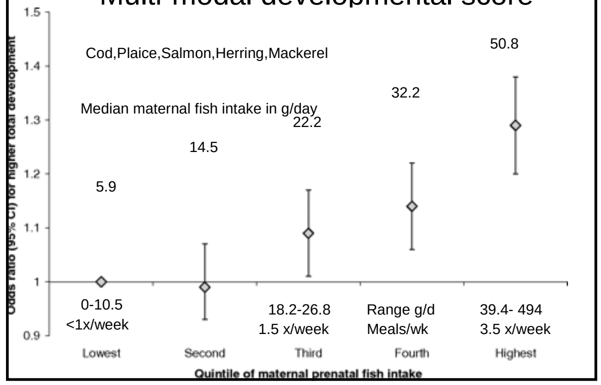
Dunstan randomized trial

- 33 mothers received DHA(2.2g) & EPA (1.1g) during pregnancy
- 39 mothers received olive oil
- Evaluation at 30 months
  - Griffiths Mental Development Scales)
  - receptive language (Peabody Picture Vocabulary Test) and
  - behaviour (Child Behaviour Checklist).
- Eye-hand coordination improved
  - 114 vs 108 (P=0.012)
- Potential confounders
  - Many non-significant development scales
  - Possible harmful effects of olive oil
- *Dunstan et al. 2008*

PUFA Supplement Studies

Dunstan et al 2008 Australia	Pre-natal supplement	N=33 Fish Oil N=39 Olive Oil	DHA 2.2g/d EPA 1.1g/d	2.5 yrs	Eye-hand coordination
SanGiovanni et al 2000	Meta-analysis of DHA-formula			2 months 4 months	Visual acuity Improved Less difference
Asserhoj et al. 2009	Danish children with PUFA during lactation	Total N=98 FO=1.5g/d v Olive Oil		7 yrs	PUFA led to higher BP andlower physical activity

Oken etal 2008b 25,446 Danish Children Multi-modal developmental score



Oken et al. 2005 Boston Project Viva n=135 Change in Visual Recognition Memory % novelty preference [95%CI]

Model	Effect/weekly serving	Effect / 1 ppm in hair
Fish intake only	+2.1	
Hair Hg only		-4.3
Fish + Hg	+ 3.9	-8.1
The multivariate model produced stronger and more significant independent effects than the individual regressions. No interaction term presented		

About 1 servings/week → 0.17 ppmin hair in this study isua

Birch et al. (2000) fed babies from day 5 to wk 17 formula supplemented with DHA (0.35%)N=17 or DHA+AA.N=19 Controls n=20 (Texas)

	Control diet n=20	+ DHA (n=17)	+DHA+AA (n=19)
MDI Mental Development Index	-1.7	2.4	5.6 (p<.05)
PDI Psychomotor Development Index	-1.4	-.06	1.7 (P=.13)
BRS Behavioral Rating Scale	7.3	6.4	8.1 (p=.3)

MDI at 18 months correlated with Plasma DHA at 4 months r=.32 p<.016

No correlation with EPA, AA LA, LNA

Cordier et al. "Neurodevelopmental investigations among methylmercury-exposed children in French Guiana Env. Res 89A:1-11 (2002)

8 year old tests	Awala Low Hg	Maroni High Hg		
Hair Hg				
Copying test	10.9 ± 0.2	8.9 ± 0.3	P<.001	N=103
Digit span recall forward	5.2 ± 0.1	4.8 ± 0.2	P=.06	N=103
Digit span recall back	2.2 ± 01	1.5 ± 0.2	P=.006	N=103
Finger tapping	47.2 ± 1.3	47.7 ± 1.3	P=.77	N=71

Is salmon the answer?

- **Organic pollutants are NOT just in farmed fish**
- **Bad farming is profitable and harmful to environment**
  - **Escapes and genetic pollution**
  - **Sea lice and diseases**
  - **Habitat destruction**
  - **Some places still use fish meal**
- **Wild fishing would not be a problem IF? IF? IF?**
  - **the catches are kept within the bounds of production.**
  - **But wild Atlantics have collapsed, and**
  - **Pacific salmon have declined south of Canada,**
    - **are collapsing in Canada, and**
    - **remain strong only in Alaska.**
    - **THOSE OF YOU FROM THE NORTHWEST PLEASE COMMENT?**
    - courtesy Carl Safina BLUE OCEAN INSTITUTE cellphone and mobile device users at fishphone.org. info@blueocean.org
    - .

Data Needs

- Fish consumption
  - Type (species), frequency;amount
- Species & location specific fish data
  - Contaminants (by size & availability)
  - Beneficial nutrients (by size & availability

PPM of MeHg (ug/g)		MONTHLY 7.5	EPA	WEEKLY 32	12 oz/wk	2X/WEEK	DAILY	TRIBE 549
		MICROGRAMS Mercury/DAY FOR 70 KG-ADULT						
0.05	Salmon	0.005	0.013	0.023	0.035	0.046	0.162	0.391
0.1	Lite Tuna	0.011	0.025	0.046	0.070	0.093	0.324	0.783
0.2		0.022	0.051	0.093	0.139	0.185	0.648	1.566
0.3		0.032	0.076	0.139	0.209	0.278	0.972	2.348
0.4	Canned Tuna	0.043	0.102	0.185	0.278	0.370	1.296	3.131
0.5		0.054	0.127	0.231	0.348	0.463	1.620	3.914
0.6		0.065	0.153	0.278	0.417	0.555	1.944	4.697
0.7		0.076	0.178	0.324	0.487	0.648	2.268	5.479
0.8		0.086	0.203	0.370	0.557	0.741	2.592	6.262
0.9		0.097	0.229	0.417	0.626	0.833	2.916	7.045
1		0.108	0.254	0.463	0.696	0.926	3.240	7.828
1.2	High Sushi tuna	0.130	0.305	0.555	0.835	1.111	3.888	9.393
1.4		0.151	0.356	0.648	0.974	1.296	4.536	10.959
2	Swordfish	0.216	0.509	0.926	1.391	1.851	6.480	15.656
4	Shark	0.432	1.017	1.851	2.783	3.703	12.960	31.311

Compute relative benefit/harm
How much fish do you need to reach the 250 mg/day benefit level

Fish	PUFA g/100 g	MeHg µg/g	Grams/wk needed to supply 250 mg/d	Ug/Hg in that amount of fish	HQ for RfD of 49ug/wk (.1)		
	variability						
Salmon	1.59	.035	110	3.9	0.1		
Mackerel	1.79	.081	97.8	7.9	0.2		
Sardines	0.98	0.10	179	17.9	0.4		
Seabass	0.49	0.13	357	48.2	1.0		
Cod	0.24	0.12	729	88.2	1.8		
Tuna (ave) optimistic	0.7 1.2	0.4 0.4	257 146	103 58	2.1 1.2		
Swordfish	0.58	0.95	302	286	5.8		
Pike	0.14	0.31	1250	387	7.9		
Shark	0.22	1.33	795	1056	21		

COMPOSITE DOSE-RESPONSE CURVES

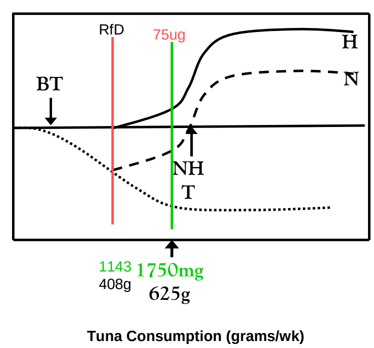
IS THERE A POINT AT WHICH YOU GET ALL THE BENEFITS BUT NONE OF THE RISKS?

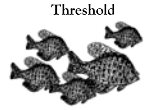
ACTUALLY NOT A LOT OF RELEVANT DATA

We come back to this graph later

BT=Benefit Threshold

NHT=Net Harm Threshold





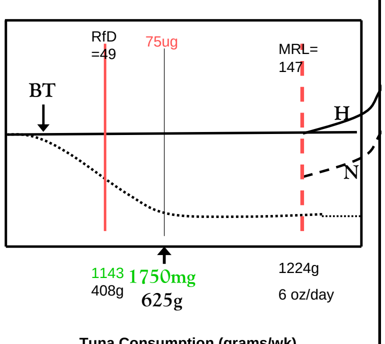
Gochfeld & Burger (2005) Neurotoxicology 26:511

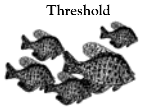
COMPOSITE DOSE-RESPONSE CURVES

USE ATSDR MRL instead of EPA RFD

BT=Benefit Threshold

NHT=Net Harm Threshold





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COMPOSITE CURVE FOR SALMON

Salmon gives you better numbers

ACTUALLY NOT A LOT OF RELEVANT DATA

We come back to this graph later

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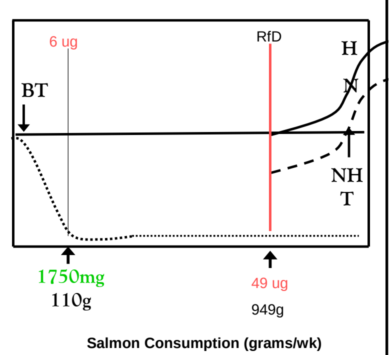
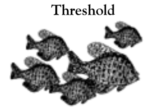




Gochfeld & Burger (2005) Neurotoxicology 26:511

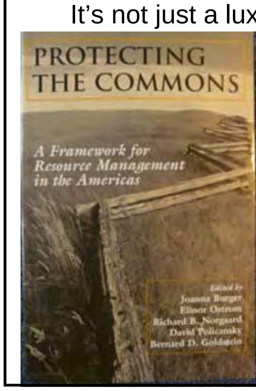
Ignoring Dose Rate or Time course of exposure

- FDA guidance: If you exceed 12 ounces in one week just cut back the next week.
- Is it OK to exceed advice one week if you compensate the next?
- Is it OK to take 7 pills on Saturday if you are supposed to take one-a-day.
- Are peak exposures problematic during critical periods of development

Just as we worry about climate

- We need to worry about fisheries
- Too many people wanting too much fish
  - The commercial fish that most of us eat
  - Come at a cost
    - Impact of fish farms and commercial fishers on coastal habitats and subsistence fishers
  - Global population predicted to "level off" at 9.5 billion by 2050

Ecologic Impact on fish stocks: It's not just a luxury for conservationists



- Global carrying capacity for biota
- Water carrying capacity for fish
- Competitive harvesting of fish
  - Non-food uses of fish
  - Non-efficient uses of fish energy/protein
- Fishing down the food chain
- By-catch
- Farming: bad practices more profitable
- Conflicts of interest in fishery management
  - Overfishing is widespread and growing
  - Despite better data and data processing
- **"Sustainability" is an oxymoron**
- **Protecting the Global Commons:**
  - **need for a comprehensive view**

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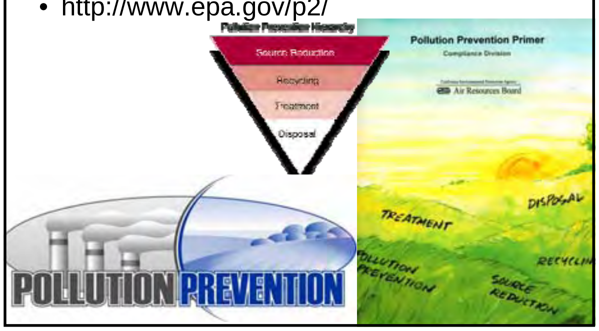
Let's not lose site of Pollution Prevention

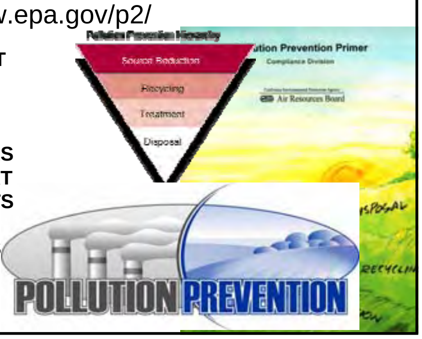
- http://www.epa.gov/p2/



Let's not lose site of Pollution Prevention

- http://www.epa.gov/p2/

LETS BE SMART ENOUGH TO RESTORE THE ENVIRONMENT TO WHAT IT WAS FOR OUR GREAT GRANDPARENTS WHO BELIEVED THAT FISH WAS A BRAIN FOOD



Recent Advances in Our Knowledge of Mercury and Selenium on Human Health

Mélanie Lemire and Donna Mergler, University of Quebec at Montreal

Biosketch

Ms. Mélanie Lemire is completing her doctorate in environmental sciences at the University of Quebec in Montreal. Her research program in environmental epidemiology was carried out within the interdisciplinary CARUSO Project in the Lower Tapajós Region of the Brazilian Amazon. The overall project sought to identify factors that affect mercury sources, transmission in the environment, and absorption and effects in humans by using an ecosystem approach to human health. Her particular research focuses on the sources and effects of selenium, an essential element and important anti-oxidant. Ms. Lemire has presented her work at national and international meetings, and she is the Quebec-Atlantique node coordinator of CoPEH-Canada, a Canadian Community of Practice in Ecosystem Approaches to Health. She has been involved in creating a dynamic collaborative network of researchers, organizing Scientific Cafés, and developing intensive summer coursework on Ecohealth. She is an active student member of the Center for Interdisciplinary Research on Biology, Health, Environment and Society (CINBIOSE), a Pan American Health Organization (PAHO)/WHO collaborating center for the prevention of work and environment-related illnesses. She has received scholarships from several institutions, including the Natural Sciences and Engineering Council of Canada, the Canadian International Development Research Centre, the Canadian International Development Agency, and the Association of Colleges and Universities of Canada.

Abstract

Contaminated fish poses a difficult challenge throughout the world. On one hand, fish is a very nutritious food source; on the other hand, it can accumulate many toxic substances, including mercury (Hg). Selenium (Se) is an essential nutrient and a well-known antioxidant. Fish is generally an important source of Se, and several studies have mentioned that HgSe covalent binding in fish would reduce Hg bioavailability and related toxicity in humans. Furthermore, experimental studies suggest that Se intake can interact with Hg to protect against Hg toxicity and Hg-mediated oxidative stress, although the underlying mechanisms remain unclear. However, epidemiological data from human studies is inconsistent.

Several studies have shown no effects of Se on Hg toxicity. In the Faroe Islands and the Arctic, where Se status is high and almost exclusively from marine diet, epidemiological studies showed no relation between in utero or current Se status and neurobehavioral performance in neonates and children. In a study of adult freshwater-fish eaters in Quebec, Se status was in the normal range. No relation was observed with fish consumption, and there was no association with neurobehavioral outcomes.

Amazonian riverside communities have the highest-reported Hg exposure in the world today. In the Lower Tapajós Region, biomarkers of Se status range from normal to very high. Brazil nuts constitute the most important source of Se (approximately 10 times more than fish); other foods, including some local freshwater fish species, eggs, meat, chicken, and game meat, also contribute to Se status. This diet represents a mixture of organic Se species. Despite Se blood concentrations above those considered toxic, the results of our studies show that there are no signs and symptoms of Se toxicity. Furthermore, plasma Se concentrations were associated with beneficial outcomes: lower prevalence of age-related cataracts and improved performance on tests of motor function.

