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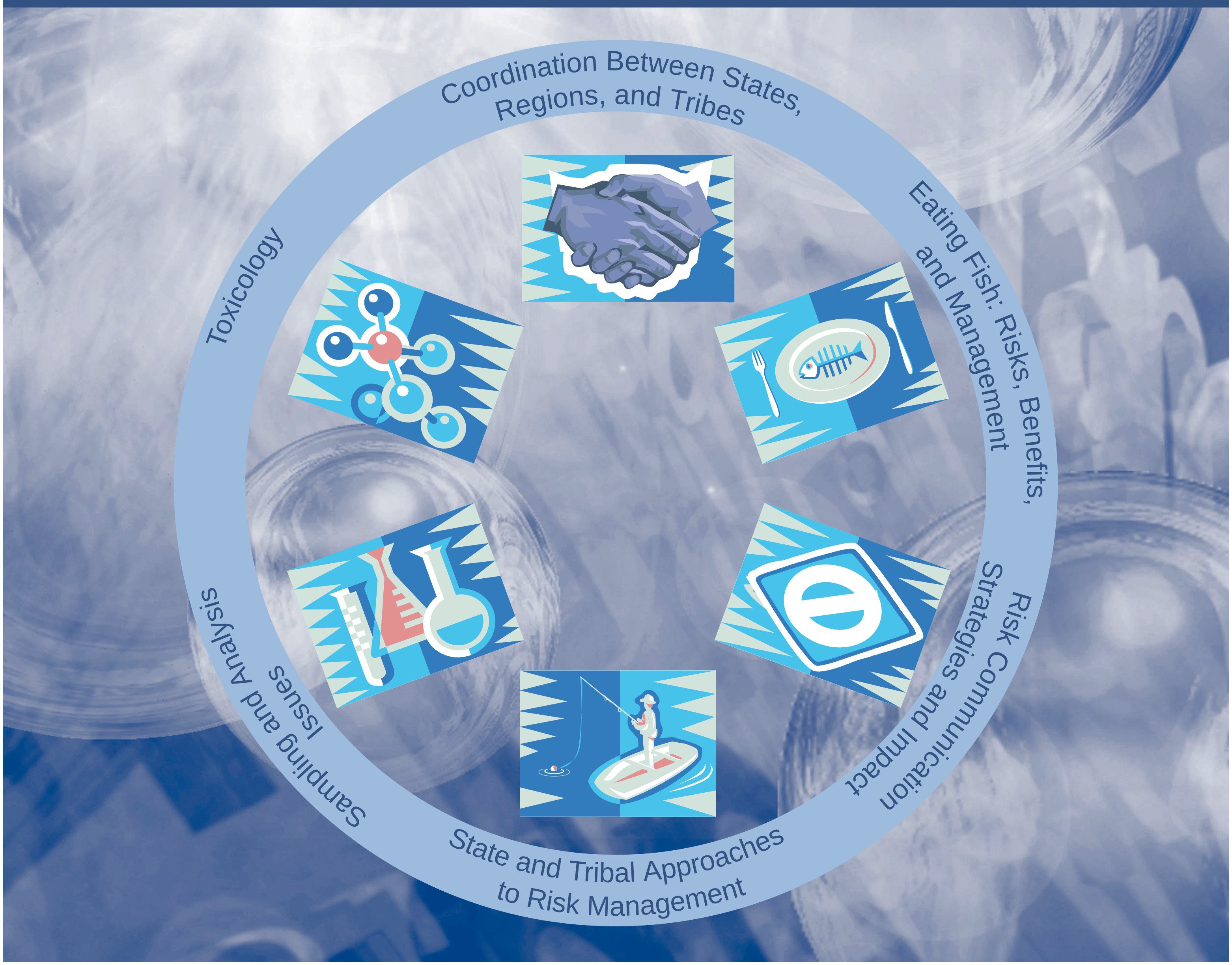
Proceedings of the 2005 National Forum on Contaminants in Fish

Baltimore, Maryland, September 18-21, 2005



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Proceedings of the 2005 National Forum on Contaminants in Fish

Baltimore Marriott Inner Harbor at Camden Yards

Baltimore, Maryland

September 18–21, 2005

EPA-823-R-05-006

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Section II-8. Risk Communication Strategies and Impacts

Acknowledgments

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Although the information in this document has been funded wholly or in part by U.S. EPA, it may not necessarily reflect the views of the Agency, and no official endorsement should be inferred.

[*] RTI International is a trade name of Research Triangle Institute.

Introduction

From September 18–21, 2005, representatives of states, U.S. territories, tribes, federal agencies, and other interested organizations and individuals attended the 2005 National Forum on Contaminants in Fish in Baltimore, Maryland. The U.S. Environmental Protection Agency (U.S. EPA) and the Maryland Department of the Environment co-sponsored the Forum.

The 2005 Forum was the eighth National Forum to be held. The first Forum was convened in 1989, and regular Forums have been held every 15 to 18 months since 1995. The location of the Forum has rotated around the country and has included Alexandria, Virginia (1999), Chicago, Illinois (2001), Burlington, Vermont (2002), San Diego, California (2004), and Baltimore, Maryland (2005).

Early Forums were attended by representatives from states and tribes, but as public interest in fish advisories increased, additional groups became involved. Attendees now include local and national environmental groups, fishing industry representatives, fish marketing firms, fish and shellfish aquaculture groups, members of the medical and allied health communities, the national press, and interested private citizens. In addition, representatives from several federal U.S. agencies including the Food and Drug Administration (FDA), the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), and the National Institute for Environmental Health Sciences (NIEHS), as well as representatives from other countries, routinely participate in the Forum.

Forum agendas are developed by steering committees, generally composed of representatives of state, tribal, and federal agencies. The agendas are developed to provide a variety of perspectives and approaches to assessing and communicating public health risks related to fish contamination. The Forums present the latest science and public health policies.

Topics for the 2005 Forum on Contaminants in Fish included:

- Coordination Between States, Regions, and Tribes
- Sampling and Analysis Issues
- Toxicology
- Eating Fish: Risks, Benefits, and Management
- State and Tribal Approaches to Risk Management
- Risk Communication Strategies and Impacts.

In addition to the technical presentation sessions, states and tribes met in workshops to discuss issues pertinent to their regions. A poster session was also held to further the exchange of ideas.

This document contains the proceedings of the Forum, including the agenda, a summary of workgroup discussions, abstracts of presentations, and slides used by the presenters. Please note that the slides in Section III are the exact presentations given at the Forum. In addition, three presentations are not included at the request of the authors due to pending publication. These are: Krabbenhoft's "Mapping Sensitivity of Aquatic Ecosystems to Mercury Inputs across the Contiguous United States" (Sampling and Analysis session), Arnold's "The Use of Human Biomonitoring as a Risk Management Tool for Deriving Fish Consumption Advice" (State and Tribal Approaches to Risk

Management session), and Knuth's "Great Lakes Indian Fish and Wildlife Commission Risk Management and Communication Program: 'Reducing Health Risks to the Anishinaabe from Methylmercury'" (Risk Communication session). The appendices include biographical information on the speakers, the attendee list, and abstracts of the posters.

This complete document can be accessed from http://www.epa.gov/waterscience/fish/.

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The steering committee for the 2005 Fish Forum included the following individuals:

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Proceedings of the 2005 National Forum on Contaminants in Fish

Section I

Agenda

2005 National Forum on Contaminants in Fish

Baltimore Marriott Inner Harbor at Camden Yards • Baltimore, Maryland
September 18-21, 2005

Agenda

Sunday, September 18, 2005

7:30 a.m. – 5:00 p.m.	*Registration*	*Grand Ballroom Foyer*
9:00 – 10:20 a.m.	State and Tribal Regional Workgroups *Topics of Interest to Group Members*	
10:20 – 10:40 a.m.	***Break***	
10:40 a.m. – 12:00 noon	State and Tribal Regional Workgroups (continued)	
12:00 noon – 1:15 p.m.	***Lunch (on your own)***	
1:15 – 1:30 p.m.	Welcome State and Tribal Coordinators *Jeffrey Bigler, Office of Science and Technology, U.S. Environmental Protection Agency* *Joseph R. Beaman, Technical and Regulatory Services Administration, Maryland Department of the Environment*	*Grand Ballroom*
1:30 – 1:50 p.m.	Joint Federal Mercury Advisory: EPA's Choice of the One Meal/Week Limit for Freshwater Fish Consumption *James F. Pendergast, Office of Science and Technology, U.S. Environmental Protection Agency*	

State/Regional Cooperation Projects

1:50 – 2:10 p.m.	Consistent Advice for Striped Bass and Bluefish Along the Atlantic Coast *Eric Frohmberg, Maine Bureau of Health*	
2:10 – 2:30 p.m.	Great Lakes Mercury Protocol *Pat McCann, Minnesota Department of Health*	
2:30 – 2:50 p.m.	Dealing with Interstate Inconsistencies in Fish Consumption Advisory Protocols in the Upper Mississippi River Basin *John R. Olson, Iowa Department of Natural Resources*	
2:50 – 3:10 p.m.	Gulf Coast State Fish Consumption Advisory for King Mackerel *Joseph Sekerke, Florida Department of Health*	
3:10 – 3:40 p.m.	***Break***	
3:40 – 4:00 p.m.	Advisories in Shared Waters—Two States Achieve Consistent Advice *Gary A. Buchanan, New Jersey Department of Environmental Protection*	
4:00 – 4:20 p.m.	Q&A Session	

Coordination Between State and Tribal Nations

4:20 – 4:40 p.m.	Akwesasne Mohawk Fish Advisory Communication *Anthony M. David, Environment Division, St. Regis Mohawk Tribe*	
4:40 – 5:00 p.m.	Development Processes of Consumption Advisories for the Cheyenne River Sioux Indian Reservation *Jerry BigEagle, Environmental Protection Department, Cheyenne River Sioux Tribe*	
5:00 – 5:20 p.m.	Q&A Session	
	Break for Dinner (on your own)	
7:00 – 9:00 p.m.	Workgroup Meeting: Atlantic Coast PCB Advisory	*Chesapeake Room*
9:00 p.m.	*Adjourn for the Day*	

Monday, September 19, 2005

8:00 – 8:20 a.m.

Formal Welcome and Introductions — *Grand Ballroom*

General Forum Moderators:
Jeffrey Bigler, Office of Science and Technology, U.S. Environmental Protection Agency

Joseph R. Beaman, Technical and Regulatory Services Administration Maryland Department of the Environment

Welcoming Remarks

Benjamin Grumbles, Office of Water, U.S. Environmental Protection Agency

Kendl P. Philbrick, Maryland Department of the Environment

8:20 – 8:35 a.m.

EPA Advisory Program Update

James F. Pendergast for Denise Keehner, Office of Science and Technology, U.S. Environmental Protection Agency

8:35 – 8:50 a.m.

Seafood Safety Program FDA Advisory Program Update

Donald W. Kraemer, Food and Drug Administration

Sampling and Analysis Issues

Moderator: Robert Brodberg, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency

8:50 – 9:00 a.m.

Introduction

Robert Brodberg, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency

9:00 – 9:20 a.m.

Key Considerations in Fish Tissue Sampling Design

Lyle Cowles, Region 7, U.S. Environmental Protection Agency

9:20 – 9:40 a.m.

How Many Fish *Do* We Need? Protocol for Calculating Sample Size for Developing Fish Consumption Advice

Jim VanDerslice, Washington State Department of Health

9:40 – 10:00 a.m.

US FDA's Total Diet Study

Katie Egan, Food and Drug Administration

10:00 – 10:20 a.m.

Break

Sampling and Analysis Issues (continued)

10:20 – 10:40 a.m.

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

David McBride, Washington State Department of Health

10:40 – 11:00 a.m.

Seafood Safe Case Study: Voluntary Seafood Contaminant Testing and Labeling Program

Henry W. Lovejoy, Seafood Safe, LLC

John R. Cosgrove, AXYS Analytical Services, Ltd.

Colin Davies, Brooks Rand

11:00 – 11:20 a.m.

Strategy for Assessing and Managing Risks from Chemical Contamination of Fish from National Fish Hatcheries

George Noguchi, Linda L. Andreasen, and David Devault, U.S. Fish and Wildlife Service

11:20 – 11:40 a.m.

Variability of Mercury Concentrations in Fish with Season, Year, and Body Condition

Paul Cocca, U.S. Environmental Protection Agency

11:40 a.m. – 12:00 noon

Establishing Baseline Mercury Fish Tissue Concentrations for Regulatory Analysis

Janet F. Cakir, Office of Air and Radiation, U.S. Environmental Protection Agency

12:00 noon – 1:10 p.m.

Lunch (on your own)

Monday, September 19, 2005 (continued)

Sampling and Analysis Issues (continued)

Moderator: Robert Brodberg, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency

1:10 – 1:30 p.m. — **Mapping Sensitivity of Aquatic Ecosystems to Mercury Inputs Across the Contiguous United States**
David Krabbenhoft, U.S. Geological Survey

1:30 – 1:50 p.m. — **Projected Mercury Concentrations in Freshwater Fish and Changes in Exposure Resulting from the Clean Air Mercury Rule**
Lisa Conner, U.S. Environmental Protection Agency

Toxicology

Moderators: David McBride, Washington State Department of Health
Joseph Sekerke, Florida Department of Health
Amy D. Kyle, University of California, Berkeley

1:50 – 2:00 p.m. — **Introduction**
David McBride, Washington State Department of Health
Moderator: Amy D. Kyle, University of California, Berkeley

2:00 – 2:20 p.m. — **Mercury Exposure in Wisconsin**
Lynda M. Knobeloch, Wisconsin Department of Health and Family Services

2:20 – 2:40 p.m. — **Physiological and Environmental Importance of Mercury-Selenium Interactions**
Nicholas V.C. Ralston, University of North Dakota

2:40 – 3:00 p.m. — **NHANES 1999-2002 Update on Mercury**
Kathryn R. Mahaffey, U.S. Environmental Protection Agency

3:00 – 3:30 p.m. — ***Break***

3:30 – 4:00 p.m. — **A Fresh Look at the Uncertainty Factor Adjustment in the Methylmercury RfD**
Alan H. Stern, Division of Science, Research, and Technology, New Jersey Department of Environmental Protection

4:00 – 4:20 p.m. — **Review of Cardiovascular Health Effects of Mercury—A U.S. Perspective**
Eric B. Rimm, Departments of Epidemiology and Nutrition, Harvard School of Public Health

4:20 – 4:40 p.m. — **Cardiovascular Health Effects of Mercury—European Data**
Eliseo Guallar, Johns Hopkins Bloomberg School of Public Health

4:40 – 5:10 p.m. — **Mercury Panel Discussion**
Moderator: Amy D. Kyle, University of California, Berkeley

6:30 – 8:30 p.m. — **Reception and Poster Displays** — *Stadium Ballroom, 2nd Floor*

8:30 p.m. — ***Adjourn for the Day***

Tuesday, September 20, 2005

Toxicology (continued)

Moderators: David McBride, Washington State Department of Health
Joseph Sekerke, Florida Department of Health
Amy D. Kyle, University of California, Berkeley

8:00 – 8:10 a.m.	**Introduction** *Joseph Sekerke, Florida Department of Health*	*Grand Ballroom*
8:10 – 8:30 a.m.	**Developmental Toxicity of PFOS and PFOA** *Christopher Lau, U.S. Environmental Protection Agency*	
8:30 – 8:50 a.m.	**Overview of National Toxicology Program Studies of Interactions Between Individual PCB Congeners** *Nigel Walker, National Institute of Environmental Health Sciences, National Institutes of Health*	
8:50 – 9:10 a.m.	**Establishing PCB Fish Advisories: Consideration of the Evolving Science** *John D. Schell, BBL Sciences*	
9:10 – 9:30 a.m.	**History of Mercury Action Level and PCB Tolerance** *P. Michael Bolger, Food and Drug Administration*	
9:30 – 9:50 a.m.	**U.S. EPA's New Cancer Guidelines** *Rita Schoeny, Office of Water, U.S. Environmental Protection Agency*	
9:50 – 10:20 a.m.	***Break***	

Eating Fish: Risks, Benefits, and Management

Moderator: Amy D. Kyle, University of California, Berkeley

10:20 – 10:30 a.m.	Introduction—Current Approach to Risk-Based Fish Advisories *Pat McCann, Minnesota Department of Health* *Moderator: Amy D. Kyle, University of California, Berkeley*

Omega-3 Fatty Acids

10:30 – 10:50 a.m.	Omega-3 Fatty Acids: The Basics *William S. Harris, University of Missouri-Kansas City School of Medicine*

Health Benefits of Fish Consumption

10:50 – 11:10 a.m.	Adult Health Benefits of Fish Consumption *Eric B. Rimm, Departments of Epidemiology and Nutrition, Harvard School of Public Health*
11:10 – 11:30 a.m.	DHA and Infant Development *Susan E. Carlson, University of Kansas Medical Center*
11:30 – 11:50 a.m.	DHA and Contaminants in Fish: Balancing Risks and Benefits for Neuropsychological Function *Rita Schoeny, U.S. Environmental Protection Agency*
11:50 a.m. – 1:00 p.m.	***Lunch (on your own)***

Tuesday, September 20, 2005 (continued)

Health Benefits of Fish Consumption (continued)

1:00 – 1:20 p.m. **Fish Consumption and Reproductive and Developmental Outcomes**
Julie L. Daniels, School of Public Health, University of North Carolina at Chapel Hill

1:20 – 1:40 p.m. **Panel Discussion on the Health Benefits of Fish Consumption in Adults**
Moderator: Amy D. Kyle, University of California, Berkeley

Balancing Risks and Benefits

1:40 – 2:00 p.m. **Nutrient Relationships in Seafood: Selections to Balance Benefits and Risks**
Ann L. Yaktine, Institute of Medicine, The National Academies

2:00 – 2:20 p.m. **Maternal Fish Consumption, Hair Mercury, and Infant Cognition in a U.S. Cohort**
Emily Oken, Harvard Medical School

2:20 – 2:50 p.m. ***Break***

Toxicology (continued)

Moderators: David McBride, Washington State Department of Health
Joseph Sekerke, Florida Department of Health

2:50 – 3:10 p.m. **PBDE Exposure and Accumulation in Fish: The Impact of Biotransformation**
Heather M. Stapleton, Duke University

3:10 – 3:30 p.m. **PBDEs: Toxicology Update**
Linda S. Birnbaum, U.S. Environmental Protection Agency

State and Tribal Approaches to Risk Management

Moderator: Randall Manning, Georgia Department of Natural Resources

3:30 – 3:40 p.m. **Introduction**
Moderator: Randall Manning, Georgia Department of Natural Resources

3:40 – 4:00 p.m. **"Eating Fish for Good Health": A Brochure Balancing Risks and Benefits**
Eric Frohmberg, Maine Bureau of Health

4:00 – 4:20 p.m. **The Use of Human Biomonitoring as a Risk Management Tool for Deriving Fish Consumption Advice**
Scott M. Arnold, Alaska Division of Public Health

4:20 – 4:40 p.m. **A Comprehensive Risk Framework Presented to the Mohawks of Akwesasne**
Anthony M. David, Environment Division, St. Regis Mohawk Tribe

4:40 – 5:00 p.m. **Communicating the Nutritional Benefits and Risks of Fish Consumption**
Charles R. Santerre, Purdue University

5:00 – 5:20 p.m. **Open Discussion**
Moderator: Randall Manning, Georgia Department of Natural Resources

5:20 p.m. ***Adjourn for the Day***

Wednesday, September 21, 2005

Risk Communication Strategies and Impacts

Moderator: Joseph R. Beaman, Technical and Regulatory Services Administration, Maryland Department of the Environment

8:00 – 8:10 a.m.	**Introduction** *Joseph R. Beaman, Technical and Regulatory Services Administration, Maryland Department of the Environment*	*Grand Ballroom*
8:10 – 8:30 a.m.	**Implementation of the FDA/U.S. EPA Joint Advisory** *David W.K. Acheson, Food and Drug Administration*	
8:30 – 8:50 a.m.	**Risk Communication: Lessons Learned about Message Development and Dissemination** *Joanna Burger, Environmental and Occupational Health Sciences Institute, Rutgers University*	

Communicating to Populations: Issues and Answers

Moderator: Joseph R. Beaman, Technical and Regulatory Services Administration, Maryland Department of the Environment

8:50 – 9:10 a.m.	**Maine's Moms Survey—Evaluation of Risk Communication Efforts** *Eric Frohmberg, Maine Bureau of Health*
9:10 – 9:30 a.m.	**Communication of Fish Consumption Associated Risks to Fishermen in the Baltimore Harbor and Patapsco River Area: Perspectives and Lessons Learned** *Joseph R. Beaman, Technical and Regulatory Services Administration, Maryland Department of the Environment*
9:30 – 9:50 a.m.	**Fish Consumption Patterns and Advisory Awareness Among Baltimore Harbor Anglers** *Karen S. Hockett, Conservation Management Institute, Virginia Tech University*
9:50 – 10:20 a.m.	***Break***
10:20 – 10:40 a.m.	**Great Lakes Indian Fish and Wildlife Commission Risk Management and Communication Program: "Reducing Health Risks to the Anishinaabe from Methylmercury"** *Barbara A. Knuth, Department of Natural Resources, Cornell University*
10:40 – 11:00 a.m.	**Problems With Media Reports of Fish-Contaminant Studies: Implications for Risk Communication** *Barbara A. Knuth for Judy D. Sheeshka, Department of Family Relations and Applied Nutrition, University of Guelph*
11:00 – 11:20 a.m.	**The Presentation of Fish in Everyday Life: Seeing Culture Through Signs in the Upper Peninsula of Michigan** *Melanie Barbier, Departments of Fisheries and Wildlife and Sociology, Michigan State University*

Novel Ways To Communicate

Moderator: Joseph R. Beaman, Technical and Regulatory Services Administration, Maryland Department of the Environment

11:20 – 11:40 a.m.	**Promoting Fish Advisories on the Web: WebMD Case Study** *Michael Hatcher for Susan Robinson, Centers for Disease Control and Prevention*
11:40 a.m. – 12:00 noon	**Seafood Safe Case Study: Voluntary Seafood Contaminant Testing and Labeling Program** *Henry W. Lovejoy, Seafood Safe, LLC* *Barbara A. Knuth, Department of Natural Resources, Cornell University*
12:00 noon – 12:30 p.m.	**Closing Remarks** *General Forum Moderators:* *Jeffrey Bigler, Office of Science and Technology, U.S. Environmental Protection Agency* *Joseph R. Beaman, Technical and Regulatory Services Administration, Maryland Department of the Environment*
12:30 p.m.	***Adjournment***

Proceedings of the 2005 National Forum on Contaminants in Fish

Section II

Summaries

Please note that the slides in Section III are the exact presentations given at the Forum.

State and Tribal Regional Workgroups

Forum participants were divided into six separate workgroups based on the geographical region in which they resided: Northeast, East, South, Great Lakes, Midwest/West, and West. Each regional workgroup met independently to discuss issues related to the states and tribes in their region. In addition, representatives of each state were presented with a list of issues to form the basis for much of the discussion. An additional group for attendees not representing states or tribes (the Nongovernmental Workgroup) was also organized. Summarized below are the highlights of the workgroup discussions and the questionnaires.

Northeast

The Northeast region was defined as the geographical area including the states of Connecticut, Maine, Massachusetts, New Jersey, New Hampshire, Rhode Island, and Vermont. Representatives from five states (Maine, Massachusetts, New Jersey, Rhode Island, and Vermont) and one tribe (Passamaquoddy Tribe at Pleasant Point) participated in the forum group discussion.

Evaluation of Advisories

- All five states in this region evaluate awareness or effectiveness of advisories. The frequency of such evaluations ranges from "infrequently" or "periodically" to every 3–5 years.

Coordination of Advisory Development/Management between States and Tribes

- None of the states or tribes in this region coordinates advisory development/management with other tribes or states.

Collection of Data on Adult Mercury Poisonings

- Three states and one tribe in this region collect data on adult mercury poisonings. However, New Jersey relies on occupational mercury samples that are reported to the New Jersey Department of Health on a mandatory basis (not poisonings per se).

Biomonitoring for Bioaccumulative Contaminants

- Three states and one tribe in this region do not monitor for bioaccumulative contaminants at this time.
- Massachusetts has extensive information on polychlorinated biphenyl (PCB) levels in people who live near the New Bedford Harbor and General Electric Housatonic River Superfund sites; data have shown higher PCB levels in blood of fish eaters.
- One urban New Jersey hospital obstetric department currently collects meconium, amniotic fluid, and cord blood for research. These are analyzed for phthalates, pesticides, and mercury. Analysis for PCBs and polybrominated diphenyl ether (PBDE) is anticipated.