These epidemiologic studies suggest that the effects of Se with regard to Hg toxicity is complex, and many factors may explain inter-study differences such as Se sources, Se species, and biomarkers of Se

status, as well as the level of Hg exposure. For example, in populations highly exposed to Hg, adequate—or even elevated—Se intake may be important to offset toxic effects of Hg-mediated oxidative stress and other adverse consequences of Hg toxicity and maintain optimal Se antioxidant enzymes.

RECENT ADVANCES IN OUR KNOWLEDGE OF MERCURY AND SELENIUM ON HEALTH

Lemire, M. and Mergler, D.

2009 National Forum on Contaminants in Fish
Portland, Oregon
November 2-5, 2009

What is selenium ?

An essential trace element and a well known antioxidant

- Component of 25 selenoproteins in human:
  - Glutatione peroxidase (GPx)
  - Thioredoxin reductase
  - Selenoprotein P (SelP)
- Selenoenzymes are involved in:
  - Antioxidant and redox reactions
  - Thyroid hormone metabolism
  - Se transport

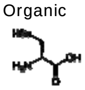
What are the sources of selenium?

Se in food and others

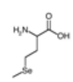
- Fish: Marine > Freshwater ML2
- Marine mammal and seafood
- Some plant species: Brazil nuts
- Organs, beef, chicken, eggs
- Occupation
- Drinking water
- Supplements

Se compounds

- Organic



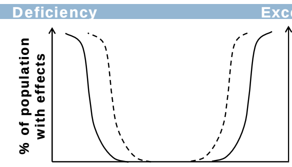
SeCys



SeMet

- Inorganic
- Inorganic and organic ?

Selenium: Deficiency versus Excess



(Ins. of Medicine, 2000) (U.S. EPA, 2002)

Blood Se levels

- Cancer
- Thyroid hormones perturbations
- Cardiovascular diseases
- Reproduction disorders

- Alterations in keratin structure
- Gastrointestinal problems
- Incidence of type 2 diabetes
- Possible neurological disorders
- Higher prevalence of cataracts

Se effects on Hg toxicity

In fish:

- Hg-Se covalent binding in fish would reduce Hg bioavailability and related-toxicity for human

Experimental studies :

- Proposed mechanisms:
  - Selenoproteins can offset Hg-mediated oxidative stress
  - Se-Hg complex can reduce Hg bioavailability to target organs
  - Se may be involved in demethylation of MeHg
  - Se intake restores selenoproteins inactivated by Hg

Human studies:

- Inconsistent epidemiological data

Human studies

Faroe Islands, Denmark
Nunavik, Canada
Amazon, Brazil

Faroe Islands – prenatal exposure

Steuerwald et al. (2000) | **Choi et al. (2008)**

- N = 182
- Cord blood Se: 103 µg/L (93 – 112 µg/L)
- Cord blood Hg: 20 µg/L (12 – 40 µg/L)

- Hg : **decrease** in the neurologic optimality score in neonates of 2 weeks of age
- Hg : **decrease** in neurobehavioral performances at 7 years of age

No effect of Se on Hg neurodevelopmental toxicity

Nunavik – Inuit preschool children

Després et al. (2005) | **Saint-Amour et al. (2006)**

- N = 110
- Blood Se: 329 µg/L (157 – 2566 µg/L)
- Blood Hg: 6 µg/L (0.2 – 38 µgL)

- Hg = **increased** hand tremor
- No effect of Se on motor functions

- Hg = **shorter** visual evoked potential latency (N75 and P100 at 95% and 30% contrast)
- Se = **longer** visual evoked potential latency (N75 and P100 at 95% and 30% contrast)

- No significant Se*Hg interactions

Nunavik - Inuit adults

Valera et al (2009)

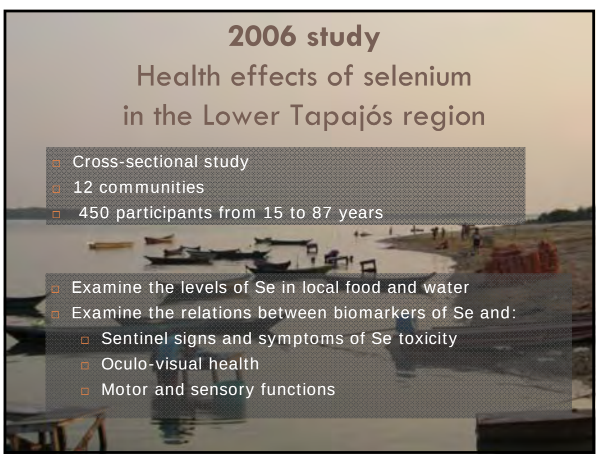
- N = 132
- B-Se: 292 µg/L (118 - 3553 µg/L)
- B-Hg: 10 µg/L (0.2 - 241 µg/L)

Selenium and blood pressure (BP):

- Taking into account co-variables (B-Hg and n-3 fatty acids), B-Se is negatively associated to:
  - systemic BP: β = -2.8, P=0.03
  - diastolic BP: β = -1.7, P=0.07

- **No interaction**: Mercury and n-3 fatty acids did not show a modifier effect on the relationship between selenium and BP parameters

Brazilian Amazon



2006 study

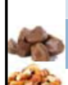
Health effects of selenium in the Lower Tapajós region

- Cross-sectional study
- 12 communities
- 450 participants from 15 to 87 years

- Examine the levels of Se in local food and water
- Examine the relations between biomarkers of Se and:
  - Sentinel signs and symptoms of Se toxicity
  - Oculo-visual health
  - Motor and sensory functions

Levels of selenium in local foods

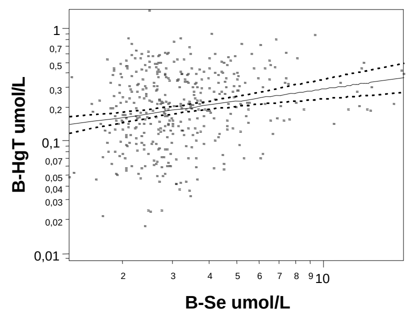
		Median	Range
Low	Drinking water (µg/L)	0.05	0.05 – 1.4
	Fruits and vegetables (µg/g)	< 0.1	
Medium	Kale, sweet potato, rice and *pupunha* (µg/g)	0.1	0.01 – 0.6
High	Chicken, game meat, eggs, freshwater fish, meat (µg/g)	0.5	0.05 – 1.4
Very high	Brazil nut (µg/g) *Bertholletia excelsa*	13.9	0.4 – 158.4



Biomarkers of Se and Hg

- Blood Se (B-Se): 228 µg/L (103 – 1500 µg/L)
- Plasma Se (P-Se): 135 µg/L (54 – 913 µg/L)
  - Highly related to Brazil nut consumption
  - Not related to fish consumption
- Blood Hg (B-Hg): 42.5 µg/L (1.7 – 288.9 µg/L)
  - Highly related to fish consumption
- Although B-Se and P-Se surpassed concentrations considered toxic:
  - **no signs or symptoms of Se toxicity were associated with these biomarkers of Se status**

Se – Hg ratio



Mean Hg/Se ratio :
0.08 ± 0.07
(0.002 – 0.58)

B-Hg µmol/L = 0.22 + 0.01*B-Se µmol/L (P = 0.005)

Motor performance

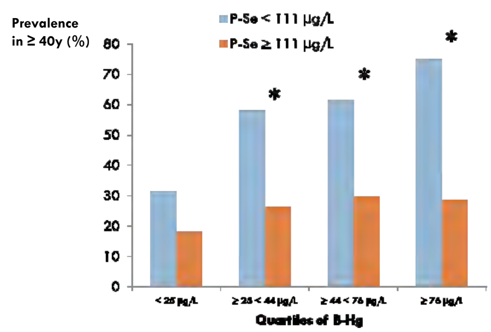
Multiple regression models (including B-Hg and co-variables)

Outcome	B-Se	P-Se	H-Se	U-Se
Motor coordination	↑ *	↑ **	ns	ns
Manual dexterity	ns	↑ *	ns	↑ †
Fine motor movement	↑ *	↑ *	ns	ns
Grip strength	↑ †	↑ *	ns	ns

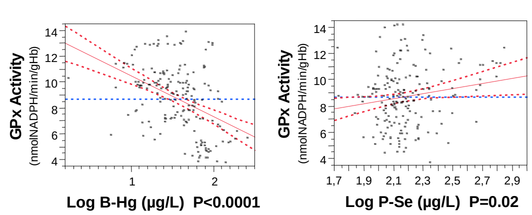
† : p < 0.10 * : p < 0.05 ** : p < 0.01 *** : p < 0.0001

No significant Se*Hg interactions

Ocular health: 32.6% age-related cataracts in adults of 40y and more



GPx activity in erythrocytes



(Grotto et al, in press)

- N = 183
- Not related to B-Se levels
- **No P-Se * B-Hg interaction on GPx activity**

Conclusions (I)

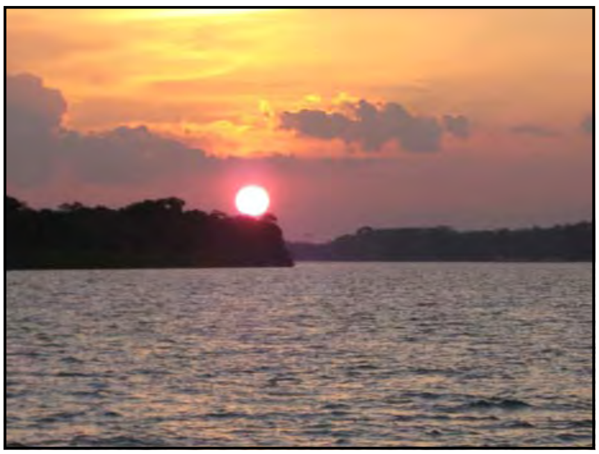
- **High Se status:** marine fish/mammals and Brazil nut eating populations
- **None of the classic toxic effects of selenium reported in the literature was observed in the Amazon:**
  - NOAEL : based on China' studies reporting Se chronic toxicity where Se exposure is both inorganic Se (mineral coal) and organic Se (food)
  - Organic forms of Se in Amazonian diet
- **P-Se = biomarker best related to health outcomes**
  - In erythrocytes proteins, there is an important non-specific incorporation of SeMet, which is probably less bioavailable for selenoprotein synthesis
- **No statistical interactions between Se and Hg biomarkers and the health outcomes were observed**

Conclusion (II)

- **All of the human studies performed to date were on populations with high Hg and high Se**
- In populations highly exposed to Hg:
  - **Adequate, or even elevated, Se intake may be important** to:
    - offset toxic effects of Hg
    - maintain optimal Se antioxidant enzymes
  - **There may be less 'excess' of Se and consequently little or no Se toxicity**

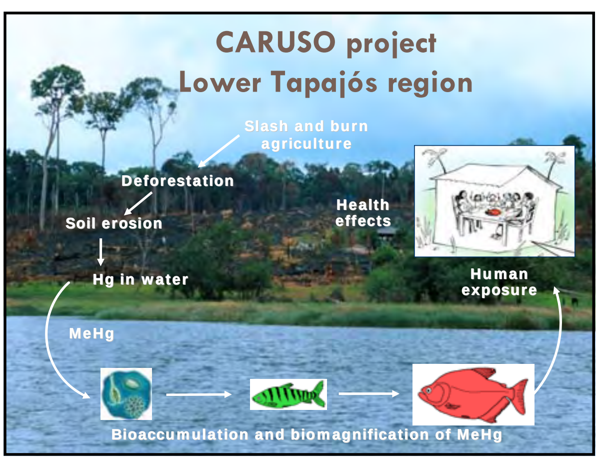
Conclusion (III)

- The effects of **Se with respect to Hg toxicity are complex** and many factors may explain the inter-study differences:
  - Se sources and Se speciation
  - Biomarkers of Se status
  - Levels of Hg exposure
  - State of development (*in utero* vs adult)
- **More studies are needed to better understand the conditions under which Se intake from food affects health outcomes in populations with moderate Hg intake**

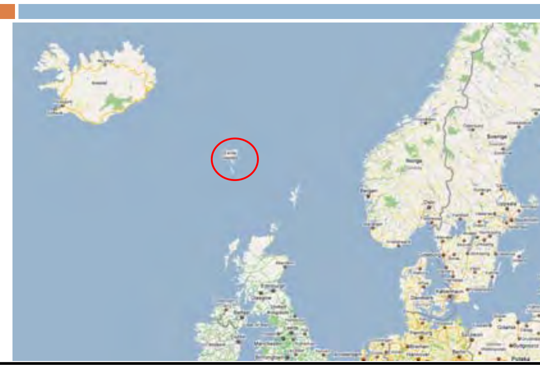


Rewiew of human studies

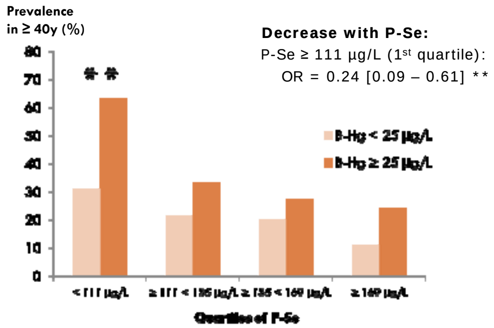
Study	Se sources	Biomarkers	Pop.	Hg effects	Se effects
Faroe	Marine mammals & fish	Normal cord B-Se High cord B-Hg	Neonates Children	↓ Neurobeha-vioral fonctions	None
Nunavik	Marine mammals & fish	Normal/High B-Se High B-Hg	Children	↑ Hand tremor	None
			Children	↓ VEP latency	↑ VEP latency
		Normal/High B-Se High B-Hg	Adults	↑ Blood Pressure	↓ Blood Pressure
Amazon	Brazil nuts & others	Normal/High B-Se High B-Hg	Adults	↑ Age-related cataract	↓ Age-related cataract
				↓ Motor functions	↑ Motor functions



Faroe Islands



Plasma Se and age-related cataracts



Nunavik

Omega-3 Levels in Fish: Data Quality, Quantity, and Future

Bruce J. Holub, Department of Human Health and Nutritional Sciences, University of Guelph, Guelph, ON, Canada

Biosketch

Dr. Bruce J. Holub (Ph.D.) is University Professor Emeritus, Department of Human Health & Nutritional Sciences, at the University of Guelph. He received his B.Sc. from the University of Guelph in 1967 and his Ph.D. (major in Biochemistry, minor in Nutrition) from the University of Toronto in 1971. Dr Holub received post-doctoral training as an MRC Fellow at the University of Michigan Medical School. He has served as President, Nutrition Society of Canada, and Chair, Nutrition Task Force (Heart & Stroke Foundation of Ontario). Dr. Holub has authored more than 200 papers in scientific journals, in addition to various books on dietary omega-3 fatty acids (docosahexaenoic acid plus eicosapentaenoic acid [DHA/EPA]) from fish/fish oils and resulting nutraceuticals plus functional foods for human health (throughout the human life cycle) and the preventions/management of cardiovascular disease and other chronic disorders. His laboratory has conducted analyses by high-performance gas-liquid chromatographic procedures for contents of DHA/ EPA and other omega-3 fatty acids on a wide range of fish/seafood from oceanic sources, freshwater fish (Great Lakes, elsewhere), fish from aquaculture operations, and processed fish products. Dr. Holub also maintains active collaborative research with clinical groups in Japan, Greenland, and Turkey; at various Canadian medical schools; at the Mayo Clinic in the United States, and in the agri-food sectors. He also serves as Scientific Director for the DHA/EPA Omega-3 Institute and a freely accessible website that provides current evidence-based health and research information on DHA/EPA from fish/seafood, fish oils, and DHA/EPA-enriched supplements and functional foods (www.dhaomega3.org).