Revisiting Mercury Advisory Sites

- All five states in this region revisit existing mercury advisory sites for tissue testing. The extent of such visits ranges from conducting continued monitoring at selected sites to revisiting sites every 5 years (if funded) or as resources allow.

Mercury Fish Tissue-Based Water Quality Criterion in Water Quality Standards

- Only two states in this region have adopted a mercury fish tissue-based water quality criterion in their water quality standards; three states and one tribe in this region have not.

Fish Tissue-Based Water Quality Criterion for PCBs

- Environmental regulatory agencies need a criterion (states would like the analytical methods for PCBs to be updated and would like health agencies to be involved.)
- Three states and one tribe in this region agree there should be a fish tissue-based water quality criterion for PCBs (two of these indicate it should be for total PCBs).

Issues/Concerns/Large-Scale Efforts

- General
  - Most/all feel the "message" about advisories is very sensitive and needs careful crafting.
  - Tribal coordination – The state of Maine and the Passamaquoddy Tribe plan to talk further (e.g., to follow up with the public health tracking person regarding asthma and perhaps other concerns).
  - There is general interest in letting states consider impacts of out-of-state sources on mercury impacts.
- Vermont
  - Sea lampreys are attacking sport fish in Lake Champlain, the Hudson River, and the St. Lawrence River. The lampreys cannot be eradicated, so they must be controlled using TFM, or 3-trifluoromethyl-4-nitrophenol (permit required for use). Human toxicity data are needed on TFM.
  - Dioxin contamination has been newly discovered in Vermont, creating concern over drinking water (e.g., city of Burlington).
- Rhode Island
  - Grocery/point-of-sale. The state is evaluating a request by environmental groups to require mercury warning on fish in grocery stores.
  - The state conducts a statewide freshwater fish survey.
  - The state has released an Atlantic Coast striped bass and bluefish PCB advisory.
- New Jersey
  - The state conducts a survey of marine estuarine fish that measures PCB analytes, pesticides, mercury, and pervasive developmental disorders (PDDs) in striped bass, bluefish, American eel, blue crab, and lobster. Levels for most contaminants have

dropped below those for previous years. The survey is done on a 5-year cycle, and each region of the state is included. This effort was started in 2002; however, funding is not available every year. If multiple chemicals are present, the state takes the most conservative for advice. Mercury levels drive freshwater fish advisories. PCB levels drive marine advice (and also some freshwater advice). The state is concerned about dioxins in New York/New Jersey Harbor.

- New Jersey will issue advice for commercial fish (mercury) later this year.
- No consensus on risk decision criteria, but getting closer.
- Recommends that advisories be simplified. Aiming for a three-tier advisory (simple):
  - 1st tier: 1 general paragraph regarding marine fish
  - 2nd tier: 1 general paragraph regarding freshwater fish
  - 3rd tier: book – waterbody-specific, detailed advice.
- Concerned about pharmaceuticals (19 pharmaceutical companies are located in the state) in drinking water in relation to human health and ecotoxicologic effects (ad hoc endocrine disrupter workgroup).

- The Passamaquoddy Tribe
  - Recently, tribal members began switching from freshwater fish to marine fish. There is a high awareness about freshwater fish advisories, and the perception has developed that all freshwater fish are contaminated. Tribal members are concerned about mercury in lobsters, clams, scallops, and winter flounder. They need more analytical data (many are now eating marine fish because they perceive them to be cleaner).
  - Tribal members are concerned about high levels of mercury in porpoise in New Brunswick. This food is eaten at funerals and baby showers; it is a traditional food for rituals and celebrations. There is regular consumption among tribal members – more than 1 time/week consumption (very high). Legal issues and tribal sovereignty complicate enforcement of the Marine Mammal Protection Act.
  - There is a high mercury load in soil along the St. Croix River, due to the world’s largest tannery (near Calais). Sediment gets stirred up when dredging (affects scallops?). The tribe requests additional monitoring. Fish consumption is high in this tribe, which has about 3,500 members on two reservations.
  - The tribe does not agree with the U.S. Environmental Protection Agency’s (U.S. EPA’s) fish consumption rate data, because people in this tribe consume much more fish more frequently than the data show.
  - The tribe uses the Women, Infants, and Children (WIC) program extensively due to increased unemployment. Therefore, its members consume the tuna that is distributed by WIC. However, the tribe believes the state WIC should switch from tuna to canned salmon, as the Hawaii WIC has done. The timing of WIC food specifics varies with state of pregnancy and age of child, etc. WIC of every state could address fish-related issues broadly. The tribe recommends that the steering committee get a WIC speaker for the next forum.

- The tribe is concerned about pharmaceuticals. The Gulf of Maine treatment facility study will (hopefully) locate discharges. On the St. John River, 60 percent of the water is not treated, and raw sewage is discharged directly into the river (affecting 100,000 people). The tribe is concerned about drinking water intakes downstream from wastewater or raw sewage outfalls and residues of pharmaceuticals in fish.

■ Massachusetts

- Behavioral Risk Factor Surveillance System (BRFSS) questions. Results are due out Spring/Summer 2006. The questions address whether the public is aware of advisory/specific consumption information by species (tuna, sportfish). BRFSS is representative of the state and allows one to look at subgroups, too.
- New Bedford Harbor. After cleanup, PCB levels are much lower. The state is evaluating policies concerning consumption, and is continuing outreach with the U.S. EPA (Fish Smart Campaign).
- General Electric Housatonic River. This fall, the state will release a major public health assessment (with Agency for Toxic Substances and Disease Registry, ATSDR, cooperative agreement).
- Education and outreach. Last year, information about fish advisories was sent to 351 local boards of health and was very well received. In addition, mailings were sent to local physicians. Brochures were translated into eight different languages.
- Summer 2003 oil spill in Buzzards Bay. The state worked with Marine Fisheries to reopen shellfish beds (polycyclic aromatic hydrocarbons, PAHs).

■ Maine

- Coastal Striped Bass and Bluefish Advisory Workgroup on PCBs). Toxicology and biology draft chapters have been posted on the Internet. Data and advisory draft chapters will be posted soon (in next 2 months). The organizational group will develop a single combined document from these chapters. How to measure the workgroup's success (evaluate consistent methods? consensus advice?) Atlantic mackerel – future work – could be a good future species to recommend eating. Need data on PCBs/dioxins.
- Evaluation of state's outreach (survey = 24 pages). Learned some definite things concerning what to do and what not to do (e.g., difficult to obtain hair samples). Wisconsin and Minnesota – new mother evaluation of advisory awareness being done (2 pages). Karen Knaebel (Vermont) evaluating awareness. Do new moms remember getting brochure from doctors during prenatal visits? Is there a variation between first pregnancy and later pregnancy? Do new moms get too much information – does message get buried?
- Brochure overhaul is a major effort. Approach/focus – changing from avoiding x-y-z fish to eating a-b-c fish.
- Benefits data from babies. Analysis of reported "benefits"—omega-3s. Question: Is fish consumption associated with increased socioeconomic status and better home environment? Premature babies do benefit. In 1999 and 2001, did surveys of women of childbearing age. In 2004, did survey of new moms.

East

The East region was defined as the geographical area including the states of Delaware, Kentucky, Maryland, Tennessee, Virginia, and West Virginia, and the District of Columbia. Representatives from five states and the District of Columbia participated in the forum group discussion. No representatives from tribes participated in this discussion group.

Evaluation of Advisories

- Two states in this region evaluate awareness or effectiveness of advisories, on either an ad hoc or one-time basis.

Coordination of Advisory Development/Management between States and Tribes

- None of the states or tribes in this region coordinate advisory development/management with tribes or states. Tennessee notes that they have no tribal lands in the state.

Collection of Data on Adult Mercury Poisonings

- Only one state (Maryland) in this region collects data on adult mercury poisonings. However, mercury poisoning is a physician-reportable / industry-reportable illness in Virginia.

Biomonitoring for Bioaccumulative Contaminants

- Only two states in this region monitor for bioaccumulative contaminants at this time. One state monitors in humans (blood and hair), while the other monitors dioxin, arsenic, cadmium, copper, lead, mercury, chromium, chlordane, PCB, DDT [1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane], DDE [1,1-
- dichloro-2,2-bis(p-chlorophenyl) ethylene)], DDD [1,1-dichloro-2,2-bis(p-chlorophenyl)], aldrin, dieldrin, and endrin in fish. Three states do not monitor contaminants in humans.

Revisiting Mercury Advisory Sites

- Four states in this region revisit existing mercury advisory sites for tissue testing. The frequency of visits ranges from annual visits to every 5 years.

Mercury Fish Tissue-Based Water Quality Criterion in Water Quality Standards

- Only three states in this region have adopted a mercury fish tissue-based water quality criterion in their water quality standards.
- Tennessee uses a value of 0.5 ppm, with no plans to lower the value to 0.3 ppm.
- The District of Columbia uses a value of 0.4 ppm.

Fish Tissue-Based Water Quality Criterion for PCBs

- Five states in this region agree there should be a fish tissue-based water quality criterion for PCBs. Three states indicate it should be based on total PCBs. Kentucky’s current analysis is based on total aroclors.

Issues/Concerns

- The East region workgroup indicates that the lack of U.S. EPA/Food and Drug Administration (FDA) cooperation is a concern (e.g., justification for FDA action level for PCBs).
- Kentucky and Tennessee raised the issue that park personnel want to stock large catfish in park lakes for their patrons, and that they need to look at feed used for aquaculture. Kentucky is monitoring its aquaculture (freshwater prawns, tilapia, catfish) and testing for PCBs, mercury, and pesticides.
- Paddlefish Roc (imported Russian caviar) is sold as swordfish. There is a problem with names of fish commercially sold.
- West Virginia has some aquaculture industry raising Arctic char in abandoned mines with good water quality (those with low-sulfur coal deposits).
- The group is concerned about how to identify subsistence fishers. In the District of Columbia, they survey every fifth fishing person in the Potomac/Anacostia/Rock Creek areas, asking:
  - Do you fish?
  - How much do you fish?
  - How long have you lived in the area?
  - Did you learn to fish from family? Intergenerational behavior?
  - Do you eat whatever you catch?

South

The South region was defined as the geographical area including the states of Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Texas. Representatives from all eight states participated in the forum group discussion. No representatives from tribes participated in this discussion group.

Evaluation of Advisories

- Three states in this region evaluate awareness or effectiveness of advisories.
- Georgia and Florida have no funding available to evaluate effectiveness of their advisories.
- In North Carolina, people use advisory warning signs as grills for cooking the fish under advisory. A Maine/U.S.EPA/Wisconsin study evaluated the effectiveness of North Carolina's and other states' advisories. They found low awareness of advisories, which prompted North Carolina to change from location-specific to fish-specific advisories.
- There is no statewide assessment in Texas, but some local areas are assessed. Texas notes that it is difficult and costly to evaluate effectiveness.

- In South Carolina, some surveys are done locally. The most effective are taken with creel surveys. It is difficult to get people to change their behavior; deaths would have to occur before individuals would adhere to fish advisories.
- Mississippi has performed local surveys via a U.S. EPA grant. This approach has proved very efficient.

Coordination of Advisory Development/Management between States and Tribes

- Six states in this region coordinate advisory development/management with tribes or states.
- States agree that there should be more coordination with tribes.
- South Carolina observes that Catawba Indians taste a creosote-like taste in catfish caught locally.

Collection of Data on Adult Mercury Poisonings

- Only three states in this region collect data on adult mercury poisonings; four states do not.
- In Florida, mercury poisoning is physician reportable, but because the state has had trouble obtaining all data from physicians, the law has been changed so that laboratory results are now sent directly to the state. The highest mercury level observed in blood was 184 µg/L. In 2004, investigations began when blood, hair, or urine exceeded criterion levels; however, several hurricanes in quick succession prevented further follow up.
- North Carolina plans to examine blood and hair mercury levels for subsistence populations, and to model major sources (air) in areas with fish advisories.
- Hair and blood monitoring is done in Texas, but not routinely.

Biomonitoring for Bioaccumulative Contaminants

- Six states in this region monitor for bioaccumulative contaminants at this time, including mercury, PCBs, aroclors, DDT, and other pesticides. On the questionnaires, some states answered this question for monitoring in humans, while others answered for monitoring in fish.
- Georgia monitors 43 contaminants, including aroclors but not congeners, in fish but not in humans.
- Florida monitors mercury in fish, but has no formal biomonitoring in humans.
- Louisiana performs biomonitoring in fish advisories and has been monitoring PCB aroclors. The state is in the process of determining whether to do dioxin-like or non-dioxin-like PCBs. They monitor pesticides in fish. Louisiana is moving toward laboratory-reportable hair and blood mercury level results.
- Alabama monitors aroclors and pesticides in fish, but has no formal biomonitoring in humans. There is monitoring in localized areas for 13 specific dioxin-like congeners.

- Texas monitors 119 PCB compounds previously in fish and now 200 congeners and has found an increased total level (predominantly non-dioxin-like) and issued advisories for 1,1,1-trichloroethane and vinyl chloride. Texas monitors mercury blood levels near Superfund sites; elevated levels have been correlated with fish consumption.
- North Carolina monitors mercury levels in the hair and blood of subsistence male fishermen in areas issued advisories. Monitoring results have shown a correlation in that the highest blood and hair mercury levels are found in those who eat more advisory fish (e.g., bowfin). The individual with the highest blood level (129 µg/L) had no signs or symptoms of mercury poisoning. The state plans to sample blood/hair mercury levels in other subsistence fishermen, monitor fish, model air sources in areas fished by subsistence fishermen, administer consumption survey (local and commercial), and try to validate the model. In fish, North Carolina monitors for mercury, 17 non-dioxin-like congeners (U.S. EPA Method 8082A), 2 dioxin-like congeners, and PBDEs (select stations, limited to urban areas, follow U.S. EPA methods). The state has researched foam manufacturers in the state that use PBDEs as fire retardants, and none were located near waterbodies.
- South Carolina monitors mercury, pesticides, and herbicides in fish at 100–125 sites per year. They do some local biomonitoring for PCBs.

Revisiting Mercury Advisory Sites

- Seven states in this region revisit existing mercury advisory sites for tissue testing, with frequency of visits ranging from every year to every 5 years.

Mercury Fish Tissue-Based Water Quality Criterion in Water Quality Standards

- Only two states in this region have adopted a mercury fish tissue-based water quality criterion in their water quality standards; five states have not.
- Georgia applies 13 different bioaccumulation factors to 0.3 mg/kg to get an acceptable water quality standard.
- Florida uses 12 ppt for freshwater fish and 25 ppt for marine fish (0.3 mg/kg is too high for Florida, but 1 mg/kg is up for discussion to account for freshwater fish). Bioaccumulation factors have been developed for the Everglades, but the state is waiting on guidance for developing bioaccumulation factors.
- North Carolina is examining more than 13 bioaccumulation factors.

Fish Tissue-Based Water Quality Criterion for PCBs

- Three states in this region agree there should be a fish tissue-based water quality criterion for PCBs (one state feels it should be for total PCBs, another for congeners).
- The states agree there are not enough scientific data and guidance currently available to develop such a level. Adequate science for toxicity assessment is needed and information to extrapolate from a level in fish to a water concentration. The U.S. EPA needs to develop adequate guidance before establishing a fish criterion for PCBs.

Great Lakes

The Great Lakes region was defined as the geographical area including the states of Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, and Wisconsin. Representatives from all 10 states and one tribe (St. Regis Mohawk Tribe, New York) participated in the forum group discussion.

Evaluation of Advisories

- Four states in this region evaluate awareness or effectiveness of advisories, but typically on a sporadic basis (e.g., when funding is available, with assistance from outside sources, as a special project).

Coordination of Advisory Development/Management between States and Tribes

- Two states and one tribe in this region coordinate advisory development/management with tribes or states, but indicate that additional coordination is needed.
- Four states indicate they have no tribal lands in their states.

Collection of Data on Adult Mercury Poisonings

- One state (Indiana) in this region collects data on adult mercury poisonings. The Indiana Poison Control Center collects these data.

Biomonitoring for Bioaccumulative Contaminants

- Five states and one tribe in this region monitor for bioaccumulative contaminants in fish. The contaminants include PCBs, mercury, organochlorine pesticides, lead, cadmium, DDD, DDT, endrin, dieldrin, chlordane, heptachlor, heptachlor epoxide, hexachlorobenzene, dioxins/furans, and mirex.

Revisiting Mercury Advisory Sites

- Eight states in this region revisit existing mercury advisory sites for tissue testing, ranging from as needed to every 15 years.

Mercury Fish Tissue-Based Water Quality Criterion in Water Quality Standards

- Only two states in this region have adopted a mercury fish tissue-based water quality criterion in their water quality standards.

Fish Tissue-Based Water Quality Criterion for PCBs

- None of the states in this region indicate there should be a fish tissue-based water quality criterion for PCBs.
- It is very difficult to detect PCBs in water.
- Wisconsin has water quality standards for PCBs in water-column concentrations to prevent accumulation in tissues. They are human health-based and wildlife health-based concentrations.

- One state is concerned over the cost and sampling complexity of a congener-based approach.

Midwest/West

The Midwest/west region was defined as the geographical area including the states of Arkansas, Colorado, Kansas, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, and Wyoming. Representatives from five states (Arkansas, New Mexico, North Dakota, Oklahoma, and Wyoming) and one tribe (Cheyenne River Sioux Tribe) participated in the forum group discussion.

Evaluation of Advisories

- Five states in this region do not evaluate awareness or effectiveness of advisories, but one tribe does through an annual angler survey.

Coordination of Advisory Development/Management between States and Tribes

- Four states and one tribe in this region coordinate advisory development/management with tribes or states, at least on a limited or informal basis.
- New Mexico coordinates with the Cochiti Tribe.
- The Cheyenne River Sioux Tribe indicates there is conflict on common waters.

Collection of Data on Adult Mercury Poisonings

- Two states in this region collect data on adult mercury poisonings on a limited basis or from occupational testing.
- States in this region indicate interest in federal money for biomonitoring.

Biomonitoring for Bioaccumulative Contaminants

- Four states and one tribe in this region monitor for bioaccumulative contaminants in fish (mercury, metals, organics, PCBs, chlordane, DDT, toxaphene, dieldrin, endrin) or humans (lead).
- The group was confused whether biomonitoring regarded fish or humans.

Revisiting Mercury Advisory Sites

- Five states and one tribe in this region revisit existing mercury advisory sites for tissue testing, ranging from variable frequency to once every 7 years.

Mercury Fish Tissue-Based Water Quality Criterion in Water Quality Standards

- Only two states and one tribe in this region have adopted a mercury fish tissue-based water quality criterion in their water quality standards; three states have not.
- New Mexico adopted 0.3 ppm.
- Oklahoma is currently using 0.75 or 1 mg/kg, but this is due to be changed.
- The Cheyenne River Sioux Tribe has its own protocol.

Fish Tissue-Based Water Quality Criterion for PCBs

- Two states and one tribe in this region agree there should be a fish tissue-based water quality criterion for PCBs (toxic equivalent [TEQ] based).
- States in this region indicate a need for laboratory tissue reference material (U.S. EPA) and certification.

Issues/Concerns

- How to communicate advisories:
  - Signs at waters
  - Regulations
  - With licenses
  - Phone numbers
- This group requests that U.S. EPA laboratories conduct a study to compare standard (or acid digestion) and direct mercury analysis methods. Oklahoma indicates the need for interlaboratory/method comparison studies.

West

The West region was defined as the geographical area including the states of Alaska, Arizona, California, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, and Washington. Representatives from eight states (Alaska, California, Hawaii, Idaho, Montana, Nevada, Oregon, and Washington) participated in the forum group discussion. No representatives from tribes participated in this discussion group.

Evaluation of Advisories

- Five states of this region evaluate awareness or effectiveness of advisories, ranging in frequency from infrequently or “first time this year” to continuously or seasonally. No special funds were available to do this work.
- Some states monitor awareness/effectiveness of advisories by connecting to the Behavioral Risk Factors Surveillance Survey (BRFSS), creel surveys, environmental health tracking, and WIC programs. It was noted that questions cost money and there are typically no state funds for this. A recommendation was made to require fish questions nationally in BRFSS.
- Some states monitor brochure distribution and Web site hits.
- Some states indicate that evaluation occurs infrequently.

Coordination of Advisory Development/Management between States and Tribes

- There is some coordination between states and tribes, but this varies.
- Five states in this region coordinate advisory development/management with tribes; three states do not; and one has no tribes in its state.

Collection of Data on Adult Mercury Poisonings

- This region's states do not collect data on mercury poisonings.

Biomonitoring for Bioaccumulative Contaminants

- Five states in this region monitor for bioaccumulative contaminants, including mercury, PCBs, arsenic, lead, and cadmium. On the questionnaire, some states answered this question for monitoring in humans, while others answered for monitoring in fish.
- Alaska monitors mercury in hair and cord blood.
- There is a state program in Hawaii where arsenic, lead, mercury, and cadmium levels are reported by doctors (results come directly from two laboratories). For mercury, they start with blood levels and then do 24-hour urine total mercury.
- Montana has a grant from the Centers for Disease Control and Prevention (CDC) to monitor arsenic in urine; if total arsenic is high, then speciation is examined.
- Two states had recent legislative proposals.

Revisiting Mercury Advisory Sites

- Five states in this region are doing some fish tissue testing at some mercury advisory sites or statewide. The frequency ranged from annually to more than 10 years between sampling events.

Mercury Fish Tissue-Based Water Quality Criterion in Water Quality Standards

- Some states have a mercury fish tissue-based water quality criterion, others do not or are in the process of doing so.
- Four states in this region have adopted a mercury fish tissue-based water quality criterion in their water quality standards (0.3 ppm is the most frequent value); four states have not.
- Hawaii has not adopted a mercury fish tissue-based water quality criterion because it is the ocean (rather than a freshwater body) that is contaminated.

Fish Tissue-Based Water Quality Criterion for PCBs

- Only two states agree there should be a fish tissue-based water quality criterion for PCBs (one believes it should be for total PCBs, the other for congeners).
- PCB toxicity is less clear than mercury; PCBs are in foods other than fish. Some would like to wait and see how the mercury water quality criterion works first before attempting PCBs.
- What to measure for PCBs – congeners or total; cancer risk or noncancer?
- Sampling for PCBs needs to be standardized and the risk assessment improved.

Issues/Concerns

- The group recommended starting to sample PBDEs now, but they acknowledged that costs would be high to get low detection limits and that they had questions about reference doses (RfDs).

- Language of advisories. Utah has translated its fish consumption advisory materials into Spanish, but materials in the rest of the states in this region are all in English.
- Utah notes that the U.S. EPA and the states should develop reference materials for a laboratory comparison study on mercury (concerned with accuracy of mercury results).

Nongovernmental

Many items were discussed in this group, including the need for:

- Improving public education on pollution prevention to eliminate fish advisories
- Improving the distributed materials to ensure better understanding of the problem.
- Improving understanding of all contaminants in the diet (from all sources) and how to reduce one's exposure.
- Better integration of fish advisories with Clean Water Act requirements for cleanups / Clean Air Act regulatory approaches – What happened to the U.S. EPA Air/Water interface concept?
- Improving knowledge base and information dissemination on the interactions of contaminants and their health effects.

Problems identified with the current approach to fish advice include:

- Warnings are inconsistent and not publicized to the persons or communities that need them.
- The public is often confused about what species/type of fish is under advisory. Local names of subspecies add to this confusion.
- Commercially sold fish are not the same as store-bought/restaurant-served fish, even though caught from the same waters in many states.
- Recalcitrant states need to become active in fish advisories.
- There are differing opinions on what matters and who is right.
- The FDA and U.S. EPA are failing to tell everyone who needs this information that it exists. New means of publicizing/distributing fish consumption advisories are needed.
- Need to be doing a better job of pollution prevention.
- Need to improve health screening processes for mercury and other contaminants, and to promote health screenings of sensitive populations when appropriate or for all populations when practical.
- Need to identify what information is critical to ensuring risk reduction.
- Need to eliminate misperceptions from current publications.
- Need to educate industry to their responsibilities.
- Need better communication about the sources of contaminants in outreach materials

Agencies need to consult the populations in need of information to gain their assistance in developing outreach materials. Too many times, outreach is done from someone else's perspective.

- Rodney, a high school student from California teaches his cousins about fish advisories through a Halloween candy analogy, telling them they need to make sure there aren't toxic pieces of candy in the treats given.
- Amy, a fellow student, said her Southeast Asian church is trying to teach elders about the concept of pollution and toxic chemicals that can harm them. Current advisories translate poorly and are confusing.

Surveys and information-gathering activities—either because they are poorly designed or poorly administered—are not reaching the people they need to inform.

Recommendation: The federal government needs to play a much more active role in getting people the information they need to make good choices. We have arrived at the point where we understand that fish consumption has benefits, but that people need to be able to select fish that are low in contaminants. The current testing methods and information provided are wholly inadequate to allow for this. The federal government needs to take a more consistent approach and to allow people to select fish that are low in contaminants through testing and labeling.

Joint Federal Mercury Advisory: EPA's Choice of the One Meal/Week Limit for Freshwater Fish Consumption

James Pendergast, Office of Science and Technology,
U.S. Environmental Protection Agency

The Joint Federal Mercury Advisory was issued in March 2004. In addition to recommendations restricting consumption of commercial fish, the advisory contains a one meal/week limit for consumption of freshwater, noncommercial fish, for areas in which no local advisory exists. The U.S. Environmental Protection Agency's (U.S. EPA's) original goals in establishing a meal limit for recreational freshwater fish consumption were: (1) consistency with state programs, (2) protection of the majority of consumers, and (3) keeping the message simple.

The advisory is consistent with the one meal/week consumption rate used in most statewide mercury advisories, as well as with the coarse meal categorization used by many states for waterbody-specific advisories. The use of the two meals/month category is inconsistent across the country.

Second, the U.S. EPA's risk management goal was to protect the majority of consumers. The Agency found that the large majority of species had average concentrations that fell within the full range of concentrations associated with a coarse one meal/week limit. The Agency used the approach of comparing the available fish data against the two, three, and four meals/month concentration limits, which ranged from >0.12 ppm to 0.47 ppm. The existing fish tissue data came from U.S. EPA's National Listing of Fish Advisory (NLFA) fish tissue database (current as of October 2003), from states and tribes (data submitted for 1987–2003), and from testing of noncommercial fish (i.e., fish caught and consumed by family and friends). The species average was calculated as the arithmetic mean of the species-specific means at each sampling station. In this analysis, national means by species range from 0.06 ppm to 0.96 ppm, with a difference factor of 16. Protecting consumers with a limit based on either end of these extremes would over- or under-protect by a factor of 16 for the low- and high-concentration species, respectively.

Finally, U.S. EPA chose to keep the message simple. Early risk communication focus group studies (October and November 2003) found that an overly detailed fish consumption advisory scared consumers away from an otherwise healthy food. Thus, developing a shorter advisory avoided covering variability from species to species, from region to region, and even from waterbody to waterbody. Recreational freshwater fish, one small component of overall consumption, was allocated just a small portion of the brief overall message. The advisory also encouraged consumers to check local and state advisories first and to use the federal advisory only when no state advisory existed.

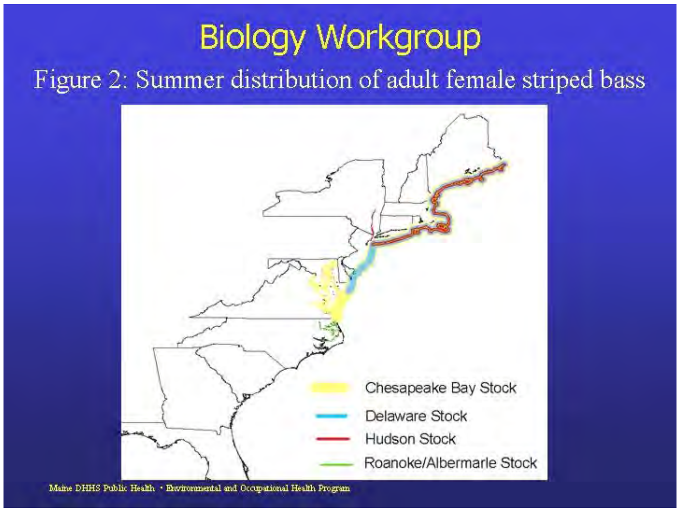
Since the release of the advisory, the U.S. EPA has performed additional analyses that support the one meal/week limit. The Agency found that a typical individual consuming a variety of freshwater fish species would be near the reference dose (RfD), and that those consuming a specific preferred species would be below the RfD for 60 percent of species, but up to twice the RfD in 35 percent of species. A conservative bias uncovered in the NLFA data in comparison to 500 randomly selected lakes and reservoirs in the National Lake Fish Tissue Survey (NLTS) was removed through data normalization techniques. This indicates that the bias in the NLFA data was a result of sampling bias towards species and sizes of fish that tend to have bioaccumulated more mercury. As a result of this inherent bias in the NLFA data, the previous risk assessment analysis is conservative; that is, the concentrations to which individuals are actually exposed over the long term will be lower than those used in the risk assessment.

Consistent Advice for Striped Bass and Bluefish along the Atlantic Coast

Eric Frohmberg, Maine Bureau of Health

A three to tenfold increase in polychlorinated biphenyl (PCB) levels in 2000 for striped bass in Maine led to a discussion within the Maine Bureau of Health about consistent advisories for migratory species. The overall objective of the Bureau's Atlantic Coast Striped Bass and Bluefish PCB Advisory project is to prepare a document assessing the feasibility of developing a common coastal advisory for striped bass and bluefish due to PCBs. The definition of "common" will be developed based on what the data suggest, whether it will include the whole Atlantic coast or regional areas (e.g., New England). A Web site for the project has been set up: http://www.maine.gov/dhhs/ehu/fish/PCBSTBhome.shtml.

Project personnel are organized into individual workgroups that focus on data, biology, toxicology, advisory, and organization, respectively. The data workgroup will compile and describe the PCB data for striped bass along the coast. This workgroup has uncovered a great deal of state-to-state variation. Also, PCB levels in striped bass appear to be decreasing over time, indicating that a new coastal-wide study of PCBs in striped bass and bluefish would be advantageous. The data workgroup has also decided that it will not recommend that states use the same methods to analyze PCBs.



The biology workgroup will summarize migratory patterns of striped bass. Research so far has found that migratory striped bass are large adult females, and that the diet is variable for both striped bass and bluefish, without a lot of overlap between the species. The workgroup has also found that it cannot predict arrival times for populations of striped bass. The findings of the biology workgroup are available as a draft chapter on the project Web site (http://mainegov-images.informe.org/dhhs/ehu/fish/BioChapDraft.pdf).

The toxicology workgroup has the goal of reviewing the basis of the existing toxicology numbers used to set advisories and reviewing any new literature. This workgroup will also evaluate the feasibility of developing a new toxicology number. Research to date reveals that the toxicology estimates are old and need to be updated. The workgroup has determined that the goal of the toxicology number should be to not increase the body burden in young women. The workgroup has also found that the quality of the data on the benefits of omega-3 fatty acids for babies is not compelling. A draft chapter of the toxicology findings may be found on the project Web site (http://mainegov-images.informe.org/dhhs/ehu/fish/DRAFT_TOX_CHPT.pdf).

The goal of the advisory workgroup is to summarize how states vary in their advice and procedures. Findings from the workgroup indicate that procedures are variable from state to state, while advisories do not differ greatly. The advisory workgroup is unlikely to recommend common procedures to the states, and instead will consider age breakdowns in order to specify what groups should be targeted for protection and to simplify communication.

Overall results of the study to date find that limited data exist for bluefish, but that conceptually a regional advisory may make sense. For striped bass, local spawning-location-based advice and consistent advice for migratory fish may be necessary. The study also indicates that toxicity estimates for PCBs need to be updated, and that a survey of PCBs in striped bass and bluefish up and down the coast is needed.

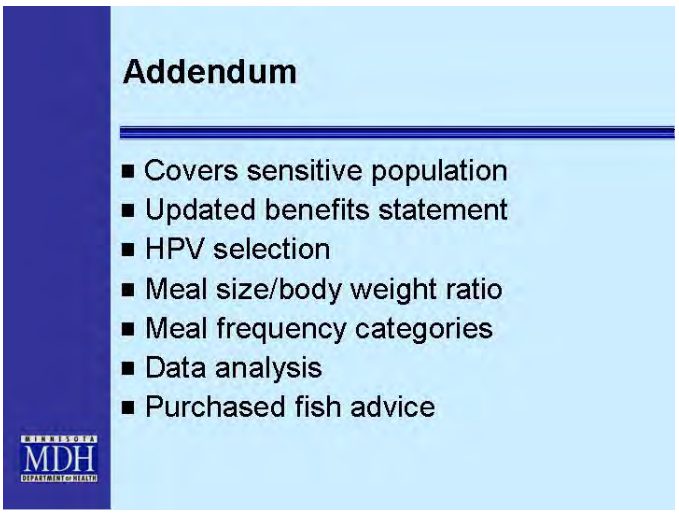
Great Lakes Mercury Protocol

Pat McCann, Minnesota Department of Health

The Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory has been instrumental in providing a common fish advisory methodology and communication structure for Great Lakes states. The states periodically coordinate communication strategies, joint outreach campaigns, and advisory awareness evaluation projects. These efforts have only addressed polychlorinated biphenyls (PCBs) and other halogenated organic fish contaminants. Moreover, there has been no mechanism to advance a coordinated mercury communication strategy in the Great Lakes states. Through a grant from the U.S. Environmental Protection Agency, Wisconsin organized a meeting in Fall 2004 in Madison and conducted follow-up conference calls to facilitate the development of the Great Lakes Protocol Mercury Addendum.

A survey to determine the current mercury advisory methods used by states was completed prior to the meeting in Madison. This survey illustrated the various mercury-based fish consumption advice provided by the Great Lake states. Each state provided both statewide and site-specific advice with strategies for calculating the site-specific advice, which is more restrictive than statewide advice. Some states also included different waterbodies. Four states (Illinois, Indiana, Wisconsin, and Minnesota) used a two-tier approach with established health protective values (HPVs) of 0.1 and 0.3 µg/kg/day for sensitive and general populations, respectively. Two states (Pennsylvania and Ohio) issued the same advice for all populations, and two more states (New York, Michigan) used a two-tier approach based on the Food and Drug Administration (FDA)/modified FDA action level. Each state also examined different meal consumption rates. Pennsylvania, Ohio, Illinois, Indiana, Wisconsin, and Minnesota provided similar HPVs for the consumption rate of one meal/month when normalized by the default body weight under study. Four states are currently working toward or are already providing quantitative advice for purchased fish consumption. Four states have no plans to provide this type of advice.

A draft of the Great Lakes Protocol Mercury Addendum is now available. U.S. EPA staff members involved with fish consumption advisories from the Great Lakes states developed this document. Like the PCB protocol, it recommends an HPV (safe dose) and provides guidelines for deriving consistent consumption advice for mercury-based advisories. Several meal consumption rates were analyzed, and a two meal/week option was added. The addendum covers sensitive populations, emphasizes the meal size to body weight ratio, and provides more options for defining site-specific and general data analyses. The benefits statement uses a tiered approach to outline risks and benefits for both commercial and locally caught fish. It also includes information on omega-3 fatty acids. The addendum will be finalized after this forum.



Dealing with Interstate Inconsistencies in Fish Consumption Advisory Protocols in the Upper Mississippi River Basin

John R. Olson, Iowa Department of Natural Resources

Two general approaches are used for fish consumption advisories (FCAs) in the five states of the Upper Mississippi River (UMR) basin. Illinois, Minnesota, and Wisconsin use a risk-based approach for all contaminants, and they use the 1993 Great Lakes Protocol (GLP) for PCBs. Iowa and Missouri continue to base most of their advisories on action levels published by the Food and Drug Administration (FDA). These inconsistencies in fish consumption advisory protocols in the UMR basin result in conflicting and confusing consumption advice for persons catching and consuming fish from the UMR, which forms a shared boundary for these states. These inconsistencies also result in conflicting water quality assessments and impaired waters listings in the UMR basin states. Illinois, Minnesota, and Wisconsin have consistent reference doses (RfDs) for a range of fish consumption rates for PCBs, chlordane, and mercury based on the GLP. Iowa and Missouri continue to use an FDA action level-based approach.

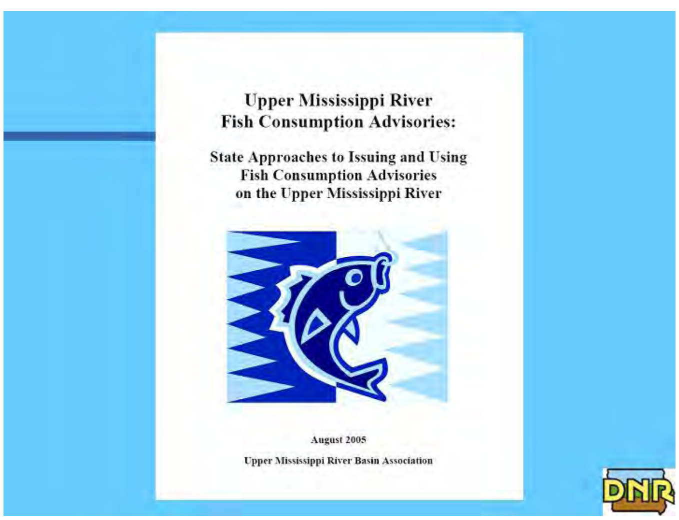
The Upper Mississippi River Basin Association (UMRBA) was formed in 1981 to facilitate dialogue and cooperative action among the five UMR states and to work with federal agencies on inter-jurisdictional programs and policies (http://www.umrba.org). In 1998 UMRBA created a Water Quality Task Force to facilitate consultation between the UMR states on water quality-related issues. Past activities have addressed 305(b) assessments and 303(d) listings. Future tasks include assessing siltation/sedimentation/turbidity impacts.

In 2005 the task force began to summarize the status of FCA protocols with the goal of improving interstate consistency regarding these protocols. With a grant from the U.S. Environmental Protection Agency (U.S. EPA), UMRBA hired a contractor to facilitate this process and to prepare summary reports. Meetings of staff from state departments of water quality, health, and fisheries in the UMR basin, along with representatives from U.S. EPA Regions 5 and 7, were held in March and May 2005. Several levels of inconsistency between the states were identified during these meetings and include:

- FDA versus risk-based approaches (e.g., GLP)
- Different approaches for issuing and rescinding fish consumption advisories
- Different FCA approaches used in the states to the west of Iowa and Missouri
- Different approaches for assessing support of fish consumption uses (for Section 305(b)) and for identifying Section 303(d) impaired waters.

A five-state data comparison was completed using data for mercury and PCBs in fish fillet samples from the last 10 years from all states. A compilation of these data by the Minnesota Department of Health was presented at the May 2005 meeting. Using these data, it was determined that if Iowa employed the GLP to calculate fish advisories, all 11 UMR pools in the state would have some type of advisory and would need to be placed on Iowa's 303(d) list.

A report entitled *Upper Mississippi River Fish Consumption Advisories: State Approaches to Issuing and Using Fish Consumption Advisories on the Upper Mississippi River* (available at http://www.umrba.org/reports.htm) was finalized in August 2005. This report: (1) summarizes the current status of FCAs and their uses in the UMR basin, (2) summarizes the discussions conducted during the two meetings, and (3) makes recommendations to improve interstate consistency in FCAs in the future. The report recommends that there be consistent FCAs for the UMR (FCA = guidance and issuance), because the UMR is a shared waterbody and inconsistency generates confusion and unfavorable public perception. The report also recommends that a minimum set of contaminants, fish species, sizes, sampling locations, sample frequencies, and sample preparations,



among other factors, be standardized for all states. Finally, Clean Water Act Section 305(b) & 303(d) processes should be revisited after obtaining consistency in data and FCAs.

Although no states have as yet made changes to their FCA protocol as a result of the UMRBA effort, the discussions and exchange of ideas that occurred during this process will serve as a basis for achieving this goal.

Gulf Coast State Fish Consumption Advisory for King Mackerel

Joseph Sekerke, Florida Department of Health

The Gulf Coast States Marine Fisheries Commission (GCSMFC) is a federal group intended to coordinate marine fisheries activities in the Gulf of Mexico. In 2002 a task force was established to propose a common fish consumption advisory for King Mackerel in the Gulf of Mexico. Representatives of the five member states (Florida, Alabama, Mississippi, Louisiana, and Texas), the U.S. Environmental Protection Agency (U.S. EPA), U.S. Fish and Wildlife Service, and the GCSMFC held several meetings to determine the advisory currently used by each state for King Mackerel. Data on the concentration of methylmercury in King Mackerel taken from Gulf waters were reviewed. The primary King Mackerel population in the Gulf is the "East Gulf" population, which ranges from the southern tip of Florida to the Rio Grande River. Two other populations have ranges that overlap the range of this population. The "Atlantic" population extends into the gulf along the most southwestern coast of Florida, and the "Mexico" population extends north of the Rio Grande over the southern half of the Texas coast. The levels of mercury correlated with fish length for all populations and were similar. Each state included advisories for adults, women of childbearing age, and children. Criteria were based on fork length or total length of the fish.

The task force was left to resolve issues including: fork length versus total length, age of children on which to base the standard, size criteria, and the reference dose. In June 2005, the GCSMFC sent a unified King Mackerel advisory to the member states to be considered for inclusion in each state's Fish Consumption Advisories. The proposed advisory stated that women of childbearing age and children under the age of 15 should not consume King Mackerel. All others may consume two 8-ounce meals per month of King Mackerel measuring up to 31 inches in fork length. King Mackerel 31 inches or greater in fork length should not be consumed. Due to Hurricane Katrina, efforts in four of the five participating states have been put on hold. Florida plans to take action on the issue in October 2005.

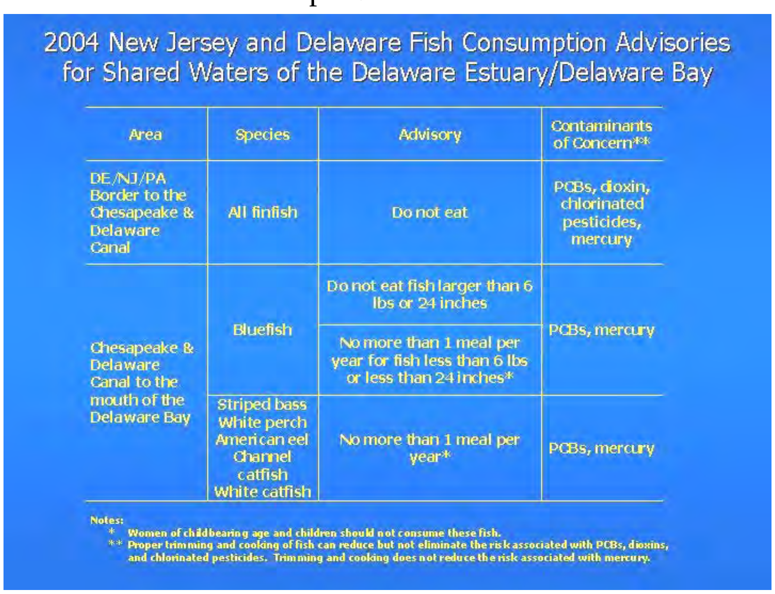
Advisories in Shared Waters—Two States Achieve Consistent Advice

Gary A. Buchanan, New Jersey Department of Environmental Protection

There are numerous benefits for establishing consistent advisories in shared waters, especially for large waterbodies, such as Delaware Bay. These include a uniform and more effective message to anglers and fish consumers in adjoining states, coordinated state outreach efforts, improved public comprehension, and most importantly, increased protection of public health from the bioaccumulative contaminants found in elevated levels in certain local fish species.

In 2003 the states of Delaware and New Jersey began a dialogue to develop consistent fish consumption advisories in shared waters of the Delaware Estuary. Establishing consistent advisories was a key goal in the Management Plan for the Delaware Estuary Program. Disparity in advisories resulted from differences in risk assumptions, cancer risk level, data, individual contaminants versus multiple contaminants, and contaminant assessment approach. Inconsistent advisories in the same waterbody can be confusing to the public, create doubt concerning government actions, and potentially lead to apathy regarding the public health message. For the Delaware Estuary, advisories existed for the Delaware River and the Delaware Bay, for different species of fish, and for different cancer risks (10^{-4} and 10^{-5} in New Jersey and 10^{-5} in Delaware).

A joint request by the Commissioner of the New Jersey Department of Environmental Protection (NJDEP) and the Secretary of the Delaware Department of Natural Resources and Environmental Control that consistent fish advisories be created for the shared waters of the two states was key to successfully establishing consistent advisories. Resolution of differences was relatively straightforward once both states agreed to cooperatively develop the consistent advisories. Several consistencies between the New Jersey and Delaware advisories already existed and were built upon. Both states issued consistent fish advisories in March 2004 for their entire shared waters of the Delaware Estuary. The resolution was for Delaware to add a bluefish advisory using New Jersey data, while New Jersey dropped the two-tier approach to focus only on a 10^{-5} cancer risk. Both states would also use Delaware 2002 striped bass data and New Jersey assumptions for the advisories. The advisories are divided between the river (advisory for all finfish) and bay (advisory for bluefish and advisory for others). Multiple contaminants are addressed in all advisories. The advisories list the


2004 New Jersey and Delaware Fish Consumption Advisories for Shared Waters of the Delaware Estuary/Delaware Bay

Area	Species	Advisory	Contaminants of Concern**
DE/NJ/PA Border to the Chesapeake & Delaware Canal	All finfish	Do not eat	PCBs, dioxin, chlorinated pesticides, mercury
Chesapeake & Delaware Canal to the mouth of the Delaware Bay	Bluefish	Do not eat fish larger than 6 lbs or 24 inches	PCBs, mercury
		No more than 1 meal per year for fish less than 6 lbs or less than 24 inches*	
	Striped bass White perch American eel Channel catfish White catfish	No more than 1 meal per year*	PCBs, mercury

Notes:
* Women of childbearing age and children should not consume these fish.
** Proper trimming and cooking of fish can reduce but not eliminate the risk associated with PCBs, dioxins, and chlorinated pesticides. Trimming and cooking does not reduce the risk associated with mercury.

fish consumption rate and, in some cases, size of fish consumed. Delaware and New Jersey plan to continue coordination, communication, and data sharing to ensure that consistent and current advice is available to the public.

Akwesasne Mohawk Fish Advisory Communication

Anthony M. David, Environment Division, St. Regis Mohawk Tribe

Traditionally, the Mohawks of Akwesasne (bordered by the state of New York and the provinces of Ontario and Quebec) have depended upon fish as a crucial supplement to their diets. Today, science helps us appreciate even more the nutritional benefit of fish, in addition to its cultural and religious significance. However, contamination from three local Superfund sites and from other atmospheric pollutants in the area has threatened the safety of those consuming large quantities of fish, and has presented the difficult task of getting community members to limit their consumption. Over the years this effort has been largely successful. Now the task remains to refine advisories and to communicate risk in a more succinct and understandable form.

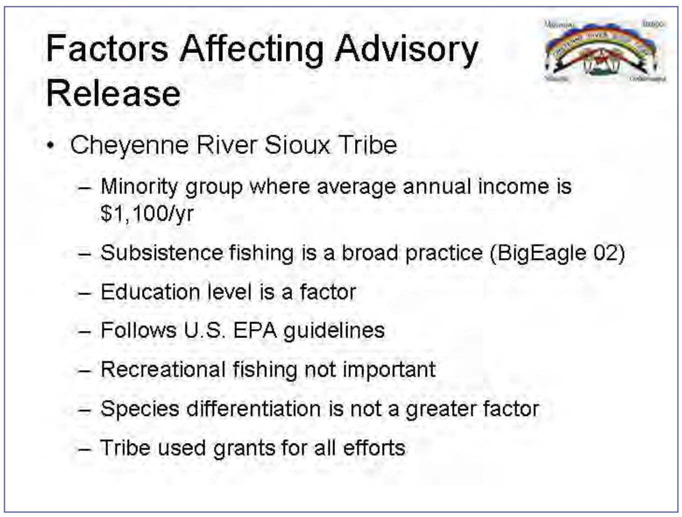
The Mohawks of Akwesasne are a fishing and agriculturally based traditional culture of about 10,000–12,000 people. Their 4,000-acre land sits in close proximity to three (two Alcoa and one General Motors) Superfund sites. Several public health studies involving their people have been conducted from the 1980s to the present. Existing advisories for the lands they inhabit have been issued by the St. Regis Mohawk Tribe (SRMT) Health Service (1986), the New York State Department of Health (NYS DOH) (2005), and the Canadian environmental agency. The warnings from 1986 specify that women and children should not consume area fish and men should consume only one meal per week. The NYS DOH set specific advisories to avoid consumption of fish from the Grasse River and the bay at General Motors along with other general advisories. The Canadian environmental agency advisories included greater species specificity, a regional breakdown of the St. Lawrence River, and allowed for meals of several species of fish.

The Mohawks have conducted their own workshops on how to clean and prepare fish to reduce contaminants. They follow general advisories to select species of fish that are generally cleaner, to harvest from "clean" locations, and to select smaller fish. They see the need for better and more recent data, including postremediation sampling at the Superfund sites with a focus on mercury as well as polychlorinated biphenyls (PCBs).