Abstract

Recent recognition of the health importance of long-chain omega-3 fatty acids as docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) throughout the human lifecycle, ranging from pregnancy to cardiac care, has led to public health recommendations that target either fish or DHA/EPA intakes. There are many exceptions to the perception that oceanic fish from colder/deeper waters have more DHA/EPA per serving. Also, some freshwater species (e.g., from the Great Lakes) are very concentrated sources of DHA/EPA. Although the compositional data are rather limited, the levels of DHA/EPA in various species of fish vary considerably depending upon many factors, including source, time of sampling, and the dietary intakes of DHA/EPA. Regarding the latter factor, certain species of commercially farmed fish have been found to have more omega-3 fatty acids and less contaminants than wild fish and vice versa, depending upon the diets used and the water quality in the aquaculture operations.

A knowledge of the ideal intakes of DHA/EPA for certain health outcomes in appropriate sectors of the population, the serving sizes of specific fish to meet these targets, the provision of DHA/EPA contents of fish per serving at point-of-purchase, and information on contaminant issues, should help in improving fish consumption advisories. All of this information is important because improved advisories will help better balance contaminant concerns with the need to significantly increase the intakes of DHA/EPA in much of the North American and other populations.

Omega-3 Levels in Fish: Data Quality, Quantity, and Future

2009 National Forum on Contaminants in Fish
Portland, Oregon
November 4th, 2009

Bruce J. Holub, Ph.D.
University Professor Emeritus
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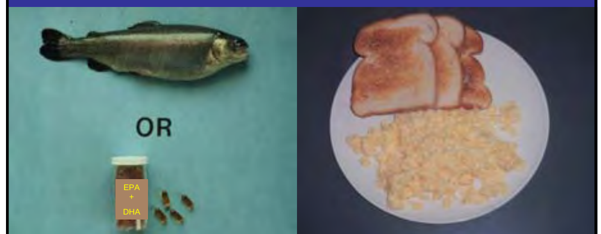
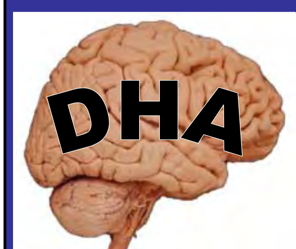
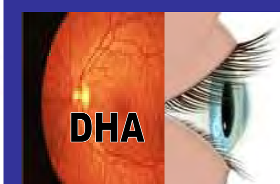
Fish-based Omega-3 Fatty Acids
(EPA – eicosapentaenoic acid plus DHA – docosahexaenoic acid)





Brain DHA



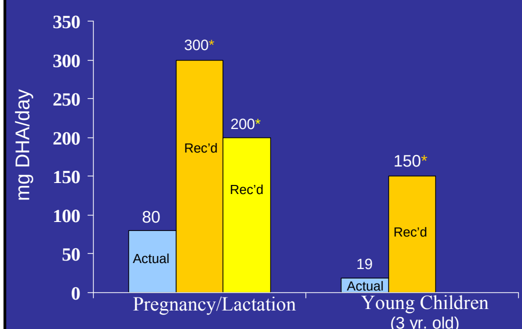
Retina (eye) DHA

NB: The amount of DHA in the brain increases approximately 30-fold from about 24 weeks gestation to about two years of age

(*Neonatal Network* 2007; **26**: 229-234).

BJ Holub

Actual vs. Recommended Intakes* of DHA (omega-3) for Women During Pregnancy and Lactation and in Young Children



*NIH Workshop (Bethesda, MD, USA, 1999) *European Commission (PeriLip, 2007)

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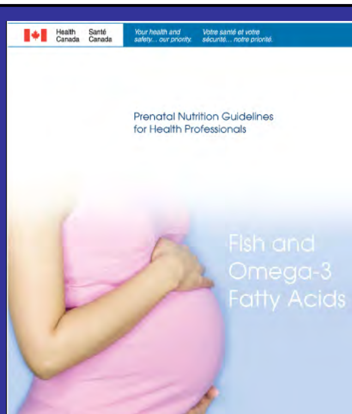


Key Messages on Fish for Women of Childbearing Age

- Have at least 150 grams (5 ounces) of cooked fish each week (incl. salmon, trout, herring, canned light tuna, sole).
- Vary the types of fish you eat and follow advice from health Canada to limit your exposure to environmental contaminants such as mercury (caution- shark, swordfish, marlin, orange roughy, fresh and frozen tuna).

Personal Commentary:

- 150 grams Atlantic Salmon (farmed) weekly provides 312 mg DHA/day
- 150 grams sole weekly provides 55 mg DHA/day
- Problem : Fish advisories/ recommendations need to carefully consider target intakes of DHA omega-3 fatty acids based on amounts of DHA or DHA/EPA per fixed serving size (eg., 3.5 oz. or 100 gm).

The Journal of Nutrition
Nutrient Requirements and Optimal Nutrition

Direct Diet Quantification Indicates Low Intakes of (n-3) Fatty Acids in Children 4 to 8 Years Old[1,2]

Sarah M. M. Madden, Colin F. Garrioch, and Bruce J. Holub*

Department of Human Health and Nutritional Sciences, University of Guelph, Guelph, Ontario, Canada, N1G 2W1

J. Nutr. 139: 528–532, 2009

TABLE 3 Intakes of (n-3) fatty acid by aged 4- to 8-y-old Canadian children in relation to recommendations from various international sources[1]

					% Meeting recommendation			
Source of recommendation	ALA	DHA	DHA+EPA	DHA+EPA+DPA	ALA	DHA	DHA+EPA	DHA+EPA+DPA
North America	900 mg	N/A[2]	Up to 90 mg	N/A	61%	N/A	22%	N/A
Australia/New Zealand	800 mg	N/A	N/A	55 mg	68%	N/A	N/A	51%
Netherlands	1% of energy	N/A	N/A	0.15–0.20 of energy	20%	N/A	N/A	20%
Belgium	0.45–1.50% of energy	0.10–0.40% of energy	N/A	N/A	83%	15%	N/A	N/A
ADA and DC	0.6–1.2% of energy	N/A	351 mg/d	N/A	68%	N/A	10%	N/A

Biological Role Claims

'Omega-3 fatty acids contribute to good health and normal growth and development.'

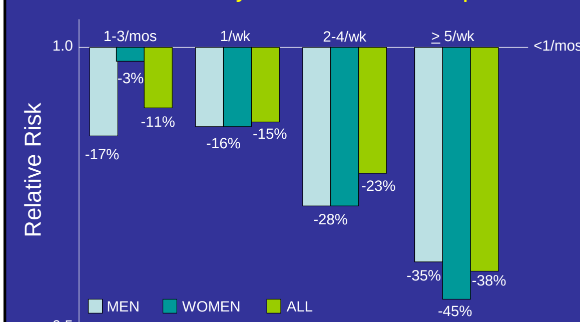
'DHA, an Omega-3 fatty acid, supports normal development of the brain, eyes and nerves.'

Fish Intake in U.S. Children

16% of U.S. children consumed no fish or shellfish during a 12-month period and the average consumption rate among those who ate fish (the remaining 84%) was <1 meal per week.

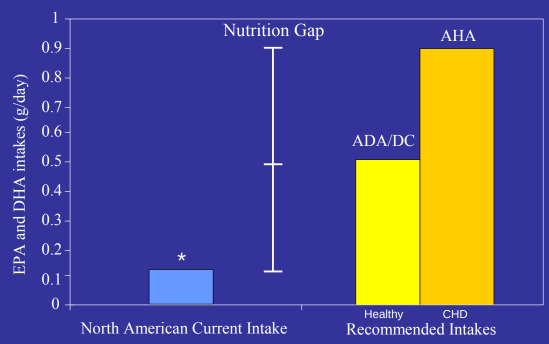
Ref: Imm *et al.*, Environ. Res., 103:198-209 (2007).

CHD Mortality and Fish Consumption



Meta-analysis of cohort studies (222,364 subjects with 11.8 yr. follow-up)
He *et al.*, Circ., 109: 2705-2711, 2004.

© B. Holub 2009



* Denomme, Stark, and Holub. J. Nutr., 135: 206-211, 2005

Are dietary recommendations for the use of fish oils sustainable?

Ref: Jenkins *et al.*, CMAJ 180:633-637 (2008).

Conclusions:

'Until renewable sources of long-chain omega-3 fatty acids – derived from plant, algae, yeast or other unicellular organisms – become more generally available, it would seem responsible to refrain from advocating to people in developed countries that they increase their intake of long-chain omega-3 fatty acids through fish consumption.'

'Half of the fish consumed globally is now raised on farms, study finds'

"Aquaculture is set to reach a landmark in 2009, supplying half of the total fish and shellfish for human consumption," the authors wrote.

"The huge expansion is being driven by demand," said lead author Rosamond L. Naylor, a professor of environmental Earth system science at Stanford University and director of the Stanford Program on Food Security and the Environment. "As long as we are a health-conscious population trying to get our most healthy oils from fish, we are going to be demanding more of aquaculture and putting a lot of pressure on marine fisheries to meet that need."

Ref: Naylor *et al.*, Proc. Nat. Acad. Sci. Sept,8 (2009).

Quantitative analysis of the benefits and risks of consuming farmed and wild salmon

Ref: Foran *et al.*,J. Nutr. 135: 2639-2643 (2005).

'Recommended levels of (n-3) fatty acid intake, as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), may be achieved by consuming farmed or wild salmon while maintianing and acceptable level of noncarcinogenic risk.'

'However, the recommended level of EPA+DHA intake cannot be achieved solely from farmed or wild salmon while maintaining an acceptable level of carcinogenic risk.'

NUTRA ingredients-usa.com

Breaking News on Supplements & Nutrition - North America

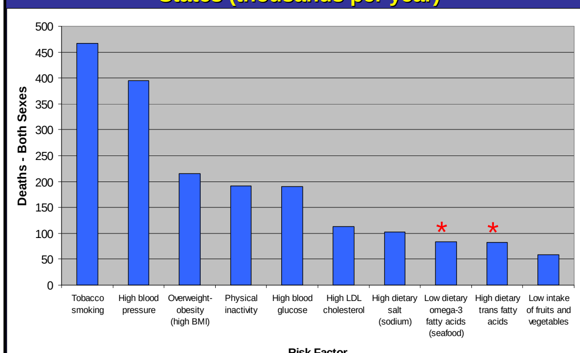
Omega-3 deficiency causes 96,000 US deaths per year, say researchers

By Shane Starling, 26-Jun-2009

Related topics: Nutritional lipids and oils, Cardiovascular health, Cognitive and mental function

Omega-3 deficiency is the sixth biggest killer of Americans and more deadly than excess trans fat intake, according to a new study.

Preventable Causes of Death (all-cause) in the United States (thousands per year)



Ref: PLoS Med., 6(4), (2009).

Risk/Benefit Assessment of Health Risk Parameters (End- Points) ?

Eg., 'Acceptable' carcinogenic risk (1 in 100,000 or 0.001%) due to contaminants in fish vs. 30% higher risk of cardiovascular disease due to insufficient intakes of DHA/EPA from fish.

USDA ars Agricultural Research Service NUTRIENT DATA LABORATORY

Search the USDA National Nutrient Database for Standard Reference

http://www.nal.usda.gov/fnic/foodcomp/search/index.html

The content of favorable and unfavorable polyunsaturated fatty acids found in commonly eaten fish

Ref: Weaver *et al.*, J. Am. Dietetic Assoc., 108:1178-1185 (2008).

'…tilapia (the fastest growing and most widely farmed fish) and catfish have much lower concentrations of n-3 PUFA, very high ratios of long chain n-6 to long chain n-3 PUFAs, and high saturated fatty acid plus monounsaturated fatty acid to PUFA ratios.'

'For individuals who are eating fish as a method to control inflammatory diseases such as heart disease, it is clear from these numbers that tilapia is not a good choice.'

Globe Life

Farmed tilapia may be no better for you than a doughnut

CARLY WEEKS

From Wednesday's Globe and Mail Published on Wednesday, Aug. 06, 2008 9:00AM EDT Last updated on Tuesday, Mar. 31, 2009 8:27PM EDT

'…eating farmed tialpia, a widely consumed fish that has been steadily growing in popularity, may be no better than dining on bacon, hamburgers or doughnuts.'

'New U.S. research has found that farmed tilapia have low levels of omega-3 fatty acids – and surprisingly high levels of potentially detrimental omega-6 fatty acids.'

'It is a finding that could have serious implications for people who suffer from arthritis, asthma and other illnesses or allergies because the omega-6 fatty acids may cause inflammation, which can damage blood vessels and vital organ tissue, according to the findings, published in last month's Journal of American Dietetic Association.'

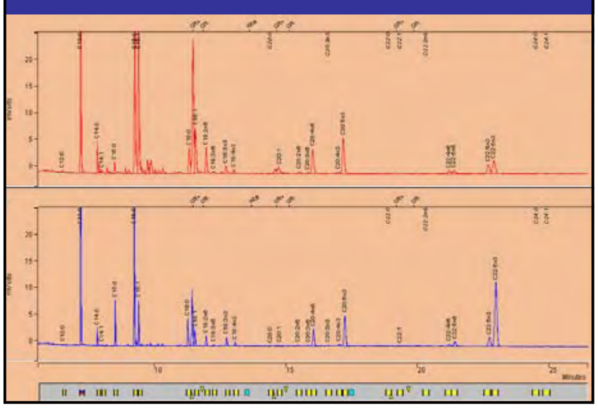
'But consuming too much omega-6 can contribute to cancer, asthma, depression and heart disease, among other ailments.'

'Omega-6 Fatty Acids and Risk for Cardiovascular Disease':

A Science Advisory From the American Heart Association Nutrition Subcommittee of the Council on Nutrition, Physical Activity, and Metabolism; Council on Cardiovascular Nursing; and Council on Epidemiology and Prevention Ref: Harris *et al.*, Circ., 119:902-907 (2009).

'In summary, the AHA supports an omega-6 PUFA intake of at least 5% to 10% of energy in the context of other AHA lifestyle and dietary recommendations. To reduce omega-6 PUFA intakes from their current levels would be more likely to increase than to decrease risk for CHD.'