Development Processes of Consumption Advisories for the Cheyenne River Sioux Indian Reservation

Jerry BigEagle, Environmental Protection Department, Cheyenne River Sioux Tribe

Awareness of possible elevated levels of mercury contamination from the Homestake Mine effluent near Lead, South Dakota, into the biological food chain of the Cheyenne River eventually led to investigations in the early 1970s and consumption advisories focusing on the health risks from consuming fish. Realizing the enormity of the problem, environmental groups began studying the effects of dioxins found in direct, naturally generated food sources related to minority groups. Several agencies have developed, conducted, and ultimately compared scientific methodology for the analysis of the harmful effects of mercury and published consumption advisories over shared jurisdictions with different degrees of health risk assessment. The state of South Dakota and the Cheyenne River Sioux Tribe began on the same path trying to grasp the possible impacts of carcinogenic poisoning, but over time have taken separate roads.



The Cheyenne River Sioux Tribe of South Dakota inevitably created its own advisory. Other tribal groups may be able to ascertain the benefits of certain aspects of this process when pursuing coordination efforts for mercury advisory development. Those factors affecting the tribe's advisory are directly related to the fact that fish consumption is for subsistence and is also a dietary supplement for wild game, which is inversely related to a very low average annual income. The second factor affecting the tribe's consumption advisory is the lower educational level of those affected by the advisory. The tribe's advisory, written in straightforward language, is for all surface waters within the reservation. It also follows U.S. Environmental Protection Agency (U.S. EPA) guidelines. The advisory states:

- Do not keep or eat large, older fish. Keep smaller fish for eating. In addition to tasting better, younger, smaller fish have had less time to accumulate contaminants than older, larger fish. Selecting smaller fish for consumption reduces risk to your health.
- Eat smaller meals when you eat big fish and eat them less often. Freeze part of your catch to space the meals out over time.
- Eat those that are less contaminated. Contaminants build up in large predatory fish. **Limit the amount of smaller fish eaten to one 4-ounce meal per week**.
- High risk individuals such as women of childbearing age, pregnant women, and children under the age of seven should not eat fish caught on the reservation.

The state of South Dakota's mercury advisory, however, was and is not meant to influence the same targeted population. The state's advisory is weighted heavily toward recreational fishing revenues, and therefore, reflects and encourages more liberal fish consumption not relevant to subsistence. The state's advisory consists of advisories for specific lakes and a general advisory for remaining surface waters. In some cases, specific fish are listed with their own advisory based on size and consumption rate.

The risk assessment for anglers may be the same for both advisories and the benefit to the public is a collection of information that targets a wider variety of people and has led to more acceptance and knowledge of the benefits of fish consumption. The advisories between the groups differ only slightly for healthy adults: state advisory = 7 ounces per week; tribal advisory = 4 ounces per week.

Future plans for the tribe include obtaining a National Indian Health grant, as well as a permanent funding source in order to gather more samples and to sample annually. The tribe also plans to test for arsenic and other dioxins. They will also test their drinking water.

Welcoming Remarks, Monday, September 19, 2005

Benjamin Grumbles, Office of Water, U.S. Environmental Protection Agency

I want to extend my sincere thanks to all of you for taking the time to attend this forum. In this room we have the knowledge, enthusiasm, and solid science to understand contaminants in fish. Thank you to those who put this meeting together and to the state of Maryland for hosting us.

I know that many of you, as water experts and program managers, have been working tirelessly to protect the public in the aftermath of Hurricane Katrina. Thank you for your efforts. Some of our colleagues could not be here today because they are affected by Hurricane Katrina; please keep them in your thoughts.

This recent disaster underscores the importance of water as a natural resource, the importance of conserving our wetlands, and the importance of maintaining and restoring our coastal environments. As a result of Katrina, the whole country has been considering water-related issues and policy issues. The U.S. Environmental Protection Agency (U.S. EPA) has been focused on these issues, as have others, including the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey (USGS). Katrina provided a challenging opportunity to provide sediment and water quality monitoring data and to make it available.

In the coming weeks, there will be many questions about the safety of eating fish and shellfish from the areas affected by Hurricane Katrina. We are all working to address these issues. The news media and the public have an increased awareness about fish issues, and their interest does not appear to be waning.

Over the years, this forum has presented us with the opportunity to hear from and learn from our nation’s top fish experts—from the states, tribes, territories, sister federal agencies, academia, industry, and the environmental community.

We share a common interest, and together, we are addressing contemporary scientific and policy issues, and are developing the answers to questions about contaminants in fish.

The Release of the 2004 Fish Advisory Data

Late last week, we released our 2004 National Listing of Fish Advisories, a joint effort by the Agency and our partners (states, tribes, and territories). With more monitoring, more fish advisories are listed.

Our latest recreational data show that 3,221 fish advisories were issued in 2004, alerting residents to the potential health risks of eating contaminated fish caught locally in lakes, rivers, and coastal waters.

The consumption advisories vary but may include recommendations to limit or avoid eating certain fish species caught from specific bodies of water. Advisories may be issued for the general population or for such groups as pregnant women, nursing mothers, and children.

Increased Monitoring

Together, we have generated more and better information to help us continue to protect public health. Over the last 12 years, states and tribes have been monitoring fish in more of their waters. Many of these fish have not been previously monitored. Where high levels of contaminants have been found, more fish consumption advisories have been issued. At the same time, this increased monitoring effort has also led to an increased number of "safe eating guidelines," monitored waters or species where no restrictions on eating fish apply.

Efforts invested in monitoring more waters leads to better public information about the kinds of fish that are safe to eat and where these fish are located in a particular waterbody.

U.S. EPA/FDA Memorandum of Understanding

For many years, the U.S. EPA and the Food and Drug Administration (FDA) have collaborated on fish and shellfish food safety issues. Recently, we were able to formalize this work through a Memorandum of Understanding (MOU).

We now have a very promising framework for communicating and interacting to promote the use of best available science in developing public heath policies regarding commercial, noncommercial, and recreationally caught fish and shellfish.

We are excited about collaborating on this important topic, and about breaking new ground together. We will hold our first joint meeting on Tuesday, September 27, 2005, to develop an agenda on cooperative/collaborative projects for the coming year.

We will also continue to work on implementing the joint National Mercury Advisory. It is important that we assess how well the public is assimilating this important information, and we will continue conducting surveys to find out more about the level of awareness about fish consumption issues, including the National Mercury Advisory.

Future Prospects

It is clear that we have a number of accomplishments, but there is still much work ahead. We are exploring ways to help states, tribes, and territories revisit their existing advisory sites to help determine if there is a basis for keeping or changing the existing advisories.

We recognize there is a growing concern about emerging contaminants, such as polybrominated diphenyl ethers, or PBDEs. We are exploring how the Agency would be able to help states address emerging contaminants in fish.

One action we have underway is the Integrated Risk Information System (IRIS) review of PBDE. Once this review is complete, we will know more about the toxicology of this important emerging contaminant.

We are interested in hearing ideas of how we can work with states, tribes, and territories to address these emerging contaminants.

We will continue to reach out to our state and federal partners to identify and to invite more Tribes, Alaska villages, and representatives of various ethnic groups (especially those with subsistence fishing concerns) to join us at future Fish Forums.

Thank you again for joining us here today and sharing your knowledge and insight to protect the American people from risks and exposure to contaminants in fish.

Welcoming Remarks, Monday, September 19, 2005

Kendyl P. Philbrick, Maryland Department of the Environment

Welcome to the state famous for Maryland blue crab, native oysters, and rockfish—or striped bass for those who do not live here.

I am pleased to be here today, and thank you for inviting me to discuss the Maryland Department of the Environment's (MDE's) role in keeping the public informed about safe fish consumption.

The fishing and tourism industry is an important part of our heritage and economy. Some communities even rely on fish they catch in our watersheds as an important source of protein for their families' diets every day. Our job is to help people make informed choices regarding fish consumption, while at the same time providing significant commercial and recreational benefits to Marylanders.

The public basically wants to know: "How much fish is safe to eat?" Our mission at MDE is to protect public health and the environment for the benefit of present and future generations.

We have obligations both in the arenas of pollutant reduction as well as risk communication. We realize that reduction of persistent pollutants is a long-term goal; therefore, in the meantime, communication is important to our success in the protection of public health. Interagency communication between federal and state agencies is **key**, particularly with respect to announcing U.S. Environmental Protection Agency (U.S. EPA) and Food and Drug Administration (FDA) recommendations for safe consumption levels in recreationally and commercially caught fish. This is of primary importance for protecting sensitive populations most at risk.

MDE works hard to maintain a federal and state cooperative partnership. Both FDA and U.S. EPA advisories are incorporated into our materials. We keep communication lines open on technical issues, communication strategies, and measures of progress. Federal agencies provide the states with risk assessment guidance that allows for a range of parameters that can be modified relative to our region. We not only provide a number for safe fish portions, we also provide fish preparation and cooking recommendations to help reduce health risks.

The public also wants to know **why** they are limited to the amount of fish they can eat. We as professionals know that it is due to the pollutant content. But how we communicate the "**why**" is important to the consumption behavior of recreational fishermen and their families.

We consulted with WIC (Woman, Infants, and Children) at the Maryland Department of Mental Health and Hygiene to help develop MDE's brochures. We wanted to ensure that the language was simple and clear enough to be easily understood. We are reaching our target audience with both brochures and posters that are bilingual.

In Maryland, we have concentrated our efforts in our state's region of concern: the Baltimore Harbor and Back River watersheds. We have posted bilingual signs in the back of the room on partitions, and have dedicated staff to provide outreach and brochures to fishermen at docks and other public access points.

Currently, East Coast experts are developing a white paper on the potential for coastal advisories on striped bass (yes, Maryland rockfish) and bluefish, because they are migratory species. Every state has different recommendations due to variation in monitoring and analytical programs. The goal is to have a consistent message across the board, to allow for appropriate levels of safe consumption.

Our advisory program has come a long way. In 1988, limited advisories for chlordane (a banned pesticide) were issued, due to an exceedance of the FDA action level in Baltimore Harbor and Back River.

In 2001, we went from very limited advisories to widespread consumption information for both polychlorinated biphenyls (PCBs) and mercury. Statewide advisories were issued for mercury in fresh waters, and numerous advisories for Chesapeake Bay tributaries were announced due to PCBs.

In 2004, we released a Bay-wide advisory for rockfish based on 3 years of monitoring data. The data were based on over 150 samples of rockfish. We also updated our Baltimore Harbor advisories and issued more stringent advice due to PCBs. These high-profile advisories necessitated development of a risk-communication plan, which we implemented beginning 2004.

Also in 2004, the risk communication efforts directed at the Harbor and other Bay regions of concern were assessed through behavioral surveys conducted by Virginia Tech. The research found that our recent outreach efforts had reached about 80 percent of the population. While the message received widespread acknowledgment, change in behavior was minimal. This was probably due to the newness of the message and the lack of repetitive frequency in its communication. An average person needs to hear a message at least three times before it affects change.

The state of Maryland then realized efforts to change behavior needed to continue, especially for frequent fish consumers in urban areas.

In 2005, we printed about 90,000 brochures in English and Spanish. We have networked with WIC and other health organizations, and have leveraged outreach with watershed organizations in Baltimore Harbor. The Internet has been a successful tool for getting the message out, with an approximate average of 23,000 hits per month on the MDE Web site.

MDE's goal for Maryland, as a part of our commitment to achieving water quality standards, is to reduce PCBs in tidal waters to allow for consumption of at least two meals per month for **all** fish species. There are concerns with the longevity of the contaminants—the average half-life for PCBs is 9 years. We are currently working with Virginia, the District of Columbia, and the U.S. EPA to develop and limit total maximum daily loads (TMDLs) for PCBs in the Potomac River.

This consistent information, particularly in the Bay, is important in ensuring wide acceptance among fishermen and their families in different locations. We hope that this strategy will lead to behavioral change in the future.

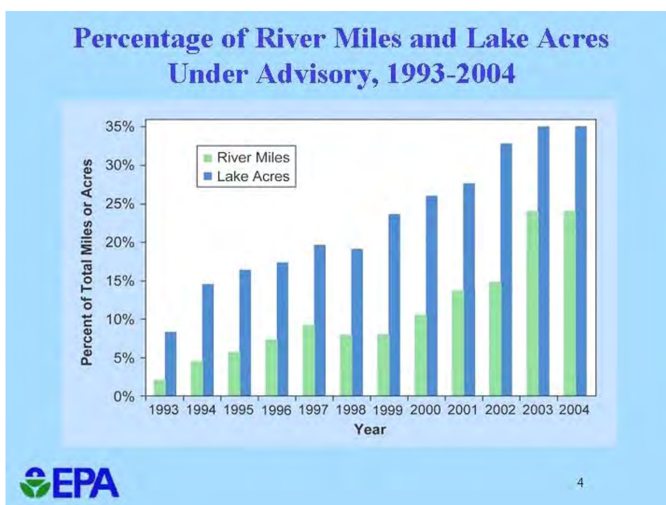
Those of us who rely so heavily on the Chesapeake Bay know that it has impaired waters, and many programs are in place to help begin to restore water quality in the Bay by 2010, so that our crabs, oysters, and fish continue to improve and thrive. MDE is taking steps to improve water quality and to minimize and mitigate impacts to those citizens who rely on fish. Our recently promulgated water quality standards are a great step toward cleaning the Bay. MDE is also taking important steps to minimize and mitigate impacts to those citizens who rely on fish.

Thank you for having me at this important forum.

EPA Advisory Program Update

James Pendergast for Denise Keehner, Office of Science and Technology, U.S. Environmental Protection Agency

The U.S. Environmental Protection Agency (U.S. EPA) advisory program provides technical assistance to state, federal, and tribal agencies on matters related to health risks associated with exposure to chemical contaminants in fish and wildlife. This assistance includes issuing national guidance documents and outreach, creating databases, holding conferences and workshops, providing grants for sampling and analysis, and conducting special studies. The program also issues advisories when necessary.



There has been an increasing trend in total percentage of river miles and lake acres under advisory in the nation. Safe eating guidelines issued by the state may be for specific waterbodies, for the entire state, a combination of the two, or statewide coastal guidelines. Some states have not issued safe eating guidelines.

The U.S. EPA published an advisory for methylmercury in commercial and noncommercial fish in March 2004. To improve outreach, the U.S. EPA plans to conduct various surveys about the public's perception of, and sources of information about, the benefits and risks of fish consumption. In June 2005, the U.S. EPA's Office of Water (OW) and the Food and Drug Administration's (FDA's) Center for Food Safety and Applied Nutrition (CFSAN) signed a memorandum of understanding (MOU) regarding greater collaboration between the U.S. EPA and the FDA regarding contaminants in fish and shellfish and safety for consumption. The MOU lays out goals and objectives and describes how they will be achieved by:

- Promoting the use of the best available science and public health policies
- Promoting the sharing and availability of appropriate information among the agencies' health and environmental professionals and the public
- Encouraging environmental monitoring efforts by FDA/CFSAN and U.S. EPA/OW and stakeholders
- Encouraging the development of public health advice that considers both risks and benefits of consumption of commercial and noncommercial fish and shellfish
- Promoting uniformity where appropriate in public health messages regarding consumption of commercial and noncommercial fish and shellfish.

Future directions for the advisory program include looking at emerging contaminants such as polybrominated diphenyl ethers (PBDEs) and perfluorooctanoic acid (PFOA) and examining the relevance of existing advisories. The program will continue work with states to identify safe-eating guidelines. The program also plans to react and respond to the National Academy of Sciences (NAS) report on risks and benefits related to eating fish. It will continue work with the FDA on environmental contaminants in fish and shellfish and the safety of fish and shellfish for consumption by U.S. consumers. Finally, it will look at advisories in interstate waters and work with U.S. EPA programs on using advisories to leverage cleanups. The advisory program also has the task of planning for the 2007 forum.

Seafood Safety Program
FDA Advisory Program Update

Donald W. Kraemer, Office of Seafood, Food and Drug Administration

The Food and Drug Administration (FDA) published the Seafood HACCP Regulation in 1995. The regulation became effective in 1997. This regulation requires processors to assess potential food safety hazards to determine if they are "reasonably likely to occur" and to develop and implement a Hazard Analysis and Critical Control Point (HACCP) plan to control those hazards.

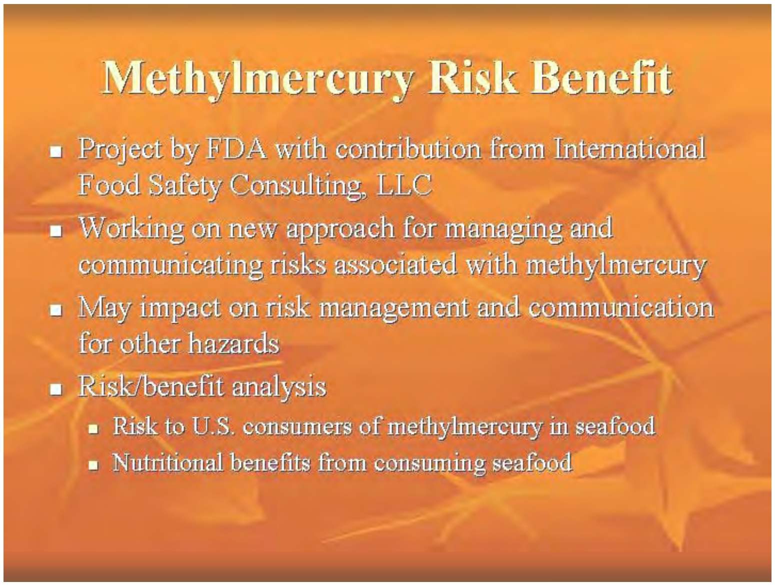
Several seafood safety hazards exist and may be grouped as follows:

- Natural toxins
- Parasites in many species of near-shore fish consumed raw

- Drug residues
- Unapproved use of food and color additives
- Microbiological contamination
- Allergens
- Physical hazards
- Environmental chemicals and pesticides.

A total diet study was conducted and consisted of measuring tuna, salmon, pollack, shrimp, and catfish for radionuclides, pesticides, polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), toxic and nutritional elementals, and folic acid. Current chemical field assignments include the pesticide, toxic elements, and dioxin programs as well as perchlorate and mercury assignments.

The 2005 pesticide program examined 175 domestic and 300 import samples for pesticides and PCBs. The Toxic Elements program looked at 10 domestic and 160 import samples for lead, cadmium, arsenic, and mercury. The Dioxin Program used 520 domestic and import samples and 85 feed samples to measure dioxins and dioxin-like PCBs. For the Perchlorate Assignment, investigators looked at 35 domestic and import samples. The Mercury Assignment measured total mercury in both domestic and imported samples. Twenty-nine (29) species made up 470 samples of fresh/frozen fish. Investigators also measured 100 fresh/frozen samples of tuna and 50 samples of canned tuna.



The Methyl Mercury Risk Benefit is a project by FDA with contribution from International Food Safety Consulting, LLC, to work on a new approach for managing and communicating risks associated with methylmercury. The project will examine the risk to U.S. consumers of methylmercury in seafood, as well as the nutritional benefits from consuming seafood. The work may impact on risk management and communication for other hazards.

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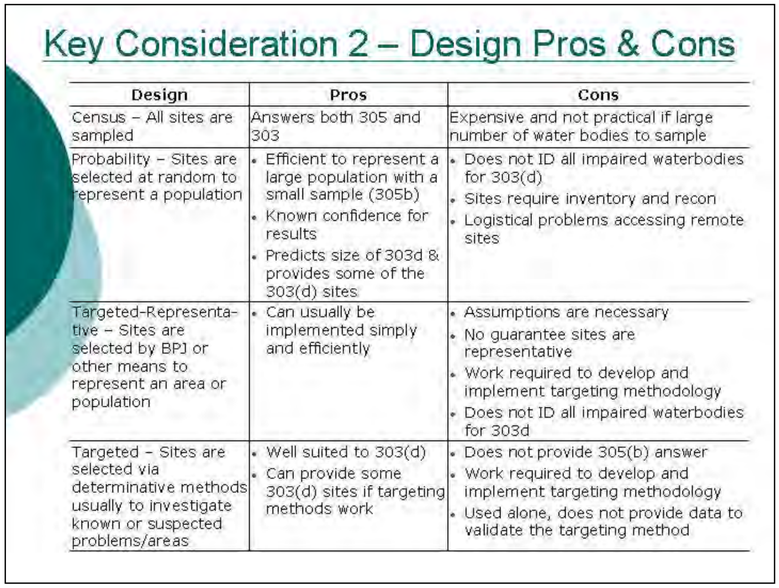
Key Considerations in Fish Tissue Sampling Design

Lyle Cowles, Region 7, U.S. Environmental Protection Agency

Monitoring to obtain critical environmental information, such as that needed for understanding the distribution and concentration of contaminants in fish tissue, is an essential requirement of the Clean Water Act. It is an ongoing challenge for the states, tribes, and the U.S. Environmental Protection Agency (U.S. EPA) to gather, assess, and provide this information (as well as other types of information) to the public, and to do so at multiple spatial scales and for many types of water resource classes (lakes, streams, estuaries, oceans) simultaneously. This presentation provides a discussion of the key considerations in designing fish tissue sampling to meet multiple Clean Water Act monitoring objectives.



Key Consideration 2 – Design Pros & Cons

Design	Pros	Cons
Census – All sites are sampled	Answers both 305 and 303	Expensive and not practical if large number of water bodies to sample
Probability – Sites are selected at random to represent a population	• Efficient to represent a large population with a small sample (305b) • Known confidence for results • Predicts size of 303d & provides some of the 303(d) sites	• Does not ID all impaired waterbodies for 303(d) • Sites require inventory and recon • Logistical problems accessing remote sites
Targeted-Representative – Sites are selected by BPJ or other means to represent an area or population	• Can usually be implemented simply and efficiently	• Assumptions are necessary • No guarantee sites are representative • Work required to develop and implement targeting methodology • Does not ID all impaired waterbodies for 303d
Targeted – Sites are selected via determinative methods usually to investigate known or suspected problems/areas	• Well suited to 303(d) • Can provide some 303(d) sites if targeting methods work	• Does not provide 305(b) answer • Work required to develop and implement targeting methodology • Used alone, does not provide data to validate the targeting method

Preparation is required to design a sampling program that meets your needs. When preparing a design program, you should:

- Know the questions (seek to balance them)
- Know the resources, subclasses, and size
- Know your coverage needs for each class
- Have a supportable design rationale and data
- Not limit your thinking.

Also, understand and choose sampling designs appropriate to your questions, resources, and needs. You should examine the pros and cons of the available sampling designs. These designs may include:

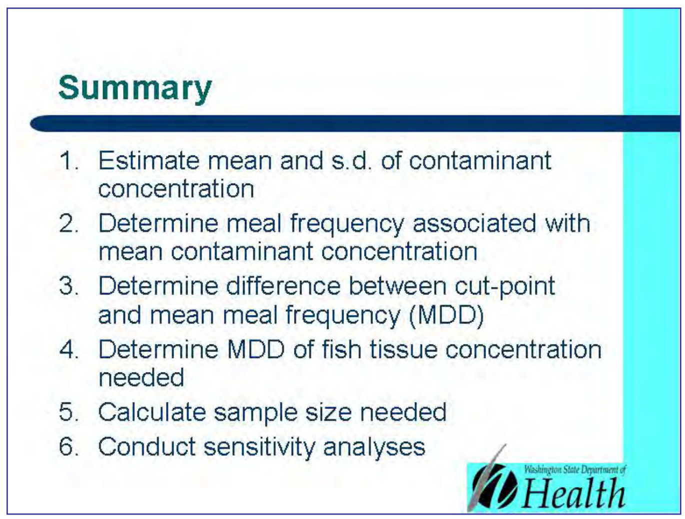
- Census – all sites are sampled
- Probability – sites are selected at random to represent a population
- Targeted-Represented – sites are selected by best professional judgment (BPJ) or other means to represent an area or population
- Targeted – sites are selected via determinative methods usually to investigate known or suspected problems/areas.

Finally, there should be considerations for balancing, integrating, and implementing multiple sampling designs. You should seek, through state strategies, to balance the monitoring needed to answer both the Section 305(b) and 303(d) questions. Some state and U.S. EPA programs have prioritized the monitoring for 303(d) without providing for 305(b). Worse, targeted 303(d) data have been used for 305(b), thus producing negatively biased assessments.

How Many Fish DO We Need? Protocol for Calculating Sample Size for Developing Fish Consumption Advice

Jim VanDerslice, Washington State Department of Health

This research seeks to answer the question: How many fish do you need to sample to calculate a fish consumption advisory? The answer depends on the precision of the estimate of mean concentration, which may be relative or absolute. It also depends on the fish populations—what species are consumed and how does the level of contamination vary between different size classes of fish. A cost approach may also be taken to determine how much money is available for sampling. Previously, sample sizes were based on arbitrary sampling objectives, such as being able to estimate the mean concentration with some arbitrary level of precision.



Washington State has a goal to develop and communicate defensible, consistent advice about healthy consumption of fish. A procedure was developed to estimate the required sample sizes, starting with the desired precision of the estimated maximum consumption rate associated with a given health reference level (e.g., a reference dose, [RfD]) and translating this into a formal sampling objective, including the desired minimum detectable difference, the desired power to detect this difference, and the level of significance of a test to detect this difference.

The steps of the procedure include:

- Estimate mean and standard deviation of contaminant concentration
- Determine meal frequency associated with mean contaminant concentration
- Determine difference between cut-point and mean meal frequency (MDD)
- Determine MDD of fish tissue concentration needed
- Calculate sample size needed
- Conduct sensitivity analyses.

The procedure provides a rational basis for estimating required sample sizes to be able to develop consumption advice with an adequate level of certainty, and it provides an idea of the variability of an estimated consumption level given a set number of available fish tissue samples.

US FDA's Total Diet Study

Katie Egan, Food and Drug Administration

The Food and Drug Administration (FDA) is responsible for conducting the Total Diet Study (TDS), which is designed to monitor the U.S. food supply for levels of toxic chemicals (pesticide residues, industrial chemicals, toxic elements) and selected nutrients (elements and folate), to observe trends and changes in intakes/exposures over time, and to identify potential public health problems related to these substances. The study was initiated in 1961 as a result of concerns about radioactive fallout and has been conducted continuously since. Over time it has evolved to include more analytes and foods, improved analytical methods, and intakes for more population groups. The model may be adapted to meet specific needs such as selected foods or regions.

Samples of approximately 280 different foods are collected and analyzed four times a year for about 500 analytes; each time foods are analyzed from one of four regions of the country. The sample collection sites, which vary from year to year, are selected from Standard Metropolitan Statistical Areas (SMSAs) close to FDA district or field offices. Three cities per region are sampled. The analytes include pesticide residues, industrial chemicals, radionuclides, elements, folate, dioxin, acrylamide, perchlorate, and furan.

The analytical results on levels of these substances in foods are combined with information on food consumption to estimate dietary exposures for the total U.S. population and 14 age/gender subgroups. The foods and beverages collected and analyzed in the TDS represent the major components of the U.S. diet as reported in national food consumption surveys. The list of foods is updated periodically to reflect changes in consumption patterns. Since the focus of the TDS is the typical American diet, the foods selected are those available nationally rather than regionally. For that reason, fish and seafood products included in the TDS are limited to those that are available throughout the year and those that are typically consumed across all regions.

Dietary Intake of Mercury from Fish/Seafood

TDS Food	Hg conc (mg/kg)	Intake (µg/day)		
		Total US	MF 2 yrs	F 25-30 yrs
Canned tuna	0.163	0.541	0.186	0.490
Fish sticks	0.004	0.008	0.005	0.005
Shrimp	0.027	0.091	0.013	0.212
Salmon	0.030	0.085	0.025	0.058

FDA 18

A unique aspect of the TDS is that foods are prepared as for consumption (table ready) prior to analyses, thus providing analytical results on levels of analytes as actually consumed and more realistic exposure estimates than those based on analyses of raw commodities or ingredients. Analytical results from 1991 through February 2001 for the TDS analytes are posted on the TDS Web site in summary form and as individual data (http://www.cfsan.fda.gov). Results for additional analytes are posted elsewhere on the Center for Food Safety and Applied Nutrition (CFSAN) internet.

Dietary intake is calculated as the analyte concentration times the amount of foods consumed. Each diet equals the consumption amount for each TDS food. The TDS intake estimates provide reasonable estimates of background intakes/exposure and average intake over time. However, they are **not** appropriate for assessing acute intakes, upper-percentile intakes, or intakes from very specific foods or specific population subgroups.

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

David McBride, Washington State Department of Health

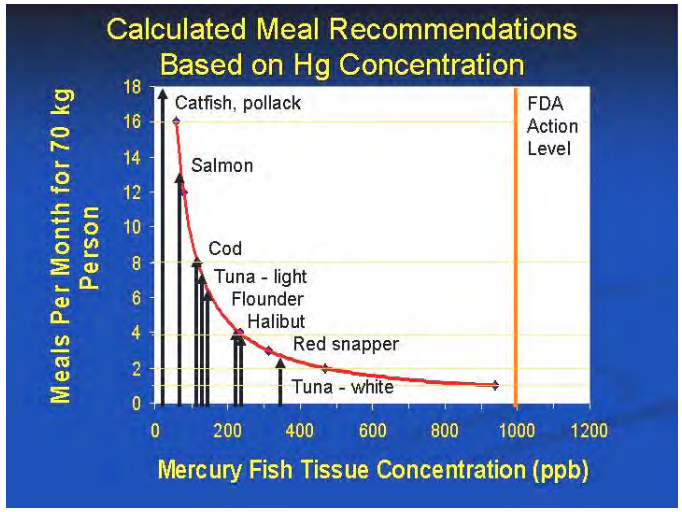
Fish advisories in Washington State have focused primarily on risks to recreational or subsistence fishers, yet the vast majority of fish that people consume are store bought. The aim of this study was to characterize levels of mercury, polychlorinated biphenyls (PCBs), and polybrominated diphenyl ethers (PBDEs) in fish sold in grocery stories in Washington State and to develop consumption recommendations based on contaminant levels. The stores from which fish purchases were made included large and small grocery stores on which data on total food sales (in dollars) could be obtained from the Washington Department of Revenue. Stores were randomly selected from a list of all retail outlets selling food, with the probability of selection proportional to the volume of food sales for the previous year.

At each selected store, samples of nine species of commonly consumed fish (canned “light and white” tuna, pollack, catfish, red snapper, halibut, flounder, Chinook salmon, cod, and large tuna) were collected. Samples were collected between October 2004 and February 2005. One sample of each available fish type (fresh/frozen) was collected from each store:

- Medium-size fillet of counter fish
- Top package of packaged fish
- Relied on sales person regarding “species.”

It was found that fish labels on store packages or signs can include different species. As an example, red snapper includes rockfish and red snapper. For canned tuna, the study listed all available “products” of canned tuna on the shelf, excluding specialty products. The study then selected two cans from all albacore types and two cans from all light tuna types.

A total of 390 fish samples was collected from forty stores and analyzed for total mercury, PCB aroclors, and nine PBDE congeners. The Washington State University Department of Ecology's Manchester Laboratory conducted the analyses. Total mercury concentrations were highest in canned albacore "white" tuna (357 ppb) and lowest in catfish (not detected). Seven out of nine species had a mercury detection limit greater than 90 percent. Total PCB concentrations ranged from nondetect in flounder to 31.5 ppb in Chinook salmon. For PCBs only, halibut, red snapper, and salmon had detection frequencies greater than 10 percent. Total PBDE concentrations in all species were below 6 ppb. Calculated consumption rates based on U.S. EPA Fish Advisory Guidance (http://www.epa.gov/waterscience/fish/guidance.html) indicated that mercury concentrations drive meal limit recommendations in seven of the nine species sampled. For these calculations, a body weight of 70 kg and a meal size of 8 ounces were assumed. Results indicated that there are no restrictions on the amount of meals per month of pollack that may be eaten to still meet reference doses for mercury and PCBs. Catfish and red snapper both contained higher levels of PCBs and thus had more strict meal restrictions applied for PCBs than for mercury.



This study found that levels of PBDEs measured in fish sold in Washington State grocery stores are similar to levels previously reported. BDE-47 (2,2',4,4'-Tetrabromodiphenyl ether (BDE 47) was the most frequently detected contaminant in fish. This study provides much needed regional information on mercury, PCB, and PBDE levels in store-bought fish. This information will aid consumers in making informed decisions about risks from fish consumption.

Seafood Safe Case Study: Voluntary Seafood Contaminant Testing and Labeling Program

Henry W. Lovejoy, Seafood Safe, LLC; John R. Cosgrove, AXYS Analytical Services, Ltd.; and Colin Davies, Brooks Rand

Over the past 2 years, the Seafood Safe model has been developed through collaborative efforts with leading academics, consumer advocacy organizations, independent laboratories, and seafood industry quality assurance and sampling specialists. Seafood Safe seeks to dispel the conflicting information consumers receive on the consumption of seafood. On the one hand, the medical community and the new U.S. food pyramid are overwhelmingly recommending seafood, especially those species high in heart-healthy omega-3 fatty acids, as part of a healthy diet. On the other hand, consumers are being warned about the presence of dangerous contaminants in some types of seafood. Consumers require a credible, user-friendly, and easy system at the point of purchase. The industry needs to confront this public relations challenge head on. An industry-wide testing and labeling program would demonstrate that the vast majority of seafood is very safe, and would increase consumption of healthy species.

First, we have assembled an independent advisory panel consisting of two of the country's leading academics on the subject of contaminants in seafood to advise on the structure, methodology, and messaging of the program. Dr. Barbara Knuth of Cornell University and Dr. David Carpenter of the University at Albany (State University of New York) Albany are Seafood Safe's advisors. We have also partnered with an independent international seafood industry consulting firm to develop company-, species-, and fishery-specific guidelines, as well as chain-of-custody and sampling protocols. Testing is performed by independent laboratories specific to mercury and polychlorinated biphenyls (PCBs). We also have partnered with Environmental Defense as a consumer advocate to provide an information clearinghouse for consumer education on the subject. Seafood Safe not only has the ability to help eliminate consumer confusion, but also to portray a much more positive image of seafood.

Seafood Safe will be an industry-sponsored program. Those companies that want to participate and be evaluated will pay for the services. The first stage of participation will be a consultation phase, where the company's product line is studied in detail, including life history, regionality, size range, seasonality, available historical data, chain-of-custody considerations, et cetera. If the product line displays the ability to be monitored successfully, the company will proceed to the independently recommended testing regime. Finally, once products are successfully tested, a company will pay a minimal licensing fee to use the Seafood Safe label on their products and to cover Seafood Safe's operating costs. It is important to note that some products may not qualify for the program, due to a number of factors, and that each species and fishery will require different testing frequencies based on their particular characteristics.

We see future participation in Seafood Safe from all sectors of seafood use. Initially we will be focusing on aquaculture and prepackaged items for retail. Because these sectors are generally the least complex, they will afford us the ability to methodically ramp up the program toward more complex sectors, such as restaurants and possibly fresh retail fish cases. Currently we test for mercury and PCBs, but we will add additional contaminants as new ones are discovered. As we all know, the latest contaminants discovered in seafood are flame retardants.

We apply our test results to the U.S. EPA Guidance and Risk-Based Consumption Tables (http://www.epa.gov/ost/fishadvice/volume2/), and convert the results into the number of 4-ounce portions a woman of childbearing age can consume in a month. We use this subpopulation because they are the most at-risk adult category.

Frozen samples are received, homogenized, and sampled at AXYS Analytical Services Ltd., in Sidney, British Columbia, Canada, for PCBs. Results so far indicate:

- Highest [PCB] in albacore tuna; lowest in mahi mahi.
- [PCB]high resolution (HR) > [PCB]low resolution (LR) in all species.
- Ratio of [PCB]HR: [PCB]LR was variable and generally increased with increasing total PCB concentrations.
- "Short" LR PCB target list included all congeners > 0.1 ng/g by HR.
- HR data provide more reliable total PCB estimate than LR data. (LR estimate may provide a contingency estimate approach for decision purposes, e.g., by doubling total LR values.)

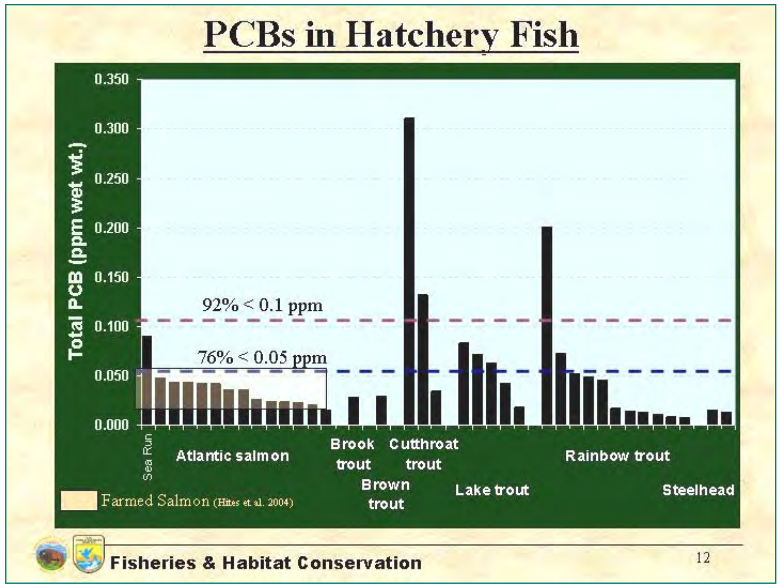
Mercury testing, completed by Brooks Rand, reveals:

- Highest [mercury] in albacore tuna and mahi mahi; lowest in keta salmon.
- Albacore tuna very consistent (relative standard deviation 6.7%).
- Mahi mahi and halibut much more variable (wider range of fish size and age).
- Methylmercury = total mercury in all finfish species.
- All shellfish low in mercury.
- Methylmercury 50–100 percent of total mercury in shellfish.

Strategy for Assessing and Managing Risks from Chemical Contamination of Fish from National Fish Hatcheries

George Noguchi, Linda L. Andreasen, and David Devault,
U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (FWS) is pursuing a proactive, science-based approach for evaluating and managing contaminant issues related to National Fish Hatchery System production. Over the past year, fish from 15 facilities, including 12 of the 39 hatcheries that produced "catchable size" fish in 2004, were analyzed for commonly measured contaminants, such as mercury and other metals, polychlorinated biphenyls (PCBs), dioxins/furans, dioxin toxic equivalents (TEQs), trace elements, and organochlorine pesticides. Facilities sampled are located in U.S. EPA Regions 1, 5, and 6. Composite samples (5 or 6 fish/sample) were used, and seven species were examined. Concentrations of mercury in hatchery fish samples were relatively low, ranging from 0.015 to 0.066 µg/g (ppm) wet weight, but were detected in all fish samples. PCBs were the only organic contaminant detected in all fish samples at significant levels, and the concentrations in skin-on fillets ranged from 0.008 to 0.31 µg /g wet weight, with most samples (> 90%) containing less than 0.1 µg /g. Concentrations of PCBs and dioxin TEQs in some samples were above U.S. EPA screening values.



In another study (A Survey of Chemical Constituents in National Fish Hatchery Fish Food) the FWS, along with the U.S. Geological Survey, analyzed fish feeds from 11 hatcheries and found that concentrations of contaminants vary between lots and between manufacturers (six analyzed). Multiple batches of feed were analyzed between 2001 and 2003. Fourteen PCB congeners were detected. When compared with earlier data obtained through similar analyses, the levels of PCBs measured in fish feeds seem to be decreasing over time. A Hatchery Contaminants Workshop was held in February 2005. The strategy developed at the workshop for assessing and managing risks from chemical contamination of fish from national fish hatcheries consists of: (1) a National Fish Hatchery System (NFHS) "healthy fish" goal, (2) clean feeds, (3) monitoring, and (4) guidance.

In light of these data, the FWS has developed interim guidance for stocking and/or transferring "catchable size" fish and a strategy for better understanding the issue, including the development of best management practices for "clean" fish production. Key stipulations of the *Draft Interim Guidelines for Hatchery Fish Management Decisions Regarding Contaminants in Catchable-Size Fish Produced by the National Fish Hatchery System* (http://www.fws.gov/northeast/fisheries/issues/Final%20memo%20to%20Regions%20with%20Interim%20Guidelines.pdf) include:

- When contaminant data are available for fish from a National Fish Hatchery (NFH):
  - If contaminant levels are below those that trigger "**do not eat**" state fish consumption advisory: Provide contaminant information to state, tribe, or federal land management agency and provide fish if requested.
  - If contaminant levels are at or above levels that trigger "**do not eat**" state fish consumption advisory: Fish should not be transferred or stocked.
- When the NFH has not yet been sampled and no contaminant data are available:
  - Make fish available unless the facility is considered potentially high risk according to the Hatchery Risk Assessment Matrix.
  - High-risk facilities: Consult with states, tribes, and federal land management agencies, as appropriate, to discuss potential risks. Applies to all activities (stocking/transfer to states, tribes, and federal lands; fishing events at NFHs).

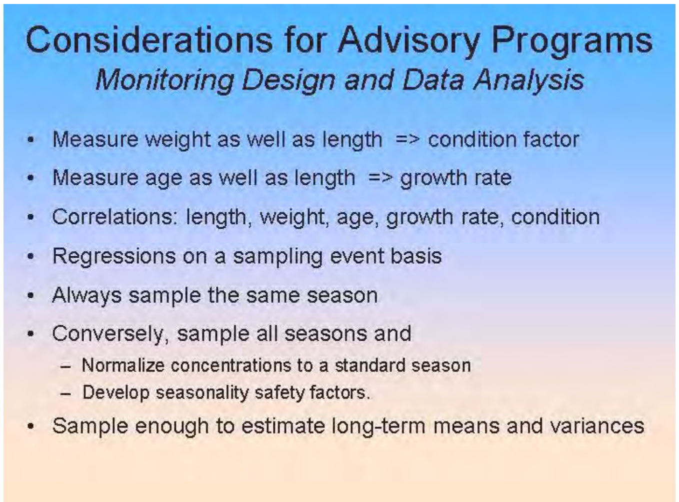
Variability of Mercury Concentrations in Fish with Season, Year, and Body Condition

Paul Cocca, U.S. Environmental Protection Agency

(Note: See presentation in Section III for full citation of studies and publications referenced in abstract.)

Though not well studied, measured seasonality in fish fillet muscle mercury concentrations has been reported in the literature in a few locations. Variations are believed to be caused primarily by fluctuations in fish growth and nutrition. Kehrig et al. (1998) found cold-season muscle mercury concentrations to be a factor of 1.6 to 3.4 times greater than warm-season concentrations for a widely consumed fish species in Brazilian estuaries. Explanations in this study included that concentrations increase when fish lose weight and that spring bioproduction dilutes the available mercury. Park and Curtis (1997) showed largemouth bass muscle mercury concentrations to be roughly twofold higher in the fall of 1994 than in the previous summer in two reservoirs in Oregon. The authors attributed the difference to the fact that environmental conditions influence methylmercury production and bioavailability and that growth dilution causes concentration decreases. A later study of one of the same reservoirs, however, showed seasonal concentration differences to not be statistically significant (Foster et al., 1999). Szefer et al. (2003) found relatively high concentrations of muscle mercury in winter-captured perch in Pomeranian Bay (Southern Baltic) and supported the seasonal differences by factor analysis. Suns and Hitchin (1990) measured interannual variability in fish mercury using yellow perch yearlings in 16 Ontario lakes (whole fish, unadjusted). The fish were monitored over a 10-year period with approximately seven sampling events per lake. The **high concentration : low concentration** ratio ranges from 1.5 to 2.2 for most lakes. Seasonal fluctuation in fish mercury has not been well studied, perhaps because it is not expected. Reported fish mercury depuration rates are quite slow.

While researchers have reported a wide range of rates, from a few days to several years, there is a central tendency towards elimination half-lives on the order of 100-200 days (Giblin and Massaro, 1973; Rodgers and Beamish, 1982; Huckabee et al., 1979 [literature review]; Burrows and Krenkel, 1973; McKim et al., 1976). Such slow loss rates would be expected to have a strong dampening effect on any fluctuations in methylmercury concentrations in fish prey. Instead, calendar-season variations in fish tissue mercury may reflect seasonal nutrition variations. Statistically higher concentrations from skinnier striped bass have been reported by Hinners (2004), as in co-authored publications (Cizdziel et al., 2002 and 2003). Their study supports, in part, the speculation by Kehrig et al. (1998) that higher fish tissue mercury levels in winter are likely caused by fish weight losses from winter reductions in food and from lower water temperatures. Mercury elimination rate has been found to be the same for fish that were starved relative to nonstarved fish (Burrows and Krenkel, 1973). The negative correlation between fish body condition (a ratio of weight to cubed length, which measures nutritional status and trends) and fish tissue mercury concentration reported by Greenfield et al. (2001) and Cizdziel et al. (2002 and 2003) has been rationalized by the latter authors as a consequence of starvation concentrating the mercury into less tissue, that is, **starvation concentration**. This could be considered the converse of the phenomenon of **growth dilution**, which has been described by a number of researchers. Simoneau et al. (2005) found lower fish mercury



concentrations to correlate with higher growth rates. Doyon et al. (1998) found dwarf whitefish to bioaccumulate mercury more rapidly than normal-size whitefish in the same lakes, and they attributed this to slower growth rates and earlier maturity in the dwarf fish. Both Doyon et al. (1998) and Greenfield et al. (2001) point out that slower growing fish would allocate more energy towards maintenance and less to flesh production and that faster growing fish reach a given size more efficiently, adding flesh at a lower energy cost and thus proportionally less mercury intake. Park and Curtis (1997) offer an alternative explanation that methylmercury accumulated during periods of high growth might be accumulated at lower concentrations due to lower availability in the food web.

After reviewing this literature, several considerations for the monitoring design and data analysis portion of advisory programs can be made:

- Measure weight as well as length ⇨ condition factor.
- Measure age as well as length ⇨ growth rate.
- Correlations: length, weight, age, growth rate, condition.
- Regressions on a sampling event basis.
- Always sample the same season.
- Conversely, sample all seasons and:
  - Normalize concentrations to a standard season
  - Develop seasonality safety factors.
- Sample enough to estimate long-term means and variances.
- Include seasons in advisories (e.g., “special note to ice fishers”).
- Include condition in advisories (e.g., “skinny bad, fat good”).
- Use condition factor as an inexpensive mercury index.
- Promote fisheries health to reduce human exposure.

Establishing Baseline Mercury Fish Tissue Concentrations for Regulatory Analysis

Janet F. Cakir, Office of Air and Radiation, U.S. Environmental Protection Agency

Human tissue contaminated with mercury has been linked to heart disease (Salonen et al., 1995) and impaired neurological function and development (Daniels, 2004). Most states have issued advisories warning people that it may be dangerous to consume freshwater fish. Fishing advisories are maintained based on samples of mercury concentrations in fish.

The latest version of the National Listing of Fish Advisories (NLFA) database contains more than 90,000 samples collected over the past four decades. For each sample it contains several key pieces of information including:

- Mercury sampled from aquatic life
- Species
- Location (extensive additional geocoding in 2002)
- Date
- Size of fish (length and weight).

The advantage of using the NLFA is that it contains a larger number of samples for large consumer fish than any other source, and the sampled locations were chosen using stratified random sampling. However, to its disadvantage, taking a simple average of all the samples in a watershed or waterbody could potentially result in misleading estimates of exposure, and waterbody-to-waterbody variability is confounded by a variety of other factors. Also, the database does not contain enough samples to conduct a benefit analysis.

There are an estimated 3.5 million miles of river and more than 250,000 square miles of lakes in the United States. To collect one sample fish from every mile of river or square mile of lake for 1 year would be prohibitively expensive and time consuming. Therefore, there is a need to make the most out of existing samples and any historical sample data available.

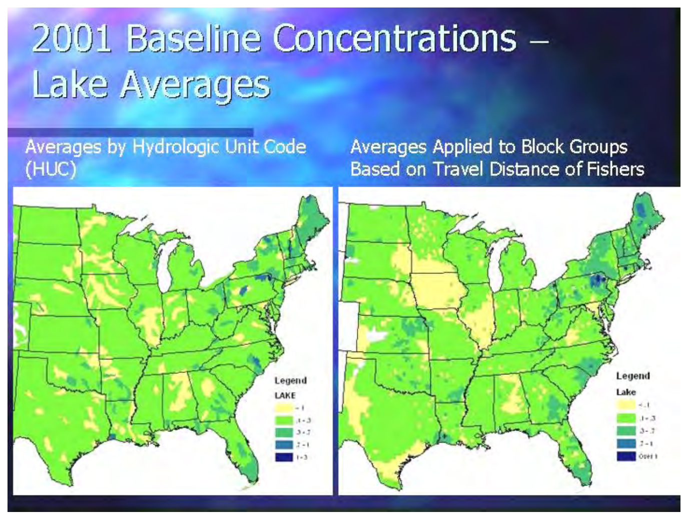
Mercury is a bioaccumulant and biomagnifies in fish over time. As a fish gets older, it has more potential to collect and store the available mercury. Additionally, other factors, such as the species and sample method, can influence the measured concentration of mercury in fish. Different fish live longer, grow larger, and have different diets from other fish. For example, an adult catfish is a bottom feeder, but can grow large. An adult sunfish is much smaller and eats terrestrial and aquatic insects. One would not expect these two fish to have the same concentrations of mercury, even if they were from the same waterbody.