GLC Top = Round Sheepshead, Bottom = Round Pickerel



Lake Erie Fish: Absolute Amounts of n-3 PUFA (mg/100 gm)

Fatty Acids	Jumbo Pickerel Filet	Round Yellow Perch	Yellow Perch Filet	Round Smelt
DHA	188.5	225.6	146.9	265.9
EPA	64.6	92.0	43.8	121.4
DHA + EPA	253.1	317.6	190.7	387.3
All n-3	294.3	361.6	211.7	464.5

Lake Erie Fish: Absolute Amounts of n-3 PUFA (mg/100 gm)

Fatty Acids	Bass Filet	Round Bass	Round Pickerel	Round Sheepshead
DHA	217.9	306.9	286.5	78.8
EPA	95.3	186.6	102.9	168.8
DHA + EPA	313.2	493.5	389.4	247.6
All n-3	395.5	676.0	465.1	345.1

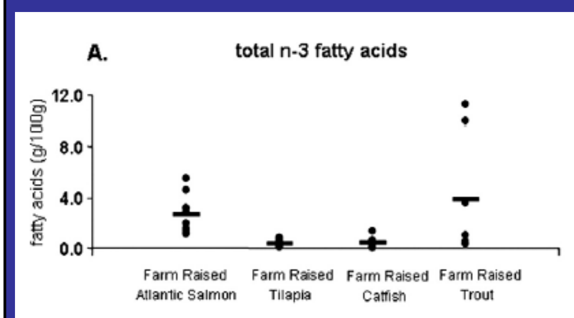
Omega-3 Contents of Siscowet Lake Trout*

Omega-3 Fatty Acid	mg/100 gm	Relative % of Total Fatty Acids
DHA	1476	11.2
EPA	792	6.0
DHA + EPA	2268	17.2
All n-3**	4664	35.3

*Sent to our lab for fatty acid analysis (July/09) by Dr. Ron Kinnunen. Total fatty acid content was 13,212 mg/100 gm (i.e., 13.2% by wt. as summed fatty acids).

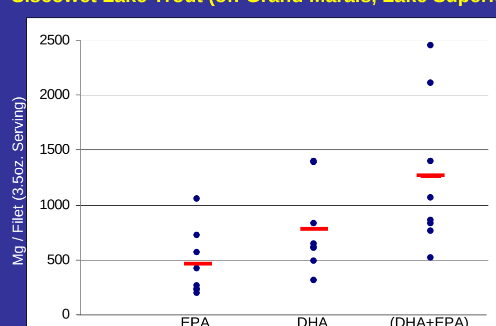
**Includes (EPA + DHA) + other 18-carbon plus 20-carbon plus 22-carbon fatty acids of the omega-3 (n-3) family.

Data provided by: Prof. Bruce Holub, Univ. of Guelph
Email: bholub@uoguelph.ca



Ref: Weaver *et al.*, J. Am. Dietetic Assoc., 108:1178-1185 (2008).

Siscowet Lake Trout (off Grand Marais, Lake Superior)



Note: Samples (different age, size, sex, depth) provided by Mike Ripley (Inter-Tribal Fisheries Assessment Pgm., Sault Ste. Marie, MI) to Prof. B Holub for analyses (Aug., 2009).

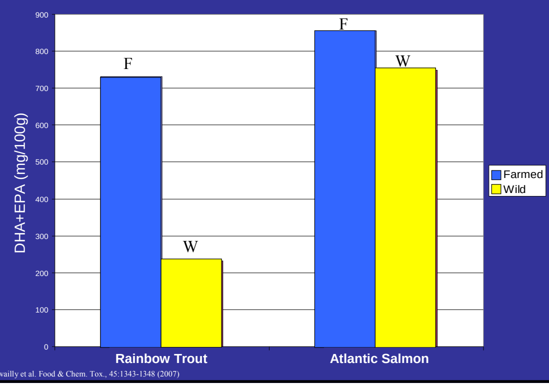

Monday, January 23, 2006 Issue 58 VOLUME 3 ISSUE 58

In This Issue

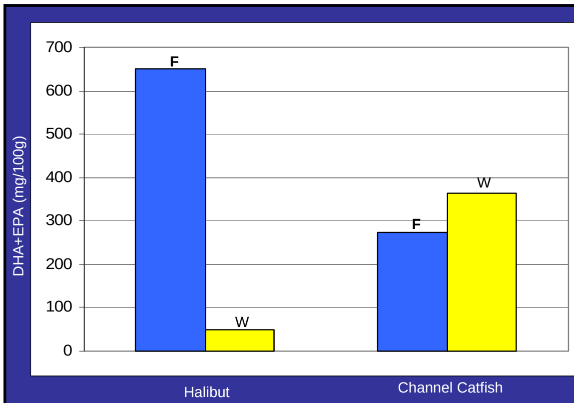
Farmed Salmon's Diet Yields Unhealthful Cardiovascular Effects

Fish doctors find plant oils in standard feed regimen may slash heart benefits of farmed salmon

Farmed vs. Wild Fish (Canada)



Dewailly et al. Food & Chem. Tox., 45:1343-1348 (2007)



Ref: Olsson *et al*., Aquaculture, 217: 191-205 (2003). USDA

Number of Fish Servings (3.5oz.) needed per week to meet target intake for DHA or (DHA+EPA)

Servings per Week

Fish	Pregnancy/Lactation (EU-200 mg DHA/day)	Child (4-8 yrs.) (N.Am. – 90 mg (DHA+EPA)/day)	Adult (ADA/DC – 500 mg (DHA/EPA)/day)
Salmon (Wild Atlantic)	1.0	0.3	1.9
Rainbow Trout (Farmed)	1.7	0.5	3.0
Cod (Pacific)	8.1	2.3	12.7
Tilapia	10.8	4.7	25.9
Round Pickerel (Lake Erie)	4.9	1.6	9.0
(S. Lake Trout (Lake Superior)	0.9	0.3	1.5

Overall Recommendations:

1) Much more extensive compositional data on the fatty acid contents (omega-3 plus others) of the numerous fish options available to consumers are needed to support the important role that fish containing DHA/DPA/EPA can play in enhancing human health throughout the life cycle and to fill the 'nutrition gap' between actual and target / recommended intakes.

2) Fish advisories / recommendations need to be based upon the known amounts of DHA, (DHA+EPA), or total long-chain omega-3 fatty acids (DHA+DPA+EPA) per specific serving size(s) as well as considering target intakes of omega-3 fatty acids for sectors within the population (pregnacy / lactation, children, healthy adults, those with various chronic disorders, and others) in conjunction with consideration of known contaminants (types / levels).

3) Due to the extremely wide variance in the amounts of DHA and EPA per serving of a given fish species (due to numerous factors), nutritional information on these omega-3 amounts should be made available at point-of-purchase for fresh / frozen fish as well as processed fish products. Such content declarations should be based on the minimal amount of DHA/EPA present per serving (with 95% confidence) or 'typical' values if such are within variance limits of 15-20% of actual amounts.

DHA·EPA OMEGA-3 INSTITUTE

DHA/EPA OMEGA-3 INSTITUTE

www.DHAomega3.org

DHA OMEGA-3 dhaomega3.org

- Overview of Omega-3 fatty acids
- DHA/EPA and life stages
- DHA/EPA news and latest research
- DHA/EPA and health conditions

Section II-G
Risk Management

Moderator:

Brian Toal, Connecticut Department of Public Health

Mr. Brian Toal has been with the Connecticut Department of Public Health for more than 20 years, working in all areas of environmental health assessment. He is currently the Program Manager of Environmental & Occupational Health Assessment, which oversees all risk assessment activity and environmental epidemiology studies within the department. He received his M.P.H. from the University of Washington and his B.S. from the University of Connecticut.

Presentations

Consistent Interstate Advisories: A Risk Management Exercise

Eric Frohmberg, Maine Center for Disease Control and Prevention/Department of Health and Human Services

The Risk of Cancer Risk Assessment for Fish Consumption Advisories

Dave Stone, Oregon State University

Are Lake Trout, *Salvelinus namaycush*, from Flathead Lake, MT, "Safe" to Eat?

Katie McDonald, Salish Kootenai College

Risk Management: When Benefits Are at Risk

Bruce Hope, Oregon Department of Environmental Quality

Comparative Analysis of State Fish Consumption Advisories Targeting Sensitive Populations

Elaine Faustman, University of Washington

Consistent Interstate Advisories: A Risk Management Exercise

Eric Frohmberg, Manager, Maine Childhood Lead Poisoning Prevention Program, Maine CDC/DHHS, Augusta, ME

Biosketch

Mr. Eric J. Frohmberg is a toxicologist with the Maine Environmental and Occupational Health Program at Maine Center for Disease Control and Prevention/Department of Health and Human Services. He is currently the Manager of the Maine Childhood Lead Poisoning Prevention Program. Previously, he developed fish consumption advisories, as well as the Maine CDC's fish advisory communication program, including the development of new brochures, testing efforts with low-literacy focus groups, and surveys to evaluate the effectiveness of the risk communication program.

Abstract

Eric Frohmberg will present a risk management perspective on the efforts of the Workgroup for Evaluating an Atlantic Coastal Advisory for Striped Bass and Bluefish based on polychlorinated biphenyls (PCBs). Based on the advisory, which was released in June 2009, this talk will explore how risk management influenced the decisions of the group, how the message was presented to the press, the impact of the resultant press coverage, and the effectiveness of the effort. The talk will also discuss some of the lessons learned and limitations and roadblocks to the process.

Consistent Interstate Advisories:

A Risk Management Exercise

Eric Frohmberg

Maine Environmental and Occupational Health Program

4 Years of Work in One Slide

Data - More data for striped bass than bluefish
Levels going down
Recent data consistent

Biology – striped bass and bluefish migrate
mature female striped bass leave estuaries

Toxicology – benchmarks not up to date
new epi data re: developmental effects compelling

Advisory – many states already at a similar point
think about consistent message not methods

Maine DHHS Public Health • Environmental and Occupational Health Program

Risk Management Decisions

Advice, not methods consistent

Recreationally caught striped bass and bluefish

Limit to PCBs

Advice was set by the states, not the workgroup

Maine DHHS Public Health • Environmental and Occupational Health Program

Striped Bass		
State	Before	After
	Sensitive Population	Sensitive Population
ME	2 meals per month	No Consumption
NH	2 meals per month	No Consumption
MA	Vary Consumption	Vary Consumption
RI	No Consumption	No Consumption
CT	No Consumption	No Consumption
NY	Varies by region	Varies by region
NJ	No Consumption	No Consumption
DE	No Coastal Advice	No Consumption
MD	No Coastal Advice	No Consumption
VA	No Coastal Advice	No Coastal Advice

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Striped Bass		
State	Before	After
	General Population	General Population
ME	2 meals per month	4 meals per year
NH	2 meals per month	1 meal per month
MA	Vary Consumption	Vary Consumption
RI	1 meal per month	1 meal per month
CT	1 meal every 2 months	1 meal per month
NY	Varies by region	Varies by region
NJ	1 meal per month	1 meal per month
DE	No Coastal Advice	2 meals per year
MD	No Coastal Advice	1 meal per month
VA	No Coastal Advice	No Coastal Advice

Maine DHHS Public Health • Environmental and Occupational Health Program

Press Coverage

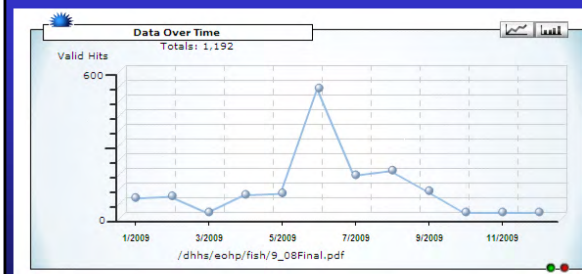
Used template for press release – each state did one

Messaging: focus on similarities

AP picked up Maine's press release

Maine DHHS Public Health • Environmental and Occupational Health Program

Website Traffic



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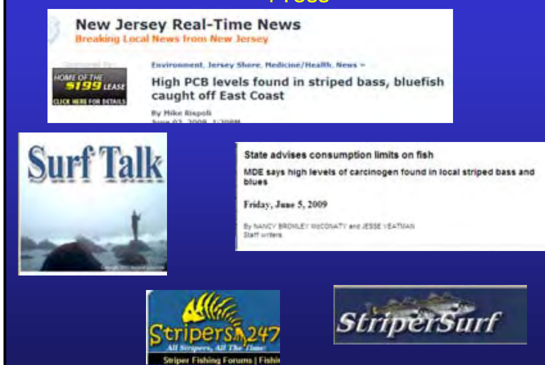
Press



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Limitations/Roadblocks/Lessons Learned

- **Limitations**
  - **Consistent advice?**
  - **Are we done?**
- **Roadblocks**
  - **history**
  - **past practice/methodology/culture**
  - **our own risk management decisions**
- **Lessons learned**
  - **Clear goals and methodologies**
  - **It WAS worth doing.**

Maine DHHS Public Health • Environmental and Occupational Health Program

Questions

Thanks. To everyone involved.

Report:
www.maine.gov/dhhs/eohp/fish/PCBSTBhome.htm

Questions, etc.,

eric.frohmberg@maine.gov

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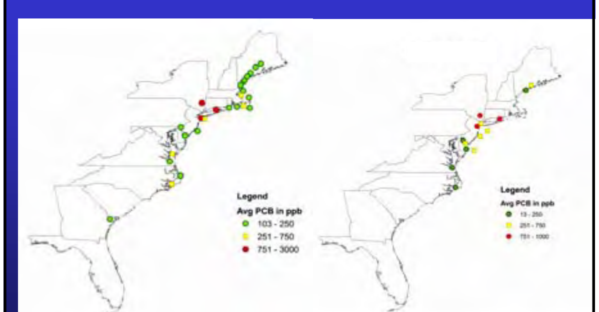
Data



Striped Bass Bluefish

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Toxicology: Risk Based Approach

	EPA Non-Cancer Action Level		EPA Cancer Action Level		Great Lakes Protocol
	W/out cooking loss	50% cooking loss	W/out cooking loss	50% cooking loss	
One meal/ week	43 ppb	86 ppb	11 ppb	22 ppb	60-200 ppb
One meal/ Month	173 ppb	346 ppb	43 ppb	86 ppb	210-1000 ppb
No Consumption					> 1,900 ppb

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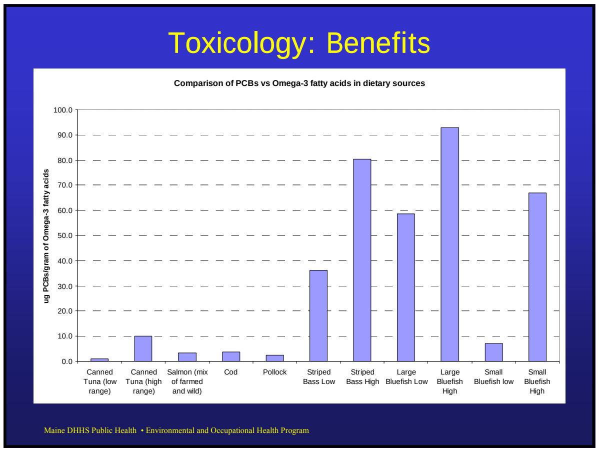

Toxicology: Benefits
Comparison of PCBs vs Omega-3 fatty acids in dietary sources
ug PCBs/gram of Omega-3 fatty acids
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Canned Tuna (low range)
Canned Tuna (high range)
Salmon (mix of farmed and wild)
Cod
Pollock
Striped Bass Low
Striped Bass High
Large Bluefish Low
Large Bluefish High
Small Bluefish low
Small Bluefish High
Maine DHHS Public Health • Environmental and Occupational Health Program

Questions and Answers

Q. There is tremendous variability in PCBs in the data. Is that due to time of year or region?

A. Some is due to where the fish come from and time of year. I'd love to see the migration sampling. The estuarine data and the older data in these maps are definitely higher. The new data outside of these areas are relatively consistently within the "do not consume" range. The biologists do say there that are differences, but it is unclear what that means in terms of setting consistent advice for PCBs. The consistent advice is based on the new data: 4 meals per year in Maine. There are opposing levels of mercury and PCBs in the New York harbor and in New Jersey, which is going to make setting consistent PCB and mercury advice difficult.