Mercury bioaccumulates in the tissues of fish. At the laboratory, the technician may take a fillet of the catfish and use the whole sunfish to determine mercury concentrations. If only a fillet is sampled, as opposed to the entire fish, the fillet would result in a higher reported mercury concentration. This difference in sample cut can add an additional source of variability in mercury concentrations between fish.

Sources of variability in mercury concentrations, such as the age or size of the fish, species, and cut of fish, can confound the ability to make comparisons between samples. The U.S. Geological Survey (USGS) has developed a statistical procedure to predict what a sampled concentration would be for one size, species, or cut of fish from a sample of another size, species, or cut of fish (Wente, 2004, available at: http://pubs.usgs.gov/sir/2004/5199/).

This ability to predict mercury concentrations for fish that meet certain size, species, or and/or cut criteria from a robust data set of hundreds of other size, species, and/or cut combinations is critical for regulatory purposes because human exposure to mercury is through the consumption of fish with high concentrations of biomagnified mercury.

The National Descriptive Model of Mercury and Fish (NDMMF), developed by Dr. Steve Wente of the USGS, establishes a statistical relationship between samples taken at different locations from different species and lengths of fish with different sampling methods. The NDMMF algorithm uses those relationships to estimate a fish tissue concentration for a selected, predefined species, size, and sampling method chosen from an actual sample with different parameters. However, the algorithm has limitations in that it does not estimate mercury concentrations where samples were not already taken. (i.e., no spatial interpolation or extrapolation). A combination of the NLFA and the National Lake Fish Tissue Study (NLFTS) would provide enough sampled concentrations to establish a “baseline” from which to predict concentration changes after proposed new regulation implementations. After screening National Listing of Fish and Wildlife Advisories (NLFWA) and NLFTS data for data entry errors, nongeoreferenced data, missing attributes, and samples collected prior to 1990, the NDMMF was used with the data to estimate fish tissue concentration at locations across the country.



To examine the performance of the NDMMF a random 10 percent of the observations where at least two samples were available from a single sample location were withheld and the NDMMFF was re-run without the samples. The withheld data set was predicted based on the statistical relationships established by the NDMMF. The resulting spread of the data remained similar. The residuals for a majority of the data are balanced around zero, and there is a slightly unbalanced tail, indicating a slight under-prediction of extremely high values. Scatterplots also indicate slight under-prediction of high values. The NDMMF is a log model. To evaluate the model, predicted values were transformed back to ppm. A log back-transformation bias is likely responsible for the slight under-prediction. For future studies, where possible, it is recommended that predictions remain in the log scale.

Mapping Sensitivity of Aquatic Ecosystems to Mercury Inputs across the Contiguous United States

David P. Krabbenhoft, U.S. Geological Survey

About 15 to 20 years ago, researchers at a few locations across the globe discovered high levels of mercury in fish from remote settings lacking any obvious mercury source. We now know that, for most aquatic ecosystems, atmospheric deposition is the dominant source, and that mercury methylation is the key process that translates low mercury loading rates into relatively high levels at the top of food webs. Presently, proposed mercury emission regulations are a key topic of debate in the United States and elsewhere, with fundamental disagreements over the magnitude and timing of ecosystem responses to changes in mercury loading. Recent field dosing studies in the Everglades and in northwestern Ontario have clearly demonstrated that mercury additions yield higher levels of mercury in fish; however, anticipating and explaining where areas of heightened concern may be has remained under evaluated. In the past year, the U.S. Geological Survey and the U.S. Environmental Protection Agency have undertaken an exploratory effort to determine whether nationally distributed data of major ion chemistry of surface waters and land use of the United States can be used in a predictive manner to assess whether we might expect to see regional differences in vulnerability among aquatic ecosystems to mercury inputs. It is well known that logical sequences of ecological regions exist across the contiguous United States, and that these settings have characteristics that are widely varying (e.g., coastal lowlands versus high-altitude alpine systems). In addition, mercury researchers across the globe have demonstrated over the past 15 years what general conditions appear to promote greater transformation of inorganic mercury (derived from deposition) to methylmercury, which bioaccumulates in food webs and is of substantial toxicological concern. This paper explores the perceived trends in “mercury vulnerability” across the United States in a first attempt to explore whether focused regional attention on this global problem is warranted.

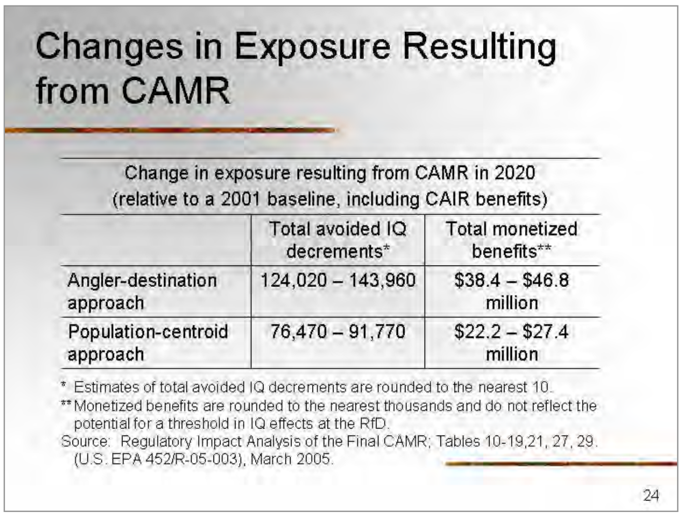
Projected Mercury Concentrations in Freshwater Fish and Changes in Exposure Resulting from the Clean Air Mercury Rule

Lisa Conner, U.S. Environmental Protection Agency

Mercury is a metal that transforms into methylmercury, a highly toxic form of mercury, when it is deposited into water. Methylmercury is ingested by the smallest to largest aquatic species and can bioaccumulate in predatory fish that consume smaller species. The major exposure pathway in humans and wildlife to methylmercury is through the consumption of fish from both freshwater and saltwater sources. In this presentation, we show two different approaches for estimating the exposure to methylmercury in women of childbearing age resulting from freshwater sources.

Present methodologies used to estimate reductions in fish tissue concentrations result from the Clean Air Mercury Rule (CAMR). Modeling impacts of CAMR on calculated mercury tissue concentrations requires the integration of several models. The mercury maps approach assumes that for a unit change in mercury deposition (e.g., 1% decrease), freshwater fish tissue will change proportionally (e.g., 1% decrease) when the ecosystem is in equilibrium. Benefits modeling assesses changes in fish tissue and improvements in human health. The focus of this analysis is on freshwater fish because there is data availability for a quantitative analysis, air quality changes occur primarily over freshwater sources, and the mercury maps approach only applies to freshwater fish.

Several factors were considered to determine the best approach to evaluate the impacts of CAMR on fish tissue. For fish tissue data, the National Listing of Fish and Wildlife Advisories (NLFWA) and the National Lake Fish Tissue Study (NLFTS) provide the most expansive set of fish tissue samples. Samples are primarily taken from freshwater sources in the eastern half of the United States (Texas to East Coast). Further mercury deposition from utility sources occurs primarily in the eastern half of the United States (Texas to East Coast). And finally, most of the change in mercury deposition will occur over freshwater sources in the eastern half of the United States.



Change in exposure resulting from CAMR in 2020 (relative to a 2001 baseline, including CAIR benefits)

	Total avoided IQ decrements*	Total monetized benefits**
Angler-destination approach	124,020 – 143,960	$38.4 – $46.8 million
Population-centroid approach	76,470 – 91,770	$22.2 – $27.4 million

* Estimates of total avoided IQ decrements are rounded to the nearest 10.
** Monetized benefits are rounded to the nearest thousands and do not reflect the potential for a threshold in IQ effects at the RfD.
Source: Regulatory Impact Analysis of the Final CAMR; Tables 10-19,21, 27, 29. (U.S. EPA 452/R-05-003), March 2005.

When modeling exposure to mercury, the amount of fish consumed and populations exposed to mercury were assessed for: women of childbearing age, Native Americans, Southeast Asian Americans, and subsistence fishers. The two approaches considered include the population-centroid approach and angler-destination approach. The population-centroid approach estimates the populations exposed within the distances typically traveled from the household to fish recreationally in freshwater lakes, rivers, and streams. The second approach, the angler-destination approach, evaluates exposure based on waterbody characteristics that are desired by anglers. The average mercury concentration of fish in each hydrological unit code (HUC) is used to determine exposure. Exposures from both the population-centroid approach and the angler-destination approach are then translated into estimates of intelligence quotient (IQ) decrements in children exposed in utero.

Analyses conducted using a simple average of the NLFWA and NLFTS data were not able to identify if differences in mercury concentrations among the samples were due to location (and possibly air deposition), or due to fish species, size, or sampling method (fillet, whole, fillet skin on, composite, etc.). Normalization of data using the U.S. Geological Survey model—National Descriptive Model of Mercury in Fish Tissue (NDMMFT)—allows for direct comparison by location. The NDMMFT runs were conducted for six key consumable fish species (bass, trout, perch, crappie, catfish, walleye). The model uses all National Listing of Fish Advisories (NLFA) and NLFTS samples for each run. Estimates are then combined into one average "fish" by location and applied to the two approaches. A simple average of the raw data is used in states for which the NLFWA does not contain a record of the size of the sample fish (Tennessee, Iowa, Ohio, Kansas, Virginia, West Virginia, Missouri, and Pennsylvania). Fish tissue concentrations are then calculated for the time period prior (baseline) to CAMR and post-

CAMR (postregulation) for both of the approaches. The maximum potential reduction based on the average estimated fish tissue concentration from utilities (and their monetized benefits) is calculated for the population-centroid approach and the angler-destination approach.

The regulatory impact analysis of the Final Clean Air Mercury Rule is available at: http://www.epa.gov/ttn/ecas/regdata/RIAs/mercury_ria_final.pdf.

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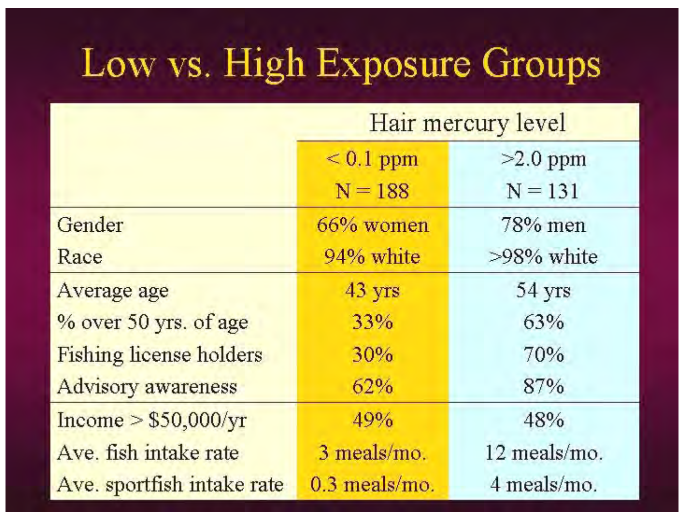
Mercury Exposure in Wisconsin

Lynda M. Knobeloch, Wisconsin Department of Health and Family Services

Fish consumption, advisory awareness, and mercury exposure were assessed among Wisconsin's adult population by adding a module to the 2004 Behavioral Risk Factor Surveillance Survey (BRFSS) and by inviting all adult residents to participate in a mercury exposure study. Four thousand two hundred and six (4,206) BRFSS participants were asked about fish consumption and advisory awareness, and 2,000 adult hair donors completed fish consumption/advisory awareness questionnaires. Research questions included: how much fish are people eating, what types of fish are they eating, how much mercury are Wisconsin residents being exposed to, and how much mercury are men being exposed to? Funding for this research was provided by the Wisconsin Department of Administration's Focus on Energy Program and by the Centers for Disease Control and Prevention.

The BRFSS provided fish consumption and advisory awareness information for more than 4,000 randomly selected adults. Weighted analysis of the BRFSS indicated that 83 percent of adults who live in Wisconsin include fish in their diets. Among fish consumers, men and women reported an average of 5.1 and 4.8 fish meals per month, respectively. In comparison, 95 percent of 2,029 hair donors included fish in their diets, with consumption rates averaging 7.6 and 7.7 fish meals per month among men and women, respectively. Hair mercury levels ranged from 0.012 to 15.2 µg/g (ppm) and exceeded the guideline value of 1 ppm in 29 percent of the men and 13 percent of the women who participated in this phase of our research.



Low vs. High Exposure Groups

	Hair mercury level	
	< 0.1 ppm N = 188	>2.0 ppm N = 131
Gender	66% women	78% men
Race	94% white	>98% white
Average age	43 yrs	54 yrs
% over 50 yrs. of age	33%	63%
Fishing license holders	30%	70%
Advisory awareness	62%	87%
Income > $50,000/yr	49%	48%
Ave. fish intake rate	3 meals/mo.	12 meals/mo.
Ave. sportfish intake rate	0.3 meals/mo.	4 meals/mo.

Hair mercury levels were significantly higher in men (0.918 ppm) than in women (0.525 ppm) and were correlated with monthly fish consumption estimates. Based on a comparison of BRFSS and hair donor data, approximately 12 percent of Wisconsin's adult population is expected to have a hair mercury level above 1 ppm, which exceeds the exposure guideline for methylmercury. Men over the age of 50 who eat sportfish and ingest more than 8 fish meals per month are more at risk for exposure. Future studies could determine: why hair mercury levels are higher in men; how non-fish eaters are being exposed to mercury; and what the mercury levels are in children.

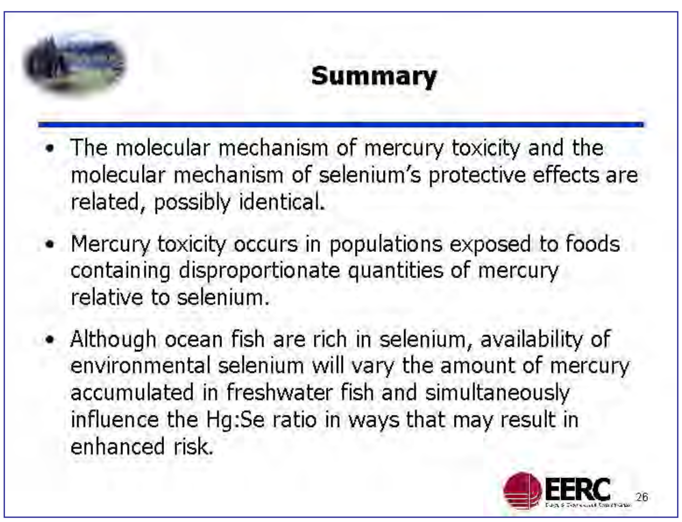
Physiological and Environmental Importance of Mercury-Selenium Interactions

Nicholas V.C. Ralston, University of North Dakota

Knowledge of selenium metabolism is central to understanding and preventing mercury toxicity. Dietary selenium is essential in supporting the synthesis of selenocysteine, the rare but important amino acid that is specifically incorporated as the functional active-site component of selenium-dependent enzymes. These enzymes are present in tissue-specific distributions in all cells of all animals, but their functions appear to be especially important in the central nervous system and endocrine organs. These numerous (25+ types) selenoproteins are important in free-radical detoxification, thyroid hormone metabolism, DNA synthesis, and selenoprotein synthesis, among other physiologically significant roles.

The molecular mechanisms of mercury toxicity and selenium's protective effects against mercury both depend on the extraordinarily high binding affinity between mercury and selenium. Selenium-dependent physiology is sensitive to mercury toxicity because selenocysteine must be resynthesized during each cycle of protein synthesis. Each cycle of selenocysteine synthesis forms selenide, which has an extremely high mercury-binding affinity (10^{45}), resulting in highly insoluble (10^{-52}) mercury selenides. Mercury toxicity occurs when excessive mercury stops selenocysteine synthesis and prevents selenoenzymes from performing their normal activities. Selenium's protective effect occurs when sufficient selenium is provided to overcome the effects of mercury sequestration and to sustain normal selenoenzyme activities.

Selenium physiology is also important to understand when considering the bioaccumulation of mercury in the environment. Mercury concentrations in lake fish appear to be inversely related to selenium availability. For example, selenium additions to selenium-deficient lakes have been found to decrease mercury bioaccumulation in fish collected from these lakes. This may be the result of mercury selenide formation in organisms of the lower food web, diminishing mercury availability to the predatory creatures that consume them. Reduced bioavailability of mercury in the lower food web will result in less mercury bioaccumulation in fish consumed by humans.

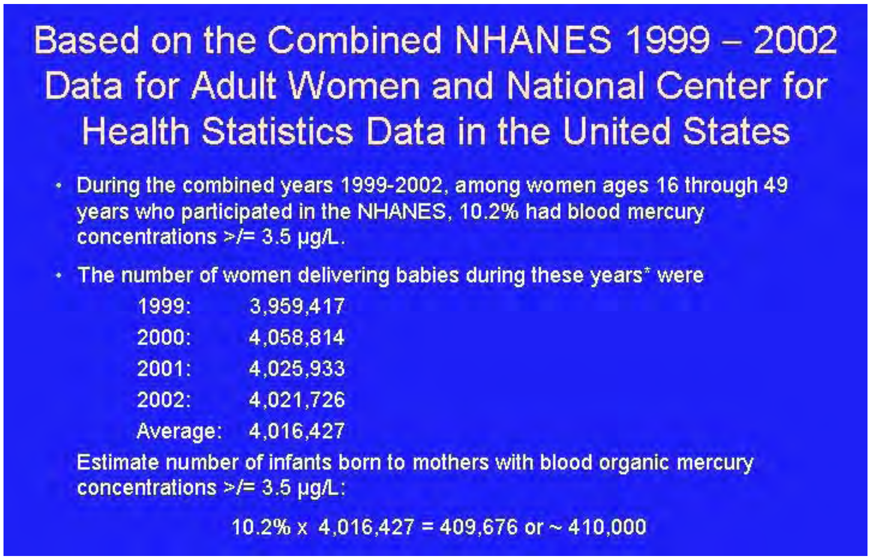


It is important to note that although selenium's geological distribution follows regional trends, selenium's availability from soils can vary dramatically over even short distances. Because mercury retirement rates in lakes can depend upon the environmental availability of selenium, selenium's role should be considered when evaluating mercury bioaccumulation in fish.

NHANES 1999–2002 Update on Mercury

Kathryn R. Mahaffey, U.S. Environmental Protection Agency
(Note: These findings do not necessarily reflect U.S. EPA policies.)

Using data for the 3,613 female examinees who participated in the National Health and Nutrition Examination Survey (NHANES) for the years 1999 through 2002, national estimates of blood organic mercury (OHg) were generated. Women whose incomes exceeded the "poverty" level of $20,000 for a household of four had higher blood mercury concentrations than those whose household income was less than the "poverty" level. Differences in the distribution of blood mercury concentrations were observed across racial and ethnic groups, with higher blood mercury concentrations reported among non-Hispanic blacks and other-Hispanics, and the highest average concentrations reported among "other" races. Similar rankings were observed at the 90th and 95th percentiles. Women residing in coastal areas had blood mercury concentrations that were 40 percent higher on average than those of women in noncoastal areas. Blood mercury concentrations for women living on the Atlantic coastal area were greater than those for women living in the Pacific coastal area, which, in turn, were greater than those for women living in the region of the Gulf of Mexico. These geographic differences may be important explanatory variables in differences between average mercury concentrations observed between NHANES 1999/2000 and 2001/2002 because they may be linked to differences in geographic sampling.

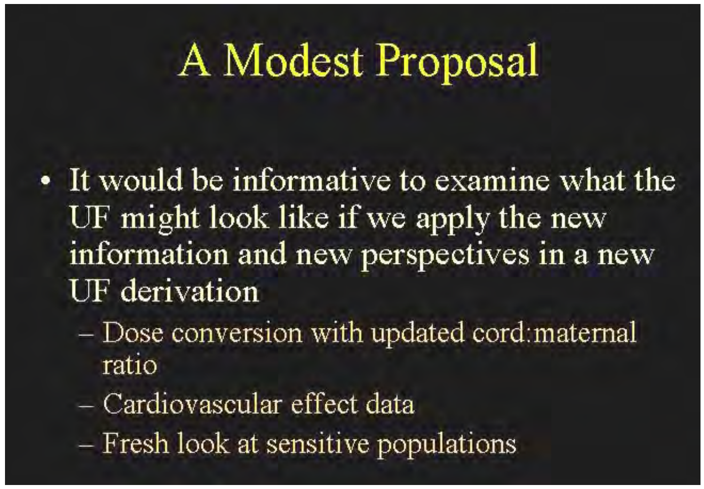


The U.S. Environmental Protection Agency's (U.S. EPA's) reference dose (RfD) for methylmercury is 0.1 µg/kg-bw/day and is associated with a cord blood mercury concentration of 5.8 µg/L. The methylmercury RfD is based on a benchmark dose lower limit of 58 µg Hg/L cord blood, utilizing an uncertainty factor of 10. Recognizing that cord blood mercury concentrations are 70 percent higher than maternal blood mercury concentrations at the mean, when assessing biomonitoring data for adult women, 3.5 µg Hg/L whole blood is equivalent to 5.8 µg Hg/L cord blood. Within the NHANES data for the years 1999 through 2002, 10.2 percent of women had blood [Hg] greater than or equal to 3.5 µg/L. Over this time period, there was an average of approximately 4,010,000 births per year. It is therefore estimated that approximately 410,000 births (i.e., 10.2% of 4,010,000) could occur to women whose blood [OHg] indicates exposures greater than U.S. EPA's RfD for methylmercury.

A Fresh Look at the Uncertainty Factor Adjustment in the Methylmercury RfD

Alan H. Stern, New Jersey Department of Environmental Protection

A critical and major element in the current U.S. Environmental Protection Agency (U.S. EPA) reference dose (RfD) for methylmercury is the uncertainty factor (UF) analysis. The UF analysis addresses both the conversion from cord blood mercury concentration to maternal intake dose (the "dose conversion") and the inherent uncertainty in the RfD derivation. Since U.S. EPA's derivation of the RfD in 2001, new data and analyses have become available that have the potential to influence the value of the dose conversion as well as the interpretation of the inherent uncertainty. For example, the ratio of mercury in cord blood to mercury in maternal blood has been established. In addition, some have analyzed how the maternal does corresponds to the cord blood benchmark dose level.



Because the description of how these factors were integrated into the existing UF analysis is imprecise and perhaps contradictory, possible revisions of the current UF analysis cannot be made by simple substitution of values for the appropriate elements in the analysis. It would be informative to examine what the new UF might look like if we applied the new information and perspectives. Specifically, we could revise the dose conversion with the updated cord blood: maternal blood ratio, review the cardiovascular effect data, and take a fresh look at sensitive populations.

In the current RfD, the dose conversion is derived probabilistically and there is uncertainty about appropriate central tendency estimates (central tendency and variability are separated). Recently, a new analysis of the dose conversion has emerged. It is no longer useful to separate central tendency and variable estimates. Updated cord blood : maternal blood ratios and their variability could be incorporated directly.

Another question is whether cardiovascular effects should be addressed by a database insufficiency. There are two major studies that show significantly elevated risk of myocardial infarction occurred within the range of current dietary exposures of the U.S. adult male population. This appears to justify application of a database insufficiency based on cardiovascular effects alone.

To include an uncertainty factor about sensitivity in humans, it is only necessary that there be a reasonable basis for assuming that the U.S. population could have a greater range of sensitivity than the population from which the RfD was derived. The homogeneity of the Faroese and the possible greater sensitivity in the varied New Zealand population argues that the U.S. population may have a greater range of sensitivity.

Possible calculations incorporating a new dose conversion, a minimum UF for database insufficiency, and a minimum UF for sensitive humans were presented. A fresh look at the UF for methlylmercury presents a range of possible appropriate values for the resulting RfD. These values extend from 70 percent of the current RfD to 20 percent of the current value. There is no uniquely correct value, but this analysis presents a basis for a rational and transparent decision.

Review of Cardiovascular Health Effects of Mercury—A U.S. Perspective

Eric B. Rimm, Harvard School of Public Health

Heart disease is the leading cause of death among men and women, and whether mercury contributes to this risk is of great concern. This presentation explores the effect of mercury on the heart. We know that mercury toxicity affects the brain, kidney, and fetus. Mercury has systemic and direct cardiovascular effects. Systemic effects include an increase in free radicals and reactive oxygen species, lipid peroxidation, coagulation, and a decrease in antioxidant system function (e.g., glutathione peroxidase). Direct cardiovascular effects include a decrease in myocardial contractile force, an increase in Ca^{++} release from myocardial sarcoplasmic reticulum, a decrease in left ventricular myosin adenosine triphosphatase (ATP-ase) activity and heartrate variability, and an increase in blood pressure.