The Risk of Cancer Risk Assessment for Fish Consumption Advisories

Dave Stone, Department of Environmental and Molecular Toxicology, Oregon State University

Bruce K. Hope, Air Quality Division, Oregon Department of Environmental Quality

Biosketch

Dr. Dave Stone is an assistant professor in the Department of Environmental and Molecular Toxicology at Oregon State University (OSU). He is the Director of the National Pesticide Information Center, a cooperative agreement between the EPA and OSU. Prior to his current position, Dr. Stone worked in the Oregon Department of Human Services, where he issued statewide fish consumption advisories and conducted public health risk assessments. Dr. Stone specializes in risk communication and human health effects related to agricultural chemicals, biotoxins, and persistent pollutants.

Abstract

Fish consumption advisories are important tools in public health practice to limit exposure to contaminants that are deemed public health concerns. However, these advisories may have negative consequences, including a diminished intake of high-quality protein and polyunsaturated fatty acids. Fish consumption recommendations based on estimated cancer outcomes are cited in scientific articles, guidance documents, and media stories. If cancer estimates are used to set a fish advisory, then this will likely result in a highly restrictive fish consumption advisory. In addition, probable benefits could be lost. For this reason, we argue that cancer risk assessments should not be used as the basis for a fish consumption advisory based on three general principles. These principles are that (1) the benefits of fish consumption are evidence-based and important; (2) the standard methodology to predict cancer risk is likely to overestimate actual risk, often by orders of magnitude; and (3) the public's real and perceived concerns about cancer may result in unintended consequences, such as avoiding fish altogether. As an alternative to cancer risk estimates, we suggest focusing contaminant advisories solely on protecting against non-cancer health outcomes and encouraging the public to consume a balanced diet that is rich in fish.

The Risk of Cancer Risk Assessment for Fish Consumption Advisories

Dave Stone[1], PhD and Bruce K. Hope[2], PhD

[1] Oregon State University
[2] Oregon Department of Environmental Quality

Authors Declare They Have No Conflicts of Interest

Thesis:

Fish advisories are important tools in public health practice. Based on the reasons outlined below, fish consumption recommendations should be limited to non-cancer health effects and not based on cancer risk estimates.

- Significant evidence-based benefits of fish consumption across broad & diverse populations.
- Cancer risk models will likely over-estimate risk (potentially by several orders of magnitude) and are less robust compared with the approach to estimate non-cancer reference values.
- Risk perceptions can interfere with rationale discussions and possibly policy

Scope of thesis:

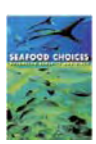
Applies to fish consumption advisories and not clean up standards, discharge permits, and similar endeavors. This thesis only applies when competing benefits are potentially minimized.

In the event of supported mechanistic information or new approaches, the basic tenets of this thesis could change.

EPA's revised *Guidelines for Carcinogenic Risk Assessment* (2005) provided a fundamental paradigm shift to include using MOA information as opposed to default assumptions and a framework based on Hill's criteria for causality in human studies (big step in the right direction).

What Benefits?

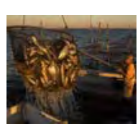
Institute of Medicine Report "Seafood Choices," 2006
-Seafood is nutritious, high-quality protein, low in saturated fat, rich in polyunsaturated fats, EPA & DHA
-Evidence-based benefit cited: reduced risk in heart disease
-Potential additional benefits: higher cognitive abilities in fetal period and visual acuity




CULTURE


FOOD SECURITY


RECREATION


ECONOMY

What Risks?

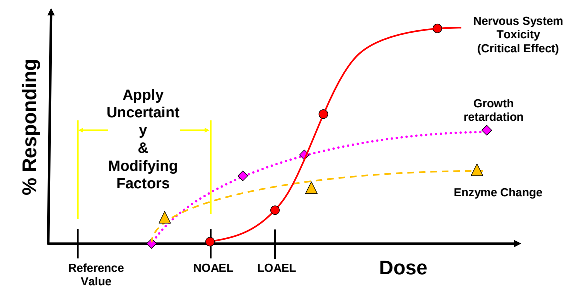
Institute of Medicine Report "Seafood Choices," 2006
-Highlighted risk of methylmercury exposure
-Potential PCB toxicity was noted for possible neurodevelopmental and immunosuppressive and neurobehavioral deficits in embryonic or neonatal stages
-The relevance of animal models to predict human cancer at realist doses was viewed skeptically
-All evidence for adverse health effects associated with persistent organic pollutants was characterized as "inconsistent"

What replaces fish as a source of protein in the diet?

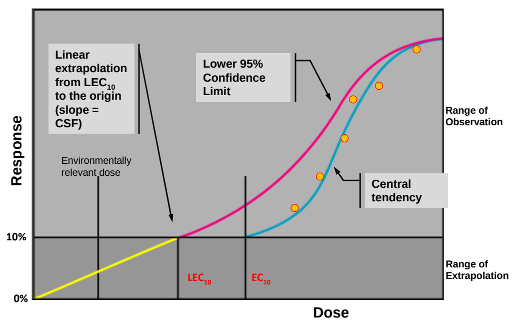
Toxicology Matters

	Avg. level Detected (ug/kg)	Non- cancer Reference Value Adult	Non- cancer Reference Value Child	Cancer Reference Value
Arsenic	72	1400	750	31
Mercury	138	467	250	---
Total DDT	30.6	2333	1250	137.3
Dieldrin	5.5	233	125	2.92
Chlordane	7.0	2333	1250	133.3
Dioxin/ Furan TEQs	0.0003	---	---	0.0003
Total PCBs	44.8	93	50	23.3

Non-Cancer Risk Assessment



Cancer Risk Assessment



Cancer Prevalence (U.S.)

Based on rates from 2004-2006, 40.58% men and women born today will be diagnosed with cancer at some time during their lifetime (NCI 2009). Typically, risk assessments calculate cancer risks to allow from 10^{-4} to 10^{-6} addition excess *lifetime* cancer risks.

10^{-5} + background = 0.45801

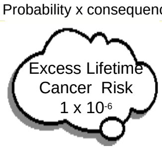
Heart Disease Prevalence (U.S.)

Based on NHANES data from 2005-2006, there were 80,000,000 U.S. adults (or 1 in 3) with one or more types of cardiovascular disease (CDC 2009).

Risk Perception

Expert's definition of risk | Public's definition of risk

Probability x consequence | Hazard + outrage



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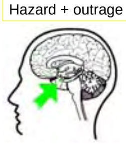


Risk Perception may not be reality, but it can affect how people act or don't act, how information is recalled and disseminated and even how legislation is crafted.

Risk Perception

Social research suggests that the public will not accept a risk, no matter how remote, if it is perceived to have serious and delayed or irreversible effects (Klein and Stefanek 2007).

The difference between actual, population-based cancer risk and estimates of 10^{-4} to 10^{-6} lifetime excess cancer risks is abstract; furthermore, it has been suggested that very low risk estimates are viewed with less credibility among the public (Johnson and Slovic, 1995).

Furthermore, if cancer risk is estimated, the focus can shift away from non-carcinogenic effects which are likely more probable compared with remote cancer outcomes.

Summary

There is a sound toxicological underpinning to protect sensitive subpopulations from non-cancer health effects.

Cancer risk assessment should not be used as the basis for determining fish consumption advisories due to: 1) competing, evidence-based benefits; 2) likely over-estimation of risks; and 3) counter-productive risk perception issues.

These suggestions are in concordance with EPA's *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories*, Volume III (2000) that emphasize flexibility in risk management.

You may only have one opportunity to get your message to someone…

Questions and Answers

Comment: There is no science behind a "1 in a million" cancer risk. This is a policy-driven decision. It's not up to us what the appropriate reference dose for cancer is. Most are there to protect subtle risks. If the public didn't care about a "1 in a million risk," we wouldn't be calculating it.

Q. I disagree with your presentation. I think there is a mixture of being upset with the measure and being upset with the endpoint approach. You don't carry through by doing a non-genotoxic approach for reference dose. It is fairly inconsistent. I hope that you will make this and the 1 in a million point separate.

A. If we come to a point where we have enough of a volume of information available, we would use those approaches for reference dose. But without it, I think the methods used right now are a gross overestimation of risk.

Q. If the way we are addressing cancer is out to lunch, our entire methodology is out to lunch. How do you approach the public with this non-cancer approach?

A. I don't feel that the cancer risk assessment will help with a population that is dealing with health issues such as diabetes, obesity, etc.

Q. Does your approach account for body burdens of PBTs?

A. We didn't specifically look at National Health and Nutrition Examination Survey (NHANES) data. I think that the evidence-based benefits of fish are so compelling that the scales are tipped towards the cancer risk assessment.

Are Lake Trout, *Salvelinus namaycush*, from Flathead Lake, MT, "Safe" to Eat?

Katie M. McDonald, N.R. Bishop, D.K. Stevens, Salish Kootenai College, Pablo, MT

Biosketch

Ms. Katie McDonald is a senior student at Salish Kootenai College, a tribal college in northwestern Montana. Ms. McDonald is from the Confederated Salish, Kootenai, and Pend d'Oreille Tribes. She is a Gates Millennium and National Science Foundation scholar with an academic major in Environmental Science, Terrestrial Sciences. Over the past 2 years, Ms. McDonald has been an undergraduate research intern in the Salish Kootenai College Environmental Laboratory and worked as a student intern in the SKC Molecular Biology and BioPhysics Laboratory on her campus. Her focus in the Environmental Laboratory has been analytical chemistry with an interest in mercury interactions in wildlife species on the Flathead Indian Reservation. After graduating with her B.S. in spring 2010, she plans to attend a Ph.D.-level graduate program in Environmental Toxicology in the Pacific Northwest.

Abstract

Mercury bioaccumulation in the food web has become a global concern. Studies have shown that selenium (Se) inhibits some negative effects of mercury (Hg) exposure from ocean fish, whereas others suggest significant benefits from omega-3 fatty acids. In Se-depleted areas, such as freshwater ecosystems of the Northwest, this may not be the case. One model has been proposed that creates a benefit index based on molar ratios of Se:Hg. Another model has been proposed that balances the benefits of omega-3 fatty acid consumption with the detriment of Hg intake. These models can be useful in establishing better consumption guidelines than currently exist. The Flathead Indian Reservation is home to the largest freshwater lake west of the Mississippi River. This lake provides an essential staple to the residents of the reservation in the form of food and provides fishing opportunities to support the local angling economy. The purpose of this study is to apply these models to evaluate the health risks/benefits of consuming Flathead Lake's main fishery, Lake Trout. A sample of 48 fish, ranging from 300–1,000 mm in length, were analyzed for Hg, Se, and polyunsaturated fatty acids (i.e., omega-3 fatty acids and omega-6 fatty acids). Results show Hg increasing in a log-linear manner with increasing length, (0.09–1.66 ppm, $r^2 = 0.74$). Se was found to be independent of length (average equals approximately 0.33 ppm). The ratio of omega-3 to omega-6 fatty acids negatively correlated with increasing length in a log-linear matter ($r^2 = 0.75$). Although the total lipid content of Lake Trout is approximately one-half that of ocean fish, such as salmon, the smaller fish exhibit similar omega-3:omega-6 fatty acid ratios. Integrating these models shows that smaller trout exhibit positive cardiovascular and anti-inflammatory benefits and positive Se:Hg, but no benefit in neurological development. Larger fish should definitely be avoided, and the data suggest that current local Lake Trout advisories are not adequately protective.

Are Lake Trout, *Salvelinus namaycush*, from Flathead Lake, MT "Safe" to Eat?

Katie McDonald, Nick Bishop, Doug Stevens, Ph.D.
Salish Kootenai College Environmental Laboratory

Lake Trout

- Long living, predacious
- Largest native trout NA
- Introduced in 1905
- Population explosion
- 1990's 800,000 fish
- Extirpated Kokanee
- Now, 400,000 fish
- 2002 first Mack Days

Why Mercury?

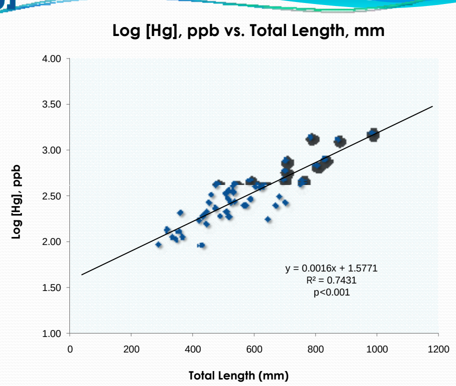
Mercury (Hg) is listed by the International Program of Chemical Safety as one of the most dangerous chemicals in the environment. [Gilbert and Grant-Webster 1995]

- Broad geographic extent of Hg accumulation
- Increasing global signal of Hg deposition
- Prior to 2003, global lacking of regulations to control the uses and disposal of Hg. [United Nations Environment Programme, 2003]
- After methylation in placid water systems, $MeHg^+$ becomes labile and readily moves through food web systems
- In terrestrial organisms, the presence of Hg has been correlated to decrease in reproductive processes, neurological damages/changes, abnormal behaviors, and ultimately, death.