The Health Professionals Follow-up Study followed a prospective cohort of 51,529 U.S. male health professionals aged 40–75 years in 1986. Dentists, veterinarians, pharmacists, osteopaths, podiatrists, and optometrists were studied. There were repeated assessments of diet, lifestyle behaviors, and medical history. During 5 years of follow up, there were 409 cases of nonfatal myocardial infarction (MI), fatal coronary heart disease (CHD), or coronary artery bypass graft/percutaneous transluminal coronary angioplasty (CABG/PTCA). Dr. Steve Morris of the University of Missouri–Columbia's Research Reactor Center completed the toenail assessment.

Mean Characteristics Between Prospectively Identified CHD Cases and Matched Controls

Characteristics	Cases	Controls
Age (years) *	60.6	60.6
Mercury (μg/g)	0.72	0.74
BMI (kg/m^2)	26.0	25.3
Current smokers (%)*	10.1	10.8
Diabetes	7.4	3.8
Hypertension	33.9	24.1
Hypercholesterolemia	15.2	10.5
Alcohol (g/day)	10.4	12.9

Long-term feeding studies suggest that toenails and hair are good markers of intake and exposure. The mean mercury concentration in prospectively identified CHD cases was 0.72 μg/g and in matched controls was 0.74 μg/g. When we compared the top quintile to the bottom quintile of mercury, we did not find an elevated risk of CHD (relative risk = 1.03; 95% confidence interval [CI]: 0.65, 1.65). However, when we excluded the dentists from the analysis and controlled for n-3 fatty acid intake, the relative risk estimate associated with higher mercury was somewhat elevated (relative risk = 1.70; 95% CI: 0.78, 3.73), although still nonsignificant.

In the Health Professionals Follow-up Study we found that toenail mercury reflects mercury intake. The cardiovascular disease (CVD) benefit of n-3 fatty acids in fish is strongly supported by a wide range of scientific evidence. Whether the mercury content of fish leads to elevated CVD has support from some European studies, less so from U.S. studies, although no study has yet had ample power across fatal and nonfatal CHD endpoints to address this issue completely. Further prospective studies are needed to help clarify the association, if any, between mercury and CHD.

Cardiovascular Health Effects of Mercury—European Data

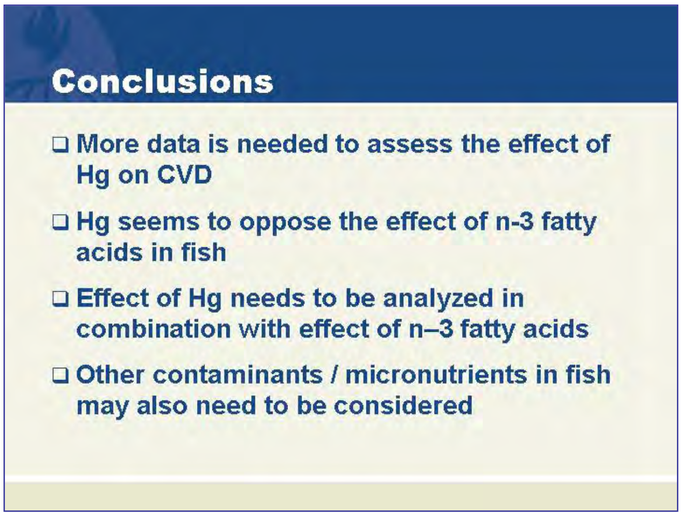
Eliseo Guallar, Johns Hopkins Bloomberg School of Public Health

This presentation explores the cardiovascular health effects of mercury by reviewing the results of European studies. Some key pathogenic processes in the etiology of atherosclerotic cardiovascular disease (CVD) include oxidative stress, endothelial dysfunction, inflammation, and thrombosis. Key risk factors include high blood pressure, high LDL (low-density lipoprotein) cholesterol, low HDL (high-density lipoprotein) cholesterol, diabetes, and insulin resistance. Mercury may relate to CVD through the following mechanisms of action. Mercury may increase oxidative stress; produce effects on blood pressure and heart rate variability; effect endothelial cells and inflammatory response; and effect intima-media thickness.

The Kuopio Ischemic Heart Disease Study was a cohort study of 1,833 men in Eastern Finland. The men were 42 to 60 years of age and had a high intake of freshwater fish from locally contaminated mercury lakes. Hair mercury content was measured by flow injection analysis—cold vapor atomic absorption spectrometry and amalgamation. The mean mercury level in hair was 1.98 µg/g. Dietary intakes of fish and mercury were associated with significantly increased risk of acute myocardial infarction (AMI). Men in the highest tertile (≥ 2 µg/g) of hair mercury content had a 2.0-fold age- and coronary heart disease-adjusted risk of AMI. However, men in the highest fifth of DHA+DPA (docosahexaenoic acid + docosapentaenoic acid) in serum total fatty acids who had a low hair mercury content (<2 µg/g) had a 67 percent reduced risk of acute coronary events compared with men in the lowest fifth who had a high hair content of mercury (>2 µg/g). Men in the highest third of hair mercury content (>2 µg/g) had an adjusted 1.60-fold risk of acute coronary event compared with men in the lower two thirds. High hair mercury content was a strong predictor of the 4-year increase in the mean carotid intima-media thickness.

The EURAMIC Study selected men aged 70 years or younger who were native residents of eight European countries or residents of Israel. Subjects were excluded if they had a previous diagnosis of myocardial infarction (MI), drug or alcohol abuse, major psychiatric disorders, if they were institutionalized, or if they had modified their dietary pattern in the past year. Cases were men with a first acute MI, confirmed by electrocardiogram (ECG) and enzyme changes, and hospitalized within 24 hours from the onset of symptoms. Cases were recruited from the coronary care units of participating hospitals. Controls were men without a history of MI, frequency matched to cases in 5-year intervals. Mercury levels in toenails were measured. After adjustment for the DHA level and coronary risk factors, the toenail mercury levels in the patients were 15 percent higher than those in controls. The risk-factor-adjusted odds ratio for MI associated with the highest as compared with the lowest quintile of mercury was 2.16. After adjustment for the mercury level, the DHA level was inversely associated with the risk of MI (odds ratio for the highest versus the lowest quintile, 0.59).

The strengths of the EURAMIC study are its large sample size; its use of toenail mercury by neutron activation analysis; its use of adipose tissue DHA; and its multicenter design. The study does have some limitations, such as the case-control design; lack of data on dietary intake; measurement error; and nonfatal cases of MI.



Reviewing the above studies leads to the following conclusions. More data are needed to assess the effect of mercury on CVD. However, mercury does seem to oppose the effect of n-3 fatty acids in fish. For this reason, the effect of mercury needs to be analyzed in combination with effect of n–3 fatty acids. Other contaminants and micronutrients in fish may also need to be considered.

(Note: For the Kuipio Study, see Salonen, J.T. et al. 1995. *Circulation* 91:645–655; Rissanen, T.R. et al. 2000. *Circulation* 102:2677–2679; Virtanen, J.K. et al. 2005. *Arterioscler. Thromb. Vasc. Biol.* 25:228–233; and Salonen, J.T. et al. 2000. *Atherosclerosis* 148:265–273. For the EURAMIC study, see Guallar, E. et al. 2002. *New England Journal of Medicine* 347:1747–1754.)

Developmental Toxicity of PFOS and PFOA

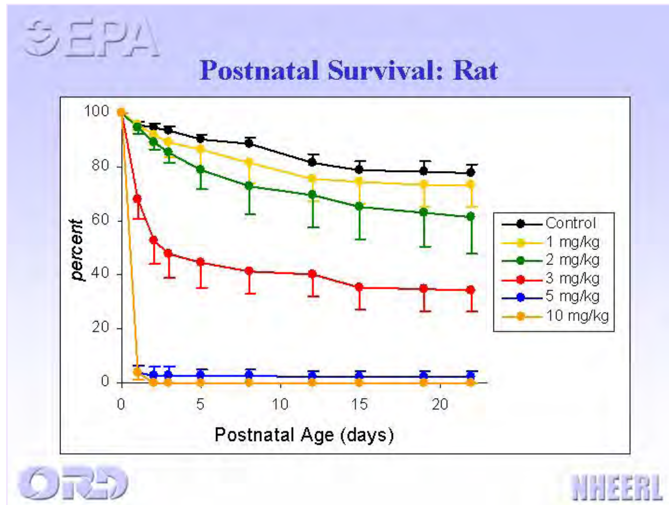
Christopher Lau, U.S. Environmental Protection Agency
(Note: This presentation does not necessarily reflect U.S. EPA policy.)

Perfluoroalkyl acids (PFAAs) are fully fluorinated organic chemicals with a carbon backbone (typically varying from C-4 to C-14) and a functional group (usually carboxylic acid or sulfonic acid). These chemicals are human made, are exceptionally stable with respect to metabolic and environmental degradation, and possess surfactant properties that lead to wide consumer and industrial applications, which include coatings for fabrics and carpets; coatings for paper products approved for food contact; fire-fighting foam; and the production of fluoropolymers and fluoroelastomers. The most widely used PFAAs in commerce are the C-8 forms, such as perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and the telomer alcohol (which is metabolized to PFOA).

Both PFOS and PFOA have been recently detected in humans and wildlife. Importantly, these chemicals are readily absorbed but poorly eliminated. In humans, elimination half-lives of

5.4 and 3.8 years have been estimated respectively for PFOS and PFOA. In 2003, the production of PFOS was phased out by its manufacturer, but its place in commerce has been taken up primarily by PFOA and by other PFAAs of different carbon chain lengths.

Developmental toxicity studies with PFOS and PFOA have been conducted in our laboratory in the past few years with rodent models. Both chemicals produced maternal toxicity, and deficits of maternal weight gains and liver enlargement were common features. Neither chemical was remarkably teratogenic, and prenatal effects were mostly composed of delayed development. Newborns from PFOS-treated rats and PFOA-treated mice were delivered live, but neonatal mortality was observed in the ensuing hours and days in a dose-dependent manner. A similar pattern of postnatal growth retardation was seen with PFOS- and PFOA-treated pups. Our results therefore suggest developmental toxicity for both C-8 PFAAs and underscore potential common mechanisms of toxicity shared by the entire class of these chemicals.

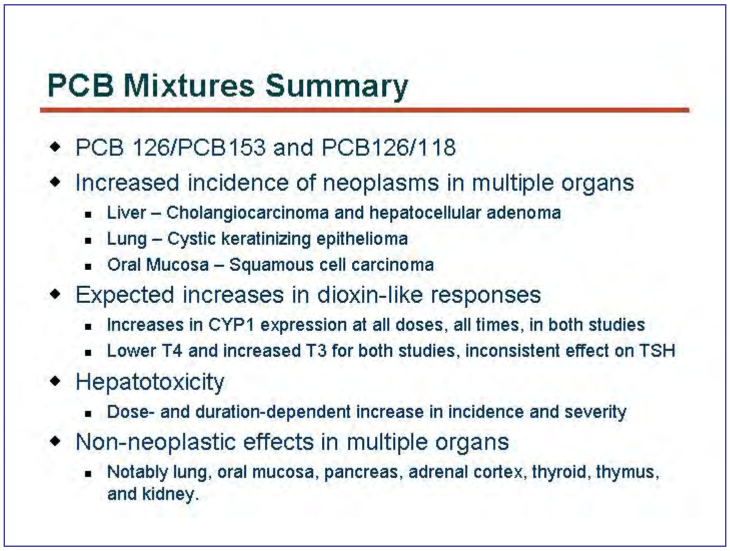


Overview of the National Toxicology Program Studies of Interactions between Individual PCB Congeners

Nigel Walker, National Institute of Environmental Health Sciences, National Institutes of Health

The dioxin toxic equivalency factor (TEF) approach is currently used worldwide for assessing and managing the risks posed by exposure to mixtures of certain dioxin-like compounds. Use of the TEF approach assumes that the combined effects of dioxin-like compounds in a mixture can be predicted based on a potency-adjusted dose additive combination of constituents of the mixture.

To test the TEF approach for carcinogenic risk, the National Toxicology Program conducted multiple 2-year rodent cancer bioassays in female Harlan Sprague Dawley rats, examining the carcinogenicity of several dioxin-like compounds, polychlorinated biphenyls (PCBs), a defined ternary mixture, and two mixtures of PCBs. Statistically based, dose-response modeling was used to evaluate the dose response for induction of both neoplastic and non-neoplastic effects seen in these studies, and to test for interactions between compounds within mixtures and interactions between dioxin-like and non-dioxin-like PCBs.



For the defined mixture of dioxin-like compounds, the dose response for induction of carcinogenicity for the mixture was consistent with an additive combination of the potency-adjusted doses of the individual compounds, when using administered dose as the dose metric. For the PCB mixtures, one of PCB 126 and PCB118 and the other a mixture of PCB126 and PCB153, the pattern of carcinogenic responses was consistent with that seen with PCB126 alone.

Overall, these data support the use of the TEF approach for potency-adjusted dose addition for use in cancer risk assessments for dioxin-like compounds. Another implication is that interactions can impact interpretation of toxic equivalent (TEQ) in mixtures of PCBs with multiple modes of action.

Establishing PCB Fish Advisories: Consideration of the Evolving Science

John D. Schell, BBL, Inc.

Most states issue polychlorinated biphenyl (PCB) advisories that are either risk/consumption based or Food and Drug Administration (FDA) based (based on the established tolerance level). In risk- or consumption-based advisories, as fish consumption goes up, the allowable fish tissue level goes down. For example, the Great Lakes Sport Fish Advisory Task Force (1993) recommends only one meal per week for fish with 0.2 ppm, and only 6 meals per year for fish with 1.9 ppm. Risk-based advisories are established by showing consumption results in a dose. Risk associated with the dose is determined using state of federally promulgated toxicity factors. Three different procedures are used to establish a trigger level.

Procedure 1 establishes a trigger level using toxicity factors derived from aroclor mixtures so PCBs in fish tissue are reported in aroclor equivalents. Advantages to this approach include that (1) aroclor-based toxicity factors consider response to multiple PCB congeners, (2) the current CSF is based on well-performed studies, (3) the approach allows consistency with historical approaches, and (4) laboratory costs are significantly lower than for the alternatives. However, the mixture in fish is not represented by aroclor mixtures, PCB concentrations can be underestimated, and some “dioxin-like” PCBs may be proportionally higher.

Procedure 2 bases advisories on toxicity factors derived from aroclor mixtures. Survey data are reported as individual congeners or homologues, summed, and expressed as “total PCBs.” Aroclor-based toxicity factors consider response to multiple PCB congeners, and the current CSF is based on well-performed studies. In addition, analysis accounts for all congeners present in tissue, so total PCBs are not underestimated. However, there are some disadvantages to this approach. Congener or homologue patterns may differ among reaches, but this approach assumes they are all equivalent. Applying aroclor-based advisory levels to variable patterns may under- or over-estimate risks. Analytical costs, especially for congener-specific data, are very high.

Procedure 3 bases advisories on toxicity factors from PCB congeners using the toxic equivalency factor (TEF) approach; compliance is congener based. Fish advisories are actually based on 2,3,7,8-TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin) cancer potency. An acceptable dioxin concentration is based on the CSF for TCDD, and TEFs for PCBs are applied to determine compliance.

The approach that should be used should be chosen for its ability to protect public health and the ability to implement the program (e.g., analytical cost and interpret results). Housatonic River data were used as an example to examine whether or not these procedures are equally protective. Concentrations of PCBs ("total PCB" and "PCB-toxic equivalent") in fish tissue were summarized. The cancer risks resulting from the different sources of CSFs were examined for aroclor, the current and proposed U.S. EPA dioxin CSF, and the California Environmental Protection Agency (Cal/EPA) dioxin CSF. Costs and benefits were considered. Aroclor analysis is the least expensive approach, PCB homologues are mid-range in cost, and PCB congeners are the most expensive.

If the toxic equivalent (TEQ) cancer potency of "dioxin-like PCBs" in fish is greater than the aroclor cancer potency of total PCBs, then we need to adopt an alternative approach. However, aroclor-based toxicity factors are adequately protective of public health. The use of homologues to estimate total PCBs in fish tissue addresses concerns that the commercial mixture does not represent an accurate characterization of the environmental mixture. Given the uncertainties associated with the TEQ approach, hypothetical "protectiveness" is not commensurate with the significant cost considerations.

History of Mercury Action Level and PCB Tolerance

P. Michael Bolger, Food and Drug Administration

A historical overview of the development of the Food and Drug Administration's (FDA's) action level for methylmercury and tolerance for polychlorinated biphenyls (PCBs) in fish and shellfish was given. Both were developed in the 1970s and were established on the basis of different portions of the federal food and drug statute. Section 402(a)(1) of the Food Adulteration Standards of the Federal Food, Drug, and Cosmetic Act state:

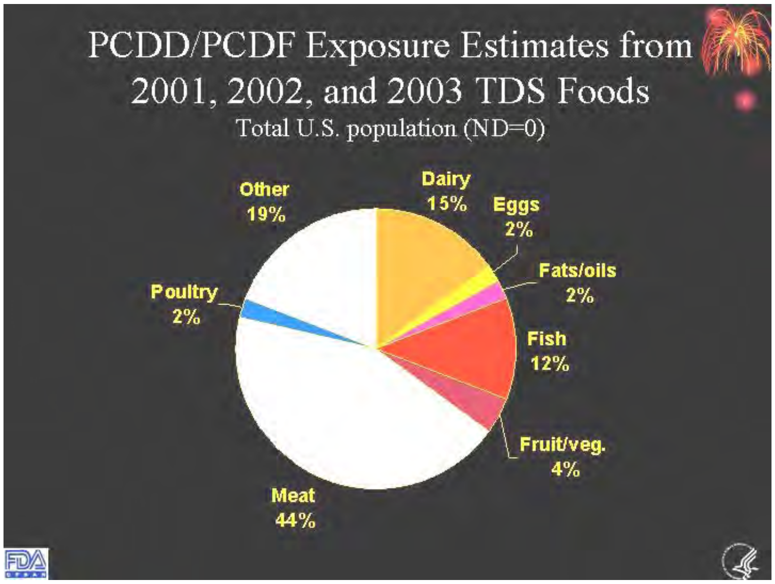
> "If it bears or contains any poisonous or deleterious substance which *may render it injurious* to health: but in case the substance is *not an added* substance such food shall not be considered adulterated under this clause if the quantity of such substance in such food does not *ordinarily render it injurious* to health."

The methylmercury action level was based on the "may render injurious to health" provision of the statute. An action level of 0.5 ppm was established in 1969 and reviewed by several committees. In 1979, the proposal was withdrawn and an action level of 1 ppm was established because of two issues raised in the *Anderson Seafoods* case involving swordfish (i.e., newer analysis indicated methylmercury exposure via fish was less than originally estimated, and analysis of dose-response data in Swedish fishermen indicated the threshold for parathesia in adults was greater than 50 ppm in hair). In 1984, the action level was changed from total mercury to methylmercury. In 1994, FDA stressed the importance of fish as a source of protein, but recommended that pregnant women and women of childbearing age should limit consumption of swordfish and shark to no more than once a month. The current methylmercury advisory recommends:

- Do not eat shark, swordfish, king mackerel, or tilefish because they contain high levels of mercury.
- Eat up to 12 oz (2 average meals) a week of a variety of fish and shellfish that are lower in mercury.
- Five of the most commonly eaten fish that are low in mercury are shrimp, canned light tuna, salmon, pollock, and catfish.
- Another commonly eaten fish, albacore ("white") tuna has more mercury than canned light tuna. So, when choosing your 2 meals of fish and shellfish, you may eat up to 6 oz (1 average meal) of albacore tuna per week.
- Check local advisories about the safety of fish caught by family and friends in your local lakes, rivers, and coastal areas. If no advice is available, eat up to 6 oz (1 average meal) per week of fish you catch from local waters, but don't consume any other fish during that week.

The PCB tolerance was also developed on the same statutory basis as well as other provisions, such as the detestability and avoidability provisions. In 1972, due to presence in diet and documented toxicity in laboratory animals and episodes of human intoxication, tolerances in several food groups were proposed, including 5 ppm in fish. In 1977, a proposal was published to lower the temporary tolerances. The temporary tolerance for fish was lowered to 2 ppm. In 1984, the tolerance for fish and shellfish was formally established.

The goals of FDA's dioxin-like contaminants (DLCs) program include identifying DLC-PCBs in food and feed suspected to contain these compounds and opportunities for DLC reduction by identifying sources/pathways that can be mitigated. The Total Diet Study is an annual market-basket program initiated in 1961 that involves the purchase of selected foods across the country and analysis for essential minerals, toxic elements, radionuclides, industrial



chemicals, and pesticides. It is designed to monitor nutrient and contaminant content of the food supply and observe trends over time. Beginning in 1999, 7 PCDD (polychlorinated dibenzo-p-dioxin) and 10 PCDF (polychlorinated dibenzofuran) congeners were monitored, and in 2004, three dioxin-like PCB congeners (PCB-77, PCB-126, and PCB-169) were added. Forty-four percent (44%) of PCDD/PCDF exposures are from meat. Fish and shellfish are among the foods sampled for the study.

In 2003, the National Academy of Sciences/National Research Council (NAS/NRC) recommended strategies to decrease dietary exposure to DLCs. Overall, the best strategy for **lowering** the risk of DLCs while maintaining the benefits of a good diet is to follow the recommendations in the Federal Dietary Guidelines. These strategies help lower the intake of saturated fats, as well as reduce the risk of exposure to dioxin.

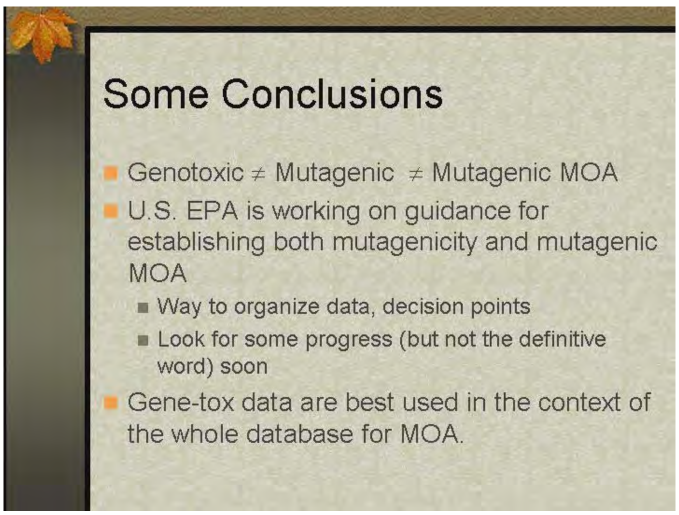
U.S. EPA's New Cancer Guidelines

Rita Schoeny, U.S. Environmental Protection Agency

The revision process for the U.S. Environmental Protection Agency's (U.S. EPA's) cancer guidelines has been underway since the early 1990s. Many incarnations were reviewed extensively. The guidelines were finalized and published in March 2005, with the concurrent release of *Supplemental Guidance for Assessing Cancer Risks from Early-Life Exposures*. Some key differences since the 1986 cancer guidelines include:

- Analyze data before invoking default options.
- Mode of action is key in decisions.
- Weight-of-evidence narrative replaces the previous "A-B-C-D-E" classification scheme.
- Two-step dose response assessment:
  - Model in observed range
  - Extrapolate from point of departure.
- Consider linear and nonlinear extrapolation.
- Address differential risks to children.

The mode of action is a sequence of key events and processes, starting with interaction of an agent with a cell, proceeding through operational and anatomical changes, and resulting in cancer formation. Mode of action is contrasted with "mechanism of action," which implies a more detailed understanding and description of events, often at the molecular level, than is meant by mode of action. The mode of action is key in hazard identification because it helps describe circumstances under which an agent is carcinogenic (e.g., high dose, route of administration) and the relevance of data for humans. The choice of low-dose extrapolation (nonlinear or linear) depends on the mode of action. When there is no evidence of linearity, but there is sufficient information to support mode of action nonlinear extrapolation at low doses, then nonlinear extrapolation is used. Linear extrapolation is used when mutagenic mode of action or another mode of action is expected to be linear at low doses or linear extrapolation is **default** when data do not establish the mode of action. In risk characterization, mutagenic mode of action risk is increased by an age-dependent adjustment factor (in the absence of data supporting separate risk estimates for childhood exposure): less than 2 years old = tenfold and 2 years to less than 16 years = threefold.