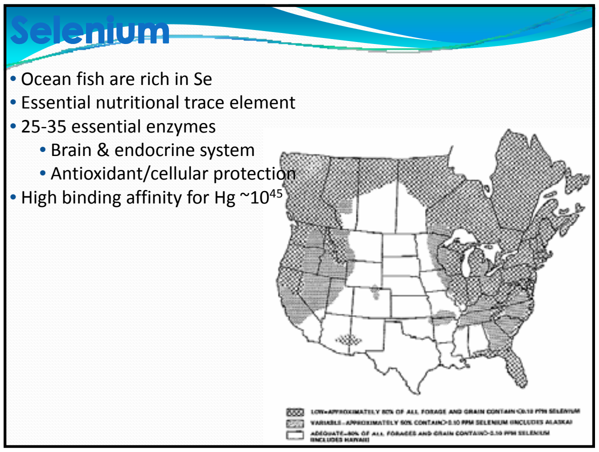
THE SOURCES:

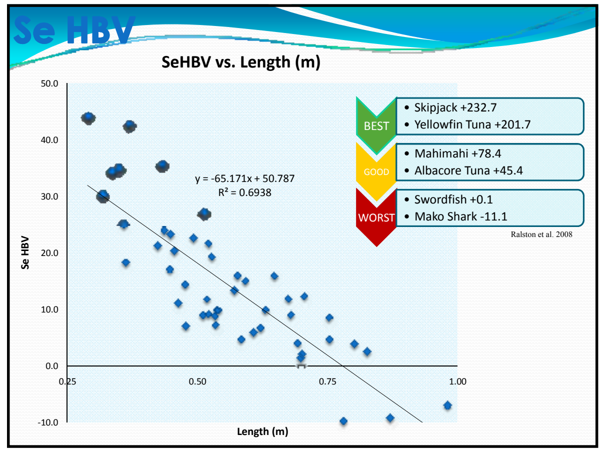
- Industrial sectors: Coal fired electric generators & mining
- Volcanoes, natural occurrence in soils as Mercuric Sulfide
- Mercury, gold, and silver mines
- Toxic waste sites
- Wastewater treatment plants/sewer
- Byproduct of chloralkali process
- Anti-fungal seed coatings

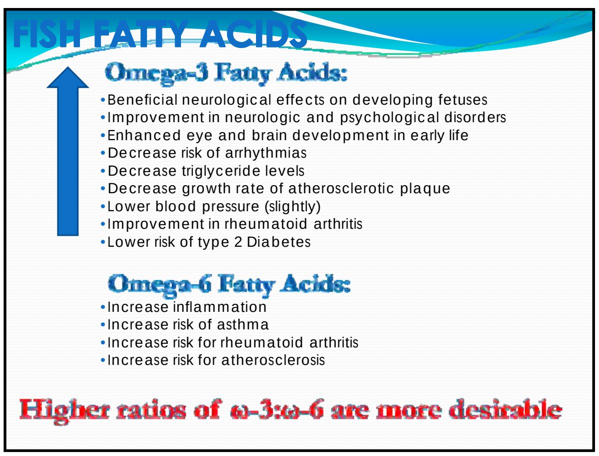
[Hg]

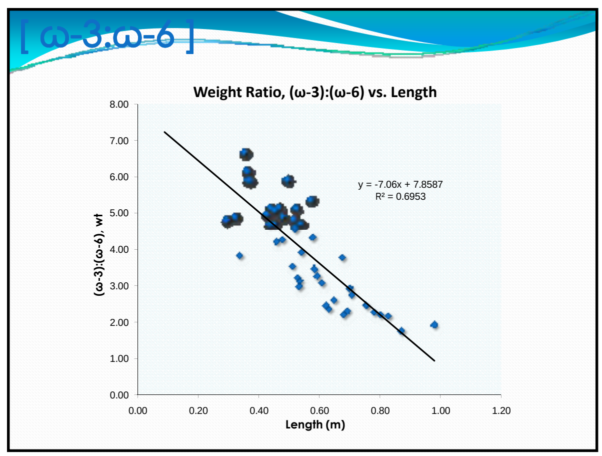


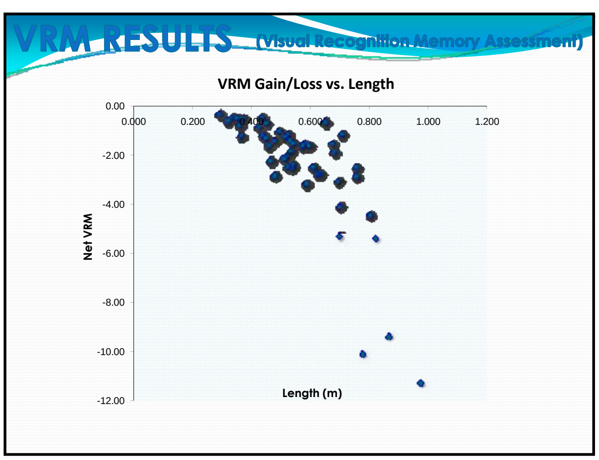
What factors can moderate $MeHg^+$ toxicity resulting from fish consumption?

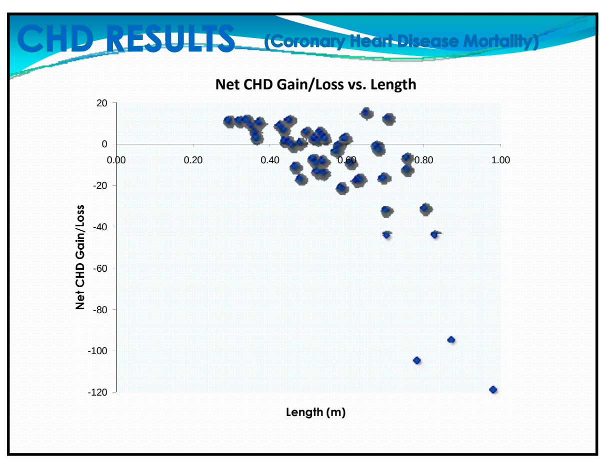

Selenium
• Ocean fish are rich in Se
• Essential nutritional trace element
• 25-35 essential enzymes
• Brain & endocrine system
• Antioxidant/cellular protection
• High binding affinity for Hg ~10^45


Se HBV
SeHBV vs. Length (m)
y = -65.171x + 50.787
R² = 0.6938
BEST
• Skipjack +232.7
• Yellowfin Tuna +201.7
GOOD
• Mahimahi +78.4
• Albacore Tuna +45.4
WORST
• Swordfish +0.1
• Mako Shark -11.1
Ralston et al. 2008
Se HBV
Length (m)


FISH FATTY ACIDS
Omega-3 Fatty Acids:
•Beneficial neurological effects on developing fetuses
•Improvement in neurologic and psychological disorders
•Enhanced eye and brain development in early life
•Decrease risk of arrhythmias
•Decrease triglyceride levels
•Decrease growth rate of atherosclerotic plaque
•Lower blood pressure (slightly)
•Improvement in rheumatoid arthritis
•Lower risk of type 2 Diabetes
Omega-6 Fatty Acids:
•Increase inflammation
•Increase risk of asthma
•Increase risk for rheumatoid arthritis
•Increase risk for atherosclerosis
Higher ratios of ω-3:ω-6 are more desirable


[ω-3:ω-6]
Weight Ratio, (ω-3):(ω-6) vs. Length
y = -7.06x + 7.8587
R² = 0.6953
(ω-3):(ω-6), wt
Length (m)


VRM RESULTS (Visual Recognition Memory Assessment)
VRM Gain/Loss vs. Length
Net VRM
Length (m)


CHD RESULTS (Coronary Heart Disease Mortality)
Net CHD Gain/Loss vs. Length
Net CHD Gain/Loss
Length (m)

FISH CONSUMPTION ADVISORIES

MONTANA CONSUMPTION LIMITS FOR WOMEN OF CHILDBEARING AGE

FISH [Hg], ppm[1]	EPA meals/mo	Size (in)[2]	MT meals/mo[3]	VRM	Se-HBV
>0.078 - 0.12	8	8 - 12	NA	0	++
>0.12 - 0.23	4	12 - 19	7	0 to -	+
>0.23 - 0.31	3	19 - 22	3	-	+ to 0
>0.31 - 0.47	2	22 - 26	3	--	0
>0.47 - 0.94	1	26 - 34	1	---	-

[1] = Taken from Table 4-3, EPA (2000)

[2] = Based on SKC data

[3] = Taken from MT Sport Fish Consumption Guidelines 2009, available at http://www.dphhs.mt.gov/PHSD/Food-consumer/food-safe-index.shtml

RESEMBLE SHARK

NEW GUIDELINES

PROPOSED NEW CONSUMPTION GUIDELINES FOR LAKE TROUT FROM FLATHEAD LAKE, MT

Size (inches)	6 - 10	10 - 14	14 - 18	18 - 22	22 - 26	26 - 30	30+
WC[1]	NA	NA	**7**	3	3	1	1
WC[2]	NA	6	**4**	3	2	0	0
Size (cm)	15 - 25	25 - 36	36 - 46	46 - 56	56 - 66	66 - 76	76+

NA = Spp. and size category not analyzed

WC = Women of childbearing age and children

[1] = Existing Montana 2009 guidelines

[2] = SKC recommendations

Discussion

Clearly the smaller fish are more beneficial to consume

- The most devastating effects of mercury are seen in pre- and postnatal brain development. These populations require conservative consumption limits whereas the effects on the remaining population are less dramatic.
- The state and tribal consumption advisories are liberal enough that they are not adequately protective. Our data indicate that length limits should be lowered, hence the proposed new guideline table.
- Current risk assessment models for $MeHg^+$ lack sufficient study data to provide precise limits. Therefore, **more study is needed before a safe $MeHg^+$ exposure can be determined.**
  - Local consumption
    - -Local fish spp. consumption?
    - -Lake Trout frequency & portion
    - -Commercial fish supplementation?
    - -Commercial fish frequency & portion

Acknowledgements

The Confederated Salish Kootenai Tribes Fisheries Program
Tribal Fisheries Biologist Barry Hansen
2008 Fall Mack Days Anglers

The National Institutes of Health

Flathead Lake Biological Station,
Craig Stafford & Jack Stanford

Connecticut Department of Public Health,
Gary L. Ginsberg

Minnesota State Department of Natural Resources,
Mark Briggs

University of Wyoming,
Bret Hess

University of Washington Center for Biomedical Statistics,
Bryan Comstock

Questions and Answers

Q. Were the more conservative guidelines well accepted?

A. The tribe wasn't very aware that this was an issue. They have been working to get the guidelines changed.

Risk Management: When Benefits Are at Risk

Bruce K. Hope, Senior Environmental Toxicologist, Air Quality Division, Oregon Department of Environmental Quality

Biosketch

Dr. Bruce K. Hope (Ph.D.) is a senior environmental toxicologist in the Air Quality Division at the Oregon DEQ. His present assignment is with the Water Quality Division on the Senate Bill 737 project, which involves the identification of persistent pollutants with respect to Oregon's waters and the development of "trigger" levels that would initiate toxics reduction plans for these persistent pollutants. Prior to joining DEQ in 1995, he was a consultant in the private sector managing human health and ecological risk assessment projects for commercial and government clients throughout the United States and Pacific Rim. In 2000–2001, he was on leave from DEQ as an AAAS risk policy fellow in Washington, DC, where he worked on food safety, microbial risk assessment, and bioterrorism issues. He has served on several EPA national advisory and review panels addressing cumulative risk, wildlife, ecological and probabilistic risk assessment issues, and environmental modeling. In 2007–2008, he was a member of a National Research Council committee evaluating EPA's human health risk assessment practices. Dr. Hope has been an adjunct faculty member at Oregon Health & Science University (Oregon Graduate Institute & School of Nursing), Concordia University (Portland), Portland State University, and Oregon State University. He holds an M.S. and a Ph.D. in biology (aquatic toxicology) from the University of Southern California and a B.A. from the University of California, Santa Barbara.

Abstract

Fish advisories are important tools in public health practice and are primarily used to translate fish contaminant levels into consumption recommendations for consumers. The need for an advisory is usually determined by technical staff (i.e., risk assessors) who compare measured tissue levels with risk-based consumption limits (RBCLs). When measured levels exceed these limits, an advisory may be appropriate. The role of the risk manager (i.e., regulatory decision maker) is to decide whether to actually issue an advisory.

Unlike a hazardous waste site, which poses risk but offers no benefits, consuming fish offers clear benefits (e.g., reduced risk of cardiovascular disease due to the intake of n-3 polyunsaturated fatty acids, cultural traditions associated with consuming fish, recreational economies), but varying degrees of risk (e.g., exposure to contaminants). A fish advisory exemplifies managing "risk in light of benefits," in that considerable trade-offs exist between maximizing public protection and minimizing an advisory's negative impacts. Therefore, U.S. Environmental Protection Agency guidance encourages risk managers to be flexible when deciding whether to issue an advisory and, if they do, in setting the nature and extent of that advisory.

But decision makers are typically under pressure from their constituencies and public opinion to avoid taking chances where the public health is concerned. These concerns, along with scientific uncertainty, can create considerable pressure for risk minimization alone. If risk is inadequately characterized (and interpreted) as simply crossing a threshold, and not as the likelihood of an adverse outcome, decision makers may feel compelled to minimize risk even if this means sacrificing benefits. In addition, as it often costs resources to avoid risk, unreasonably cautious policies can be exceedingly expensive without yielding compensatory benefits.

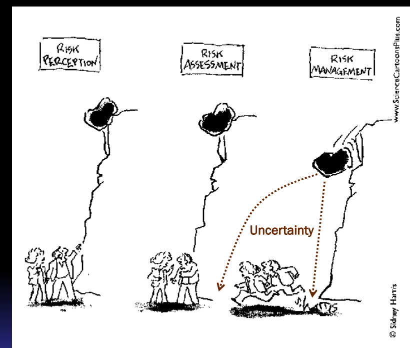
For risk managers to effectively balance risk and benefits in the presence of uncertainty, they are required to (1) understand how RBCLs are calculated; (2) be aware of, and willing to modify, policy and technical allowances for uncertainty implicit in the RBCL calculation process; and (3) be capable of interpreting these estimates and communicating risk–benefit tradeoff decisions, based on these interpretations, to their constituents.

Risk Management When Benefits Are at Risk

Bruce K. Hope
Oregon Department of Environmental Quality
Portland, Oregon

U.S. EPA National Forum on Contaminants in Fish
Portland, Oregon
November 4, 2009

If it were this simple...



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"Risk"

- A potential negative consequence
  - "People could be impacted by contaminants"
- Of some specified severity (magnitude of loss)
  - To health (non-cancer, cancer)
  - To economic, social, or cultural systems
- With some uncertainty about it actually happening
  - Where probability is one measure of uncertainty
    - Probability that exposure and dose-response will collude to increase the chance of an adverse health outcome
- Risk ≈ f(consequence, magnitude, uncertainty)

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Risk Management

- Acceptable risk problems are decision problems
- Problems which require a choice among alternative courses of action
- Where at least one course includes a threat to life or health among its consequences
- Where choosing an alternative is facilitated by knowledge of its full set of relevant positive and negative consequences

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Risky Fish

- Fish consumption offers risk <u>and</u> benefits
  - Risk from contaminants
  - Benefits from fatty acid consumption, recreational opportunities, and fulfillment of cultural needs
- Advisory must therefore manage for risk greater than zero, lest benefits be unnecessarily sacrificed
- So decision makers must understand
  - Consumption limits and their estimation
  - Policy and technical allowances for uncertainty
  - Discussion of risk-benefit tradeoffs with stakeholders

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Questions for the Risk Manager

- <u>How certain</u> are you that an advisory will minimize adverse health outcomes from fish consumption, while preserving some or all benefits related to such consumption?
- What techniques are used to reduce uncertainty in consumption limit calculations?
- How might use of these techniques affect your decision and perhaps interfere with obtaining benefits from fish consumption?

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Limits for Non-Carcinogens

$$CL_{nc} = \frac{\text{Reference Dose} \times \text{Body Weight}}{\text{Tissue Concentration}}$$

- CL_{nc} is NOT about risk (probability) - only a yes or no
- Reference dose is down-shifted from a NOAEL by uncertainty and modifying factors
  - Thus exceeding it does not mean an adverse health effect will occur or is necessarily more likely
  - Only that these allowances for uncertainty have been eroded

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Limits for Carcinogens

$$CL_{C} = \frac{\text{Acceptable Risk Level} \times \text{Body Weight}}{\text{Cancer Slope Factor} \times \text{Tissue Concentration}}$$

- CL_c is "risk-based" in that allowable uncertainty is explicit as the acceptable risk level
  - This level is purely a policy choice, not science
  - Risk level is for excess risk - that in addition to the background cancer incidence rate (25-33%, all cancers)
- Cancer slope factor is a 1-hit model extrapolation down-shifted to the 95th percentile LCL

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Tissue Concentration

- Major source of uncertainty
  - As stochastic variability + lack of knowledge
- Number & time/space distribution of samples
  - Lack of knowledge - too few samples too few places
- Appropriate species?
  - Stochastic variability - individual fish will always vary
  - Different species uptake pollutant in similar manner?
- Representation of value
  - Data usually have lognormal distribution
  - Arithmetic mean (>50th percentile) versus median (50th)

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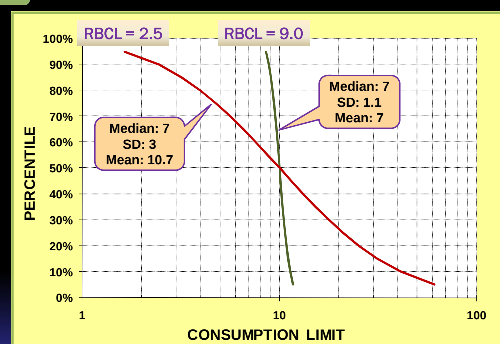
Impact of Concentration Variance



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Suggestions

- #1! Build trust & communication with stakeholders
- Read Fish Advisory Guidance Volume III
  - Suggests opportunities for management flexibility
- Consumption limits already allow for uncertainty
  - No necessary to add more
  - Re-consider cancer or an acceptable cancer risk $>10^{-6}$
- Emphasize characterization of tissue concentration
  - Sample to minimize variance
  - Check representativeness of species sampled
  - Consider median in addition to or in place of average

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Questions and Answers

Q. *How do you think current risk management approaches fits with chemical exposures?*

A. There may be more than 1 or more than 50 chemicals we are exposed to at one time. The most recent publication from Mike Cardahan in 2006 suggests that until we work simultaneous exposures out and the framework becomes operational, we should perform additive risk management. There are potentials for cumulative impacts; therefore, additivity is a neutral and balanced approach. EPA has one framework, National Academy of Sciences (NAS) has another, and until that gets figured out, additivity is conservative but about as good as it gets practically.

Q. *I take calls from citizens of South Carolina that are afraid they have poisoned their children because of the "Do Not Eat" advisories. How do you communicate to the public that if they did eat fish with a "Do Not Eat" advisory, they are not poisoning their children or themselves?*

A. Air quality has the exact same issue. If a member of the general public smells something, they think it might be poisonous. You need to have a conversation about poisoning and what acute effects look like. Minamata has an acute example. You also have to discuss that short-term elevations even above chronic levels do not necessarily translate into an immediate health concern or even a long-term effect. However, the conversation about long-term effects will vary by contaminant.

Q. *When using an additive approach, are you looking at toxicants with the same endpoint and if not, how do you deal with toxicants that don't have the same endpoint?*

A. EPA has pursued a common mode of action approach and NAS has pursued common effects approach. Pragmatically, additivity can work across either, but it assumes that there is no synergism and that they are all working all at the same time, so it is conservative. Unfortunately, state people have to make headway today even if we don't have it all worked out.

Comparative Analysis of State Fish Consumption Advisories Targeting Sensitive Populations

Elaine M. Faustman, Department of Environmental and Occupational Health
Director, Institute for Risk Analysis and Risk Communication, School of Public Health, University of Washington

Biosketch

Dr. Elaine M. Faustman (Ph.D.) is a professor in the Department of Environmental and Occupational Health and Director of the Institute for Risk Analysis and Risk Communication at the School of Public Health at the University of Washington. She is the principal investigator of the Pacific Northwest Center for the National Children's Study and a newly renewed EPA-National Institute of Environmental Health Sciences (NIEHS)-funded Child Health Center, which is evaluating key mechanisms defining children's susceptibility to pesticides. Dr. Faustman is also director of the NIEHS and National Science Foundation–funded Pacific Northwest Center for Human Health and Ocean Studies. She is an elected fellow of both the American Association for the Advancement of Science (AAAS) and the Society for Risk Analysis. She served on the advisory board for the recently released World Health Organization (WHO) environmental criteria document on children's health, and she has also served as chair for the National Academy of Sciences Committee on Developmental Toxicology and as a member for the NIEHS-National Toxicology Program (NTP) Committee on Alternative Toxicology Methods. Previously, she has served on the NIEHS-NTP Board of Scientific Counselors, National Academy of Sciences Committee in Toxicology, and the Institute of Medicine Upper Reference Levels Subcommittee of the Food and Nutrition Board. She has also served on the executive boards of the Society of Toxicology, the Teratology Society, and NIEHS Council. Dr. Faustman has also served as Associate Editor of *Fundamental and Applied Toxicology* and on the editorial boards of *Environmental Health Perspectives*, *Birth Defects Research, Reproductive Toxicology*, and *Toxicology Methods.* Her research interests include understanding mechanisms that put children and the public at risk from environmental agents. In particular, Dr. Faustman is interested in the molecular and cellular mechanisms of developmental and reproductive toxicants, characterizing in vitro techniques for developmental toxicology assessment, and the development of biologically based dose-response models for noncancer risk assessment. Dr. Faustman's research expertise also includes the development of decision-analytic tools for communicating and translating new scientific findings into risk assessment and risk management decisions. She is also an adjunct professor in the Evans School of Public Affairs at the University of Washington and has been an affiliate professor in the Department of Engineering and Public Policy at Carnegie Mellon University.

Abstract

Fish consumption advisories are issued to warn the public of possible toxicological threats from consuming certain fish species. Although developing fetuses and children are particularly susceptible to toxicants in fish, fish also contain valuable nutrients. Hence, formulating advice for sensitive populations poses challenges. We conducted a comparative analysis of advisory Web sites issued by states to assess health messages that sensitive populations might access. We evaluated state advisories accessed via the U.S. Environmental Protection Agency's National Listing of Fish Advisories and created criteria to evaluate advisory attributes, such as risk-and-benefit message clarity. All 48 state advisories issued at the time of this analysis targeted children, 90% (43) targeted pregnant women, and 58% (28) targeted women of childbearing age. Only six advisories addressed single contaminants, whereas the remainder based advice on 2 to 12 contaminants. Results revealed that advisories associated a dozen contaminants with specific adverse health effects. Beneficial health effects of any kind were associated only specifically with Omega-3 fatty acids found in fish. These findings highlight the complexity of assessing and communicating information about multiple contaminant exposure from fish consumption.

Communication regarding potential health benefits conferred by specific fish nutrients was minimal and focused primarily on Omega-3 fatty acids. This overview suggests some lessons learned and highlights a lack of both clarity and consistency in providing sensitive populations (e.g., pregnant women) with the breadth of information required to make health decisions about fish consumption during pregnancy.

For more information: Scherer, A.C., A. Tsuchiya, L.R. Younglove, T.M. Burbacher, and E.M. Faustman. 2008. A comparative analysis of state fish consumption advisories targeting sensitive populations. *Environmental Health Perspectives 116*(12):1598–1606.

This work was supported by the Pacific Northwest Center for Human Health and Ocean Studies (NIH/NIEHS: P50 ES012762 and NSF: OCE-0434087).

Comparative Analysis of State Fish Consumption Advisories Targeting Sensitive Populations


Image credit: Stock.XCHNG

Presented by Elaine M. Faustman

Pacific Northwest Center for Human Health and Ocean Studies

University of Washington

November 4, 2009

2009 National Forum on Contaminants in Fish
Portland, Oregon

Comparative Analysis of State Fish Consumption Advisories Targeting Sensitive Populations

Alison C. Scherer, Ami Tsuchiya, Lisa R. Younglove, Tom M. Burbacher, and Elaine M. Faustman

The Pacific Northwest Center for Human Health and Ocean Studies
Institute for Risk Analysis and Risk Communication
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Article published Dec. 2008:
Scherer AC, Tsuchiya A, Younglove LR, Burbacher TM, Faustman EM. 2008. A Comparative Analysis of State Fish Consumption Advisories Targeting Sensitive Populations. *Environ Health Perspect* 116(12): 1598-1606.

Introduction

- Fish consumption advisories are issued to warn the public of possible toxicological threats from consuming certain fish species
- While developing fetuses and children are particularly susceptible to toxicants in fish, fish also contain valuable nutrients. Hence, formulating advice for sensitive populations poses challenges.
- In July of 2007, the U.S. Environmental Protection Agency (EPA) made available online the 2005/2006 National Listing of Fish Advisories (NLFA), which reflects potential chemical risks only.

3

Introduction

- The NLFA database includes all available information describing state-, tribal-, and federally-issued fish consumption advisories in the United States for the 50 States, the District of Columbia, and four U.S. Territories, and in Canada for the 12 provinces and territories. The database contains information provided to EPA by the states, tribes, territories and Canada.
- We used the NLFA database contacts page to access state fish consumption advisory Web sites to assess.

4

Fish Advisories in the United States, 2007

Figure 2. Total Number of Fish Consumption Advisories in 2006

Source: US EPA, 2007

5

2008 Biennial National Listing of Fish Advisories

- In Sept. 2009, EPA released the 2008 Biennial National Listing of Fish Advisories
- In 2008, all states had fish consumption advisories (4,249 total) in effect
- 5 bioaccumulative contaminants (mercury, PCBs, chlordane, dioxin, and DDT) are responsible for 97% of advisories
- 45% of the nation's total lake acreage and 39% of the nation's total river miles are under advisory

Source: 2008 Biennial National Listing of Fish Advisories http://www.epa.gov/waterscience/fish/advisories/

Source: National Maps and Graphics: 2008 Biennial National Listing of Fish Advisories
http://www.epa.gov/waterscience/fish/advisories/

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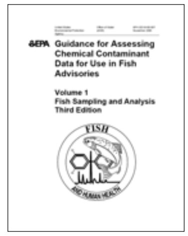
Risk Management Basis for State Fish Advisories

- Advisories are considered voluntary recommendations regarding fish consumption and are not subject to regulation. States have primacy in protecting the public's health from fish caught in state local waters (Cunningham, Smith et al. 1994)
- EPA had issued guidance from the Office of Water to states on assessing chemical contaminant data for use in fish advisories, but this does not constitute a regulatory requirement for states.



4 volumes of EPA guidance to states:

- o Volume 1: Fish Sampling and Analysis, 3rd Edition
- o Volume 2: Risk Assessment and Fish Consumption Limits, Third Edition
- o Volume 3: Risk Management
- o Volume 4: Risk Communication

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

Risk Management Basis for Federal Fish Advisories

In 2004 EPA and FDA issued a joint national fish consumption advisory.

Below are the **agency's relevant missions** as described in their Memorandum of Understanding regarding environmental contaminants in fish and shellfish and the safety of fish and shellfish for U.S. consumers:

FDA mission:

- Promote and protect the public's health by ensuring that the nation's food supply, including commercial fish and shellfish, is:
  - Safe,
  - Sanitary,
  - Wholesome, and
  - Properly labeled

EPA's mission:

- Protect human health and the environment

EPA Office of Water's goals:

- Restore and maintain water quality
- Protect human health and ecosystems
- Provide the public with information on how best to reduce their water-related risks, including risks pertaining to the consumption of non-commercial fish and shellfish

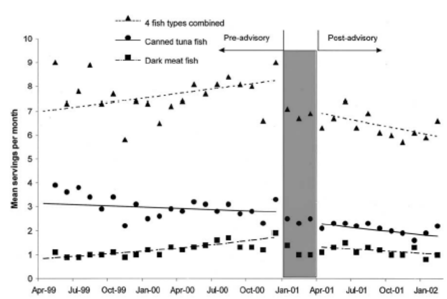
What did the 2004 Joint EPA/FDA Fish Consumption Advisory Target?

- Best science
- Development of Pub Hlth messages considering both risks and benefits
- Promoted Uniformity
- Encouraged environmental monitoring
- Sensitive populations

Source: http://www.epa.gov/waterscience/fish/advice/index.html

President's Commission 1997 –
Risk Management in Context

Introduction



Oken, E., et al., Decline in fish consumption among pregnant women after a national mercury advisory. Obstetrics and Gynecology, 2003. **102**(2): p. 346-351.

Introduction

- No study has comprehensively assessed the health messages contained in fish consumption advisories issued by states.
- In this analysis, we assessed health messages contained in advisories that sensitive groups might access through the NLFA.
- This analysis did not assess actual choices made by sensitive populations.
- However, a recent study by Tsuchiya et al has studied fish consumption choices made by local Japanese and Korean women of childbearing age:

Tsuchiya, A., J. Hardy, et al. (2008). "Fish intake guidelines: incorporating n-3 fatty acid intake and contaminant exposure in the Korean and Japanese communities." American Journal of Clinical Nutrition 87(6): 1867-1875.

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Objective

- Viewed comprehensively across states, do fish consumption advisories, which we recognize arise from a regulatory context, also address the public health questions that sensitive populations face?
- Specifically, do advisories sufficiently convey risk and benefit information on potential fish species eaten to provide context for the advice offered? Do they provide clarity for these complex risk issues?

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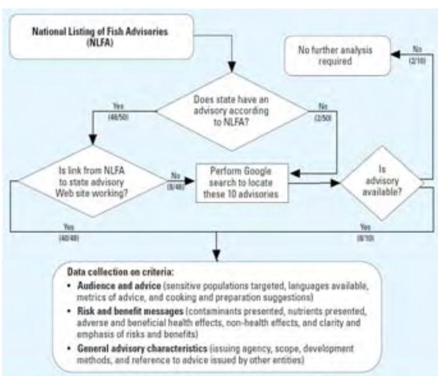

Figure 1. Flow diagram for the comparative analysis of the 48 state fish consumption advisory Web sites assessed.

Audience and Advice
Sensitive Populations Targeted

- All Web sites contained at least some advice for sensitive populations.
- All but Hawaii and Nevada offered advice that was either more strict or more cautiously worded for sensitive populations than for the general population.
- Seventeen Web sites contained specific brochures or Web pages aimed exclusively at sensitive populations, whereas the rest of the Web sites intermingled advice aimed at sensitive populations with content aimed at members of the general population.

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Audience and Advice
Languages Available

Table 1. Audience and advice attributes of the 48 state fish consumption advisory Web sites assessed.

Attribute	No. (%)
Sensitive populations targeted	
Pregnant women	43 (89.6)
Women of childbearing age	28 (58.3)
Women planning to become pregnant	20 (41.7)
Women who might become pregnant	27 (56.3)
Children	48 (100.0)
High-end fish consumers	6 (12.5)
People with certain health conditions	3 (6.3)
Languages available	
Spanish	18 (37.5)
Vietnamese	5 (10.4)
Chinese	4 (8.3)
Korean	3 (6.3)
Hmong	3 (6.3)
Russian	3 (6.3)
Khmer	2 (4.2)
Laotian	2 (4.2)
Cambodian	2 (4.2)
Serbo-Croatian	1 (2.1)
French	1 (2.1)
Haitian Creole	1 (2.1)
Portuguese	1 (2.1)

Audience and Advice
Metrics of Advice: Meal Frequency and Size

- All states, except Nebraska, offered meal frequency advice, given in terms of meals per week, month, year, or a combination thereof.
- Most states gave advice based on fish length (inches), and some based advice on the size of fish caught.

Cooking and Preparation Suggestions

- 56% of advisories gave advice about preparing and cooking fish, such as removing skin and trimming away fat before cooking.

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Risk and Benefit Messages
Contaminants Presented

- Twenty-six chemical contaminants were responsible for advisories issued by states.
- Only 6 advisories addressed single contaminants, while the remainder, 42, based advice on 2 to 12 contaminants.
- In 9 of these 42 multiple-contaminant advisories, the consumption advice was contaminant-specific
- In all but 7 of the 29 cases where advisories did contain advice integrated across contaminants, no explanation was given regarding how the integrated advice was developed.

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Risk and Benefit Messages
Nutrients Presented

Table 2. Contaminants, nutrients, and non-health effects presented in the 48 state fish consumption advisory Web sites assessed.

Attribute	No. (%)
Nutritional aspects addressed	
Protein source	37 (77.1)
Omega-3 fatty acid source[c]	22 (45.8)
Vitamin source	16 (33.3)
Mineral source	16 (33.3)
Nutritious/source of nutrients	12 (25.0)
Low in cholesterol	5 (10.4)
Low in calories	3 (6.3)
Low in sodium	2 (4.2)
Low in fat	23 (47.9)
Low in saturated fat specifically	16 (33.3)
References other protein sources	11 (22.9)
Non-health benefits addressed	
Recreation source	17 (35.4)
Provide food/supports a subsistence lifestyle	6 (12.5)
Cultural, spiritual, or traditional relevance	2 (4.2)
Economic importance	4 (8.3)

Risk and Benefit Messages
Beneficial Health Effects

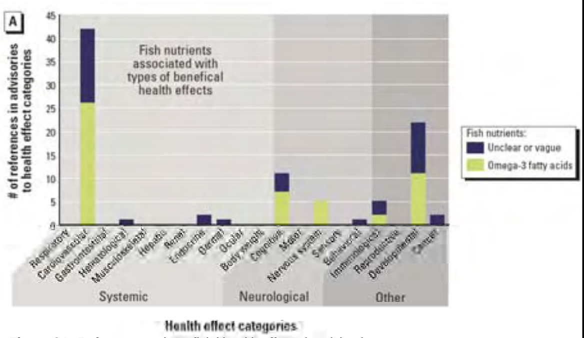

Figure 2A: References to beneficial health effects in advisories

Risk and Benefit Messages
Adverse Health Effects

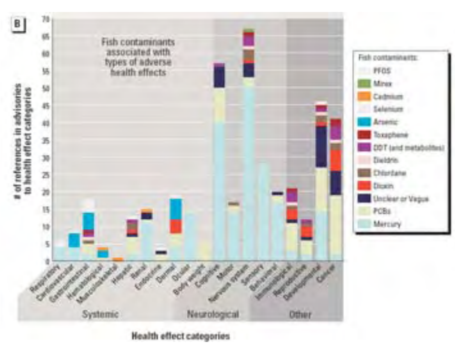

Figure 2B: References to adverse health effects in advisories

Risk and Benefit Messages
Clarity of risks

- 31% of advisory Web sites addressed risks posed by specific contaminants and explained potential adverse health effects in a clear and sufficient manner to sensitive populations.
- The following statement exemplifies clear and sufficiently explained risks: "too much mercury can affect your baby's brain and how your baby learns, moves and behaves."
- Few of the 42 advisories that addressed multiple contaminants explained the relationship between risks posed and advice in a clear and sufficient manner

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Risk and Benefit Messages
Clarity of benefits

- 27% of advisory Web sites addressed benefits posed by specific contaminants and explained potential beneficial health effects in a clear and sufficient manner to sensitive populations.
- An example of explaining health benefits in a clear and sufficient manner is as follows: "Omega-3 fatty acids are important during fetal brain and eye development. Omega-3 fatty acids also help to prevent heart disease in adults"

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Risk and Benefit Messages
Emphasis of risks and benefits

- In approximately 75% of advisories, both risks and benefits were emphasized, but risks were emphasized more than benefits.
- In the remaining cases, only risks were emphasized.

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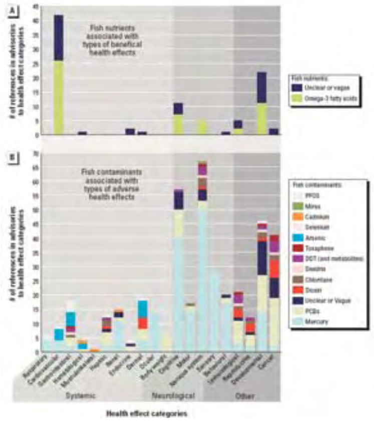

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General Advisory Characteristics
Selected results

- Health agencies, environmental agencies, or a combination of multiple agencies working in concert were responsible for the vast majority of advisories issued by states.
- 28 Web sites referenced, at least to some extent, the methods used to develop advice. Among these, 23 used what appear to be risk-based approaches
- Numerous advisories recommended that sensitive populations consult their health care providers regarding fish consumption.

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Discussion

- Results suggest that the message is uneven and that advisories may inadvertently cast a dim light on all fish consumption.
- It is not the intention of this analysis to fault state fish consumption advisories for presenting an uneven message.
- If these state advisories are a source of decision-making information for sensitive populations, then measures to improve message clarity would be valuable.

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Conclusion

- This study suggests that important lessons learned can be gained from evaluation of available state fish consumption advisories.
- Means to enhance coordination across agencies include the development of workshops or online forums to encourage collaboration and discussion to share lessons learned and move towards harmonizing approaches.
- An additional way to help provide a more complete picture of risks and benefits is to develop standard metrics for describing the risks and benefits.

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Acknowledgements

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Article published Dec. 2008:

Scherer AC, Tsuchiya A, Younglove LR, Burbacher TM, Faustman EM. 2008. A Comparative Analysis of State Fish Consumption Advisories Targeting Sensitive Populations. *Environ Health Perspect* 116(12): 1598-1606.

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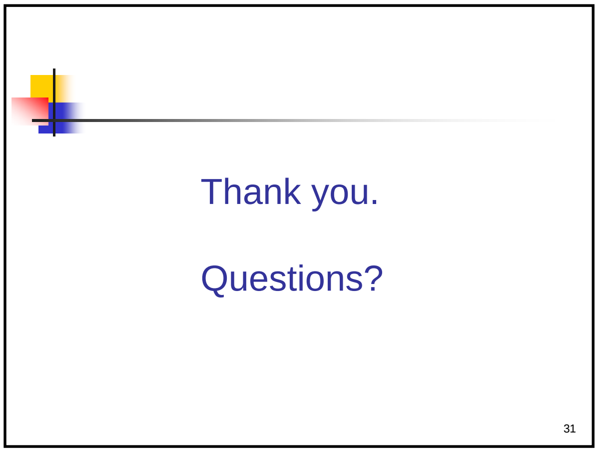
Thank you.
Questions?
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Questions and Answers

Q. What do you think the national public would think of the website you've presented, since the public seems more aware of the benefits than the risk?

A. The usability of the website is key.

Closing Remarks from General Forum Moderators
State and Tribal Regional Workgroups

Denise Hawkins, Office of Science and Technology, Office of Water, U.S. EPA

Thank you for making this a great forum. I'd like to thank our hosts in the State of Oregon, the Steering Committee, and our contractor, RTI, for working so hard over the past year to organize this event.

- We heard about fish contamination studies in Washington and Oregon.
- We learned about sampling and analysis from Alaska to New York.
- Rita Schoeny presented both a tribute to Kate Mahaffey and an update on EPA's dioxin reassessment.
- We gained insights into communicating messages about fish consumption and learned everything we don't know about the new social media tools.
- A lively debate showed us new ways to look at old issues.
- And we discussed the unquestionable benefits of eating fish as well as the unquestionable risks of eating too much of the wrong kinds of fish.

For some of you, this event isn't quite over. State and tribal workgroups will meet tomorrow on the second floor.

Once again, thanks to everyone for a great forum and I look forward to seeing you again in two years.

Deanna Conners, Toxicologist, Office of Environmental Public Health, Oregon Department of Human Services

Good afternoon. In case we haven't yet had a chance to meet in person, I am Deanna Conners a toxicologist for the state of Oregon and co-host of this year's fish forum. I would like to start by telling you that this is the first fish forum I have attended and I was very impressed with everything from the high quality of the presentations to the level of engagement from the audience. Thank you everyone for your participation. I would also like to extend a special thank you to the Environmental Protection Agency for sponsoring the forum. The biennial forum is truly a great resource for state fish advisory programs.

I understand in presenting closing comments that it is my duty to reflect on recurring themes throughout the forum. I'll be brief and just touch on two themes that struck a chord with me.

The first theme that I would like to comment on and that I believe was pervasive throughout our discussions was the need to build better partnerships. As we heard in the opening remarks, interagency collaborations and partnerships are essential to delivering effective and innovative programs aimed at reducing people's exposures to contaminants in fish. As we heard during the plenary sessions, strong partnerships are critical to such important tasks as developing standardized analytical techniques for measuring emerging contaminants of concern and for creating consistent risk communication messages that the public can count on and not be confused by. I was particularly fond of Washington's message to "Eat fish, be smart, choose wisely."

The second theme I would like to comment on was not one that was explicitly pervasive in our discussions but it was certainly implicitly pervasive and potently stated during the tribute to Kathryn Mahaffey, and that was Alan Stern's great lesson learned from Kate to "always do good science." I too believe that if we continually strive to do good science and keep that premise at our foundation, good things are sure to follow.

In closing, I do hope to see many of you tomorrow at the regional breakout sessions but, in case I don't please have a safe trip home.

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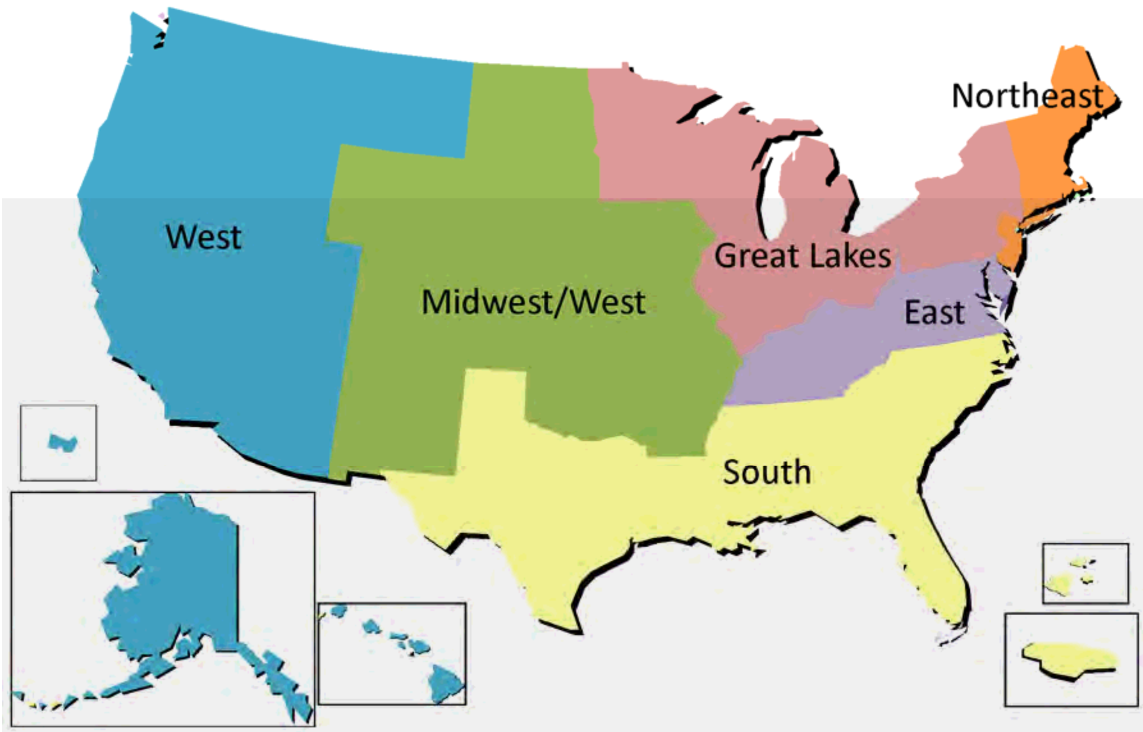
Section II-H

State and Tribal Regional Workgroups

State and Tribal Breakouts by Geographical Region



Regional Breakout Sessions General Topic Ideas

All regional groups should discuss and record recommendations for the following 6 topics:

1. Do you find the current on-line version of the NLFA useful, somewhat useful, or not useful?
2. How do you think the NLFA database can be improved to provide more useful information for government agencies? For the general public?
3. How do you think the NLFA website can be improved to provide more useful information for government agencies? For the general public?
4. Do you think the NLFA website would be more useful if it were split into a publicly accessible and a separate secure website for federal and state agencies?
5. What kind of information should EPA be providing on the NLFA website? For other government agencies and states? For the general public?
6. What types of opportunities for training on fish advisory issues would be helpful to states, territories, and tribes?

Regional Issues

- Great Lakes protocol/outreach for additional contaminants
- Great Lakes restoration initiative – consortium proposal

Sampling and Analysis Issues

- Updates of recent or planned major state and tribal fish sampling efforts
- Emerging contaminants (e.g., PBDEs, PFOAs) - Can states coordinate a regional pilot to test for a variety of emerging contaminants, alternating among states?
- New sampling or analyses methods (e.g., tissue plugs for mercury)
- Monitoring for interstate pollutant transport from regional sources via air and water
- Coordinating with federal agencies (e.g., National parks, Refuges, Superfund)

How are states and tribes:

- Funding their sampling, analysis, and communication efforts
- Reevaluating historic fish contaminant data and long-term data trends
- Regionalizing fish tissue analyses
- Streamlining monitoring programs to get most out of limited resources
- Sampling fish contamination in private lakes and farm ponds
- Handling mining contaminants and impacts
- Monitoring – what is currently monitored, data gaps, and ideas for future efforts
- Dealing with farm-raised fish issues (e.g., omega 3 vs. 6 levels, contaminant levels of PBTs such as dioxins, PCBs, pesticides)

Risk Assessment and Toxicology

- PCB congener data– how are congener data being used to assess toxicity
- Long standing fish advisories (e.g. evaluating data over many years and dealing with conflicting results from one year to the next)
- What to do about dioxin
- Dosing regimes (bolus vs. chronic exposure) and how to assess risks.

Risk Communication

- Updates on changes to recreational and commercial advice by state/tribe (including supermarket signs)
- State and tribal updates on outreach programs (e.g., recommendations and lessons learned)
- Fish advice outreach methods (e.g., listservs, newsletters, etc.)
- Advice on purchase of supermarket fish
- "Back of the truck" commercial fish sales
- Regional advisories covering a portion of a state or tribal jurisdiction
- Immigrant populations - outreach examples and challenges
- Waterfowl/wildlife advisories for mercury or other contaminants

Risks and Benefits

- Quantitative balancing of risks and benefits of fish consumption
- Evaluation of surveys (e.g., Behavioral Risk Factor Surveillance System [BRFSS])
- Biomonitoring practices by states/tribes

Risk Management

- Consistent interstate advisories - Sharing fish contaminant data among jurisdictions to maximize limited resources particularly in border or cross border waters
- Shared messages on shared waters