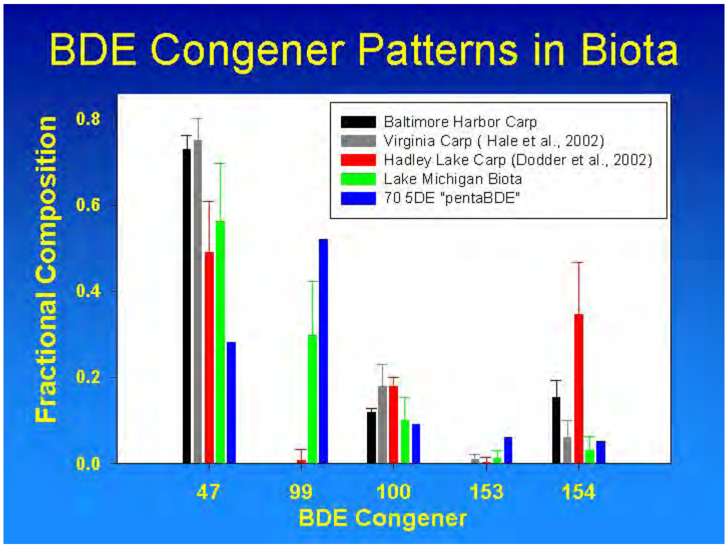
In this framework, the summary description of the hypothesized mode of action and identification of key events are included, as is the experimental support, consideration of the possibility of other modes of action, and the relevance to humans. A "key event" is an empirically observable precursor step that is itself a necessary element of the mode of action or is a biologically based marker for such an element. Genotoxic or mutagenic is not equal to mutagenic mode of action for cancer or other health effects. U.S. EPA is working on guidance for establishing both mutagenicity and mutagenic mode of action (e.g., way to organize data and decision points). Gene-tox data are best used in the context of the whole database for mode of action.

PBDE Exposure and Accumulation in Fish: The Impact of Biotransformation

Heather M. Stapleton, Duke University

Polybrominated diphenyl ethers (PBDEs) are brominated flame retardants added to numerous types of resins and plastics. These flame retardantresins and plastics are then incorporated into many common commercial products such as furniture, carpet padding, televisions, and cell phones. Due to their physicochemical properties, and the manner in which these flame retardants are applied, PBDEs leach out into the environment and accumulate in food webs and in people. In a series of exposure studies, common carp were exposed to PBDEs and polychlorinated biphenyls (PCBs) in their diet. Examination of the body burdens revealed that uptake and assimilation of PBDEs was comparable to the uptake and assimilation of PCBs.

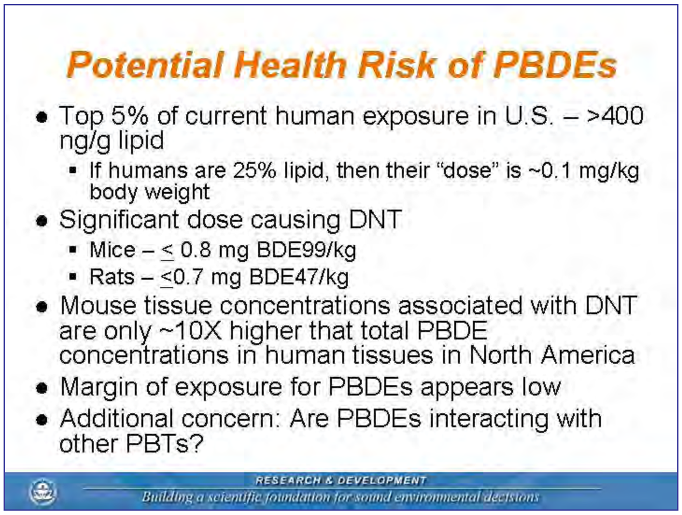
However, the half-lives of PBDEs were significantly lower than the half-life of PCBs, due to an apparent metabolic transformation. Single brominated diphenyl ether (BDE) congener exposures revealed that common carp have the ability to debrominate BDE 99, BDE 183 and BDE 209 via an enzymatic pathway. Following a 60-day dietary exposure to BDE 99 alone, common carp accumulated only BDE 47 in their tissues and no measurable levels of BDE 99. BDE 47 (2,2',4,4'-tetrabromodiphenyl ether) can be formed from BDE 99 (2,2',4,4',5-pentabromodiphenyl ether) by the removal of one meta-substituted bromine atom. In a 60 day dietary exposure to BDE 209, carp accumulated one penta, three hexa, two hepta, and one octabrominated diphenyl ether in their tissues, due to apparent metabolic transformation. These studies demonstrate that some species have the ability to metabolize PBDE congeners rapidly to less brominated analogues. Considering that toxicity studies have shown increased toxicity with decreasing bromination, some concern may be warranted.



PBDEs: Toxicology Update

Linda S. Birnbaum, U.S. Environmental Protection Agency
(Note: This presentation does not necessarily reflect U.S. EPA policy.)

Polybrominated diphenyl ethers (PBDEs) have been major commercial products used as flame retardants. While two of the commercial mixtures, Penta and Octa, have either been withdrawn or banned in Europe and the United States, respectively, the largest volume mixture, Deca, continues to be widely used. The relative congener mix in environmental samples, wildlife, and people rarely resembles that in the commercial products. The Penta mixture is the most ecotoxic, with recent studies demonstrating developmental effects in fish at low water concentrations, and immunological and hormonal effects in wildlife. While the hepatotoxicity of the commercial mixtures has been known for some time, association of the induction profiles of liver enzymes with specific congeners has shown that dioxin-like activities are due to contaminants in the commercial products.



Recent studies have focused on endocrine disruption and on developmental reproductive toxicity and neurotoxicity. The Penta mixture, as well as several congeners and/or their metabolites, are anti-thyroid, anti-progestin, and anti-androgenic, and may be either estrogenic or anti-estrogenic. Penta, brominated diphenyl ether 99 (BDE 99), and BDE 47 delay puberty and are toxic to both male and female sex organs. Penta and multiple BDE congeners, including BDE 209, are developmentally neurotoxic, impairing sensory and cognitive function as well as sex-dependent behaviors. While the Deca congener is relatively rapidly metabolized, the major lower brominated congeners are very persistent. Recent studies have shown that mice eliminate the PBDEs more rapidly in urine than do rats, suggesting a possible explanation for the wide variation of levels in people.

Given the high levels at the upper end of the distribution in Americans, there is little margin of exposure. Major questions concern Deca breakdown, interaction of PBDEs with other persistent chemicals, and the risk of alternative flame retardants. The final Integrated Risk Information System (IRIS) Assessment of four of the major congeners found in wildlife and people, BDE 47, BDE 99, BDE 153, and BDE 209, should be available by mid 2006.

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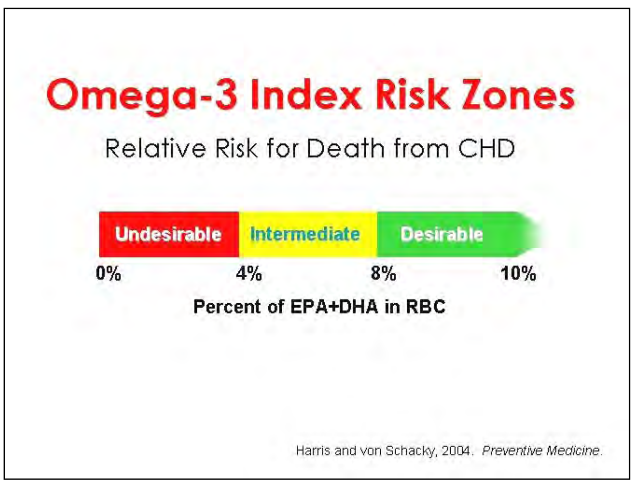
Omega-3 Fatty Acids: The Basics

William S. Harris, University of Missouri-Kansas City School of Medicine

There are two essential fatty acid families, the omega-6 family and the omega-3 family. Omega-6 fatty acids are contained in corn, safflower, and sunflower oils, as well as meat, eggs, and brains. Omega-3 fatty acids are contained in flaxseed, canola, and soybean oils; oily fish; and fish oil capsules. In adults, the conversion rate of alpha-linolenic acid (ALA) is less than 1 percent to eicosapentaenoic acid (EPA) and less than 0.01 percent to docosahexaenoic acid (DHA). There is no known need for ALA independent of its conversion to EPA/DHA. In fact, adequate EPA/DHA may eliminate the need for dietary ALA. With low consumption of EPA/DHA, a higher intake of omega-6 fatty acids will inhibit the conversion of ALA to EPA/DHA.

The cardio-protective properties of the long-chain omega-3 fatty acids found in fish oils have become clearer in recent years. The American Heart Association recommends that patients with documented coronary heart disease take 1 gram of EPA/DHA per day. The Association also recommends that patients without coronary heart disease (CHD) get about 500 mg of EPA and DHA per day. Intakes of 500 to 1,000 mg per day, either from foods or supplements have generally been associated with significantly reduced risk for CHD events, in particular, sudden cardiac death. It is interesting to note that there is slightly less EPA/DHA in wild Atlantic salmon than in farmed Atlantic salmon. There is much less EPA/DHA in wild rainbow trout than in farmed rainbow trout.



These fatty acids appear to have anti-arrhythmic properties that are unrelated to their effects on blood lipids. The evidence for the beneficial effects of the long-chain omega-3 fatty acids from fish (EPA and DHA) is much stronger than the evidence for the beneficial effects from the short-chain precursor, α-linolenic acid.

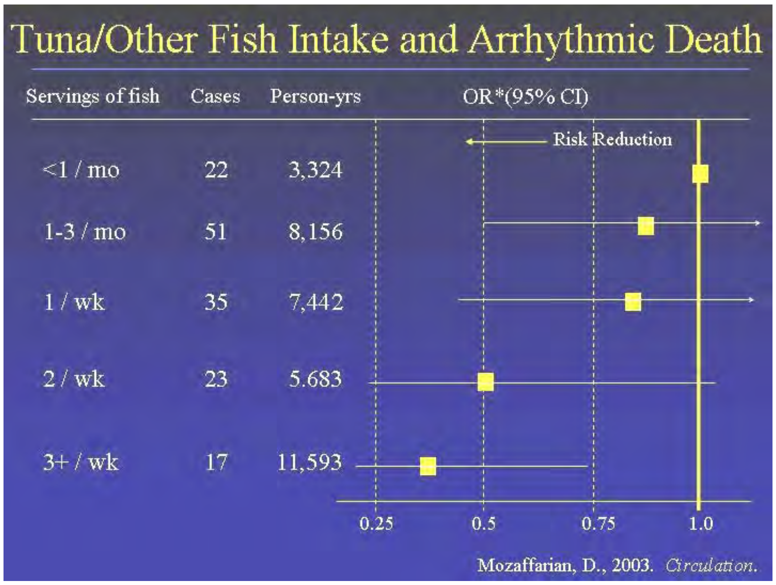
The omega-3 index is a measure of the amount of EPA and DHA in red blood cell membranes expressed as the percent of total fatty acids. At 0 to 4 percent, there is little protection against death from CHD; at 4 to 8 percent there is intermediate protection; at 8 to 10 percent there is a desirable level of protection against CHD. Blood omega-3 fatty acid levels may be the most powerful predictor of increased risk for sudden cardiac death, and may one day become a routine part of a cardiac risk panel.

Adult Health Benefits of Fish Consumption

Eric B. Rimm, Harvard School of Public Health

In the traditional diet-heart paradigm, total and saturated fat influence serum total and low-density lipoprotein (LDL) cholesterol, which influences coronary heart disease (CHD). In a more complete diet-heart paradigm, dietary habits, which include whole grain intake, glycemic load, and specific fatty acid composition such as omega-3 fatty acid intake, may influence a wide variety of health outcomes. Potential health outcomes include obesity, diabetes, atherosclerosis, acute coronary syndromes, sudden death, other arrhythmias, heart failure, and stroke.

There is strong evidence from observational and clinical trials that dietary n-3 fatty acids from fish or supplements reduce the risk of sudden death from CHD. Evidence also suggests that n-3 fatty acid intake reduces atrial fibrillation and congestive heart failure. Because of the impact of n-3 fatty acids on so many hormonal, signaling, and metabolic pathways, the health benefits of a diet high in n-3 fatty acids may be more far reaching than just those diseases described above. Some early indications suggest benefits for depression and cognitive function.

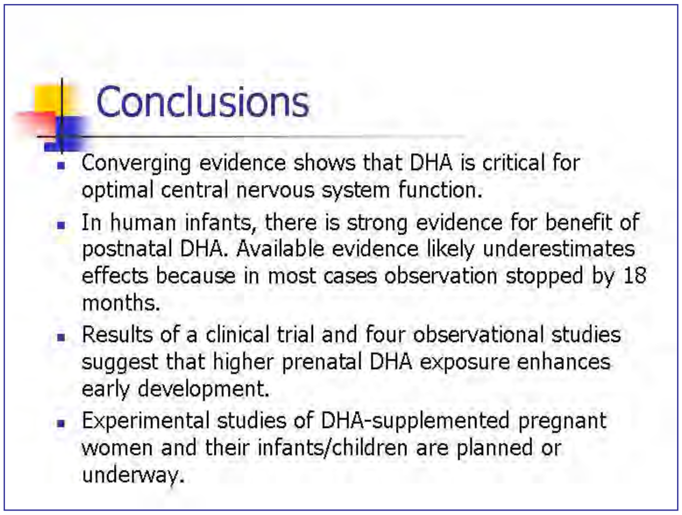


Fish intake may impact cardiovascular health through the following potential mechanisms: direct anti-arrhythmic; vascular resistance; blood pressure; heart rate; autonomic tone; left ventricular efficiency; anti-inflammatory effects; triglycerides; and/or endothelial cell function. The type of fish and preparation method are also important. For example, eating tuna or salmon higher in n-3 fatty acids has greater positive health outcomes than eating fried lean fish.

DHA and Infant Development

Susan E. Carlson, University of Kansas Medical Center

Some sources of fish have a very high concentration of docosahexaenoic acid (DHA), and fish in the maternal diet are a major source of DHA for the fetus and breast-fed newborn. Declines in maternal DHA intake, such as have been documented following the Food and Drug Administration advisories for some fish related to their mercury content, are of concern because the evidence points toward the importance of DHA for both the fetus and newborn infant. The evidence is strongest that DHA is important postnatally, but that is likely because the majority of randomized clinical trials have studied the effects of postnatal DHA intake on infant development (many through infant formula, but others by supplementing lactating women with fish oil or other sources of DHA). Results from randomized clinical trials have been presented for infants/toddlers and young children. While many studies show DHA increases visual acuity, there are fewer suggesting higher cognitive function. Higher cognitive function tends to be found more consistently in older than in younger children, which may be explained by the fact that benefits are more obvious after children develop more sophisticated cognitive function.



Newer evidence points to the likely importance of DHA during fetal life, but there has been only one randomized clinical trial, and it included postnatal as well as prenatal DHA supplementation via the mother. The majority of the current evidence that higher maternal DHA status benefits infant development comes from observational studies. The observational study results have been used to justify funding for new clinical trials that will address the effects of prenatal DHA exposure on infant development. Based on what we have learned from animal models, failure to accumulate optimal amounts of brain DHA during the prenatal period of human development may have irreversible consequences for development. Obviously, it becomes important to determine both the short- and long-term effects of variable DHA intake, especially as U.S. women typically consume less DHA than most other groups worldwide. This low intake in effect provides less DHA transferred to the fetus and breast-fed infant than in most other countries.

At present, a great deal more research is needed regarding the importance of timing and amounts of DHA exposure for optimal brain development.

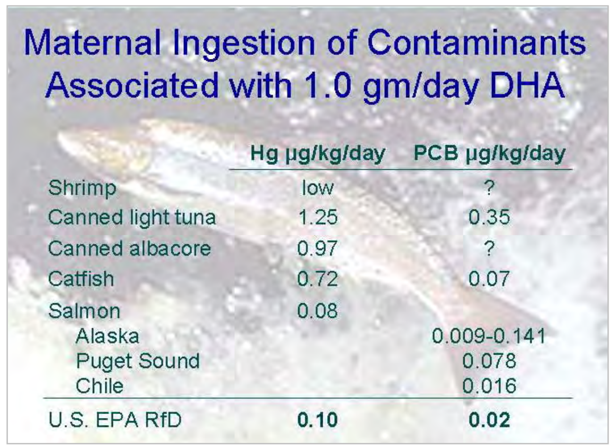
DHA and Contaminants in Fish: Balancing Risks and Benefits for Neuropsychological Function

Rita Schoeny, U.S. Environmental Protection Agency
(Note: The opinions in this paper are those of the author and should not be interpreted to be the policies of the U.S. EPA.)

There is current evidence for adverse effects of methylmercury. Methylmercury affects multiple developmental processes in brain. Several studies on rodents and monkeys have documented adverse developmental effects. Three longitudinal prospective studies and half a dozen cross-sectional studies have documented adverse effects. Effects include sensory and motor deficits; deficits in learning, memory, and attention in animals and humans; and decreased intelligence quotient (IQ) and language processing in humans. In addition, there may be cardiovascular effects.

The U.S. Environmental Protection Agency (EPA) defined an effect level based on the National Academy of Sciences (NAS) and the findings of an independent panel. The U.S. EPA calculated a range of levels; for example 58 µg/L mercury in cord blood (or 34 µg/L in maternal blood). The U.S. EPA calculated a reference dose (RfD) using a benchmark dose lower limit (BMDL) and uncertainty factors of 0.1 µg/kg bw/day. However, there is no evidence of a threshold within ranges of body burdens in epidemiological studies. Four-year data (1999–2002) from the National Health and Nutrition Examination Survey (NHANES) study showed that 5.7 percent of U.S. women had blood mercury levels above 5.8 µg/L.

There is also evidence for adverse effects of polychlorinated biphenyls (PCBs). In multiple experimental studies, rodents and monkeys had adverse effects from developmental exposure to PCBs. Four longitudinal prospective studies documented adverse effects. Effects include decreased IQ and impaired language development in humans; adverse effects on memory and attention; increased impulsivity and perseveration; impaired executive function; and effects on sexually dimorphic behavior in animals and humans. Effects observed in humans and monkeys involved the same blood concentrations of PCBs.


Maternal Ingestion of Contaminants Associated with 1.0 gm/day DHA

	Hg µg/kg/day	PCB µg/kg/day
Shrimp	low	?
Canned light tuna	1.25	0.35
Canned albacore	0.97	?
Catfish	0.72	0.07
Salmon	0.08	
Alaska		0.009-0.141
Puget Sound		0.078
Chile		0.016
U.S. EPA RfD	**0.10**	**0.02**

Studies of ω-3 fatty acids on infant development are difficult to interpret. There are at least 12 clinical trials of infants fed formula plus or minus docosahexaenoic acid (DHA). Results were compared to review growth as well as visual, motor, and mental development. Interpretation is complicated by the amount and ratio of linoleic and linolenic acids; duration of supplementation; age at testing; tests used; and the physiological significance of tests used.

Three studies report beneficial effects on visual development associated with various measures (breast feeding, DHA, ingestion of oily fish). Four studies of cognition and behavior show effects observed on some endpoints but not others. Effects are often associated with one marker and not others.

There are potential confounding factors in DHA studies. For example, the best predictor of a child's IQ is the mother's IQ. However, maternal IQ and fish intake may be correlated. The Caldwell's home observation for measurement of the environment score may be particularly important for visual development, but development of the visual system is highly dependent upon visual input.

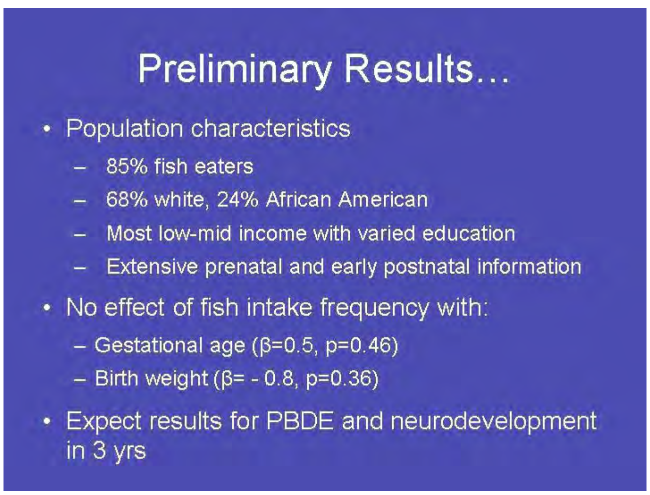
One randomized study from Norway looked at 100 infant-mother pairs who ingested 10 mL/day corn or cod liver oil (1.1 g DHA). There was no effect on memory (preferential looking) at 6 and 9 months. There was better performance on cognitive tests at 4 years associated with plasma DHA at 4 weeks, but not birth or 3 months. Another Inuit study was a prospective study of neuropsychological effects in children. The study measured contaminants including PCBs, methylmercury, lead, and pesticides, as well as omega-3 fatty acids. There was no beneficial effect of omega-3s on nervous system function. There were no protective effects of omega-3s against contaminant-associated neurotoxicity.

Omega-3 fatty acids may enhance infant development when ingested by the mother prepartum, during breast feeding, or both. However, fish is a complex mixture. Fish contains essential nutrients for mother and infant, but also contains contaminants harmful to both. Fish oils are less complex mixtures.

Fish Consumption and Reproductive and Developmental Outcomes

Julie L. Daniels, School of Public Health, University of North Carolina at Chapel Hill

Fish consumption is a source of many nutrients that can be beneficial during pregnancy, yet it is also a source of neurotoxicant contaminants, such as methylmercury. While concern over the potential for contaminants in fish to adversely affect neurodevelopment is prudent, the potential nutritional benefits of fish intake should also be considered when developing recommendations to the public about fish consumption during pregnancy and early childhood. Previous observational studies in large populations have presented mixed results for the impact of fish consumption on reproductive and developmental outcomes.



We evaluated the association between maternal fish intake during pregnancy and reproductive and early language development in a large cohort of British children born in 1991–1992. Fish intake by the mother and child was measured by questionnaire. The child's cognitive development was assessed using adaptations of the MacArthur Communicative Development Inventory at 15 months of age and the Denver Developmental Screening Test at 18 months of age. In subsets of this cohort, maternal fish consumption was correlated with maternal serum levels of long-chain fatty acids as well as umbilical cord tissue levels of mercury. Total mercury concentrations were low and were not associated with neurodevelopment. Fish intake by the mother during pregnancy, and the infant postnatally, was associated with slightly longer gestation and increased birth weight. Fish intake was also associated with higher mean developmental scores, as well as a decreased probability of low developmental scores. While the effects associated with fish intake are small in magnitude, the impact of such effects on the larger population could be marked. The use of epidemiologic data requires awareness of several caveats, including imprecise measurement of dietary fish consumption and the associated contaminants and nutrients. However, the potential benefit from moderate fish intake, when fish are not contaminated, should be considered when making recommendations to the public.

Nutrient Relationships in Seafood: Selections to Balance Benefits and Risks

Ann L. Yaktine, Institute of Medicine, The National Academies

The National Academy of Sciences (NAS) was created in 1863 by President Lincoln and Congress as a separate entity from government. The National Academies include the National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, and the National Research Council. National Academy committees deliberate in an environment free of political special interest and agency influence. Checks and balances are applied at every step in the study process to protect the integrity of the reports and maintain public confidence in them. Data-gathering meetings are open to the public and the study task, committee biographies, meeting dates, and summaries are posted on the Academy Web site (www.nationalacademies.org). Public comments can be made through the "Current Projects" link on the National Academies Web site.

Seafood contributes a variety of nutritional benefits to the American diet. They are sources of protein, calcium, iodine, copper, zinc, and omega-3 fatty acids. Furthermore, some nutrients may affect bioavailability, toxico-dynamics, and target-organ transport, and thus affect the toxicological response to certain compounds. Contamination of marine resources, however, whether by naturally occurring or introduced toxicants, is a concern for U.S. consumers because of the potential for adverse health effects. Human exposure to toxic compounds through seafood can be managed by making choices that provide desired nutrients balanced against exposure to such compounds in specific types of seafood that have been found to pose a particular health risk. Consumers, particularly subpopulations that may be at increased risk, need authoritative information to inform their choices.

This study will

- Assess evidence on availability of specific nutrients in seafood compared to other food sources
- Evaluate consumption patterns among the U.S. population
- Examine and prioritize exposure to naturally occurring and introduced toxicants through seafood
- Determine the impact of modifying food choices to reduce exposure
- Develop a decision path, appropriate to the needs of U.S. consumers, for guidance in selecting seafood to balance nutrient benefits against exposure risks
- Identify data gaps and recommend future research.

A draft report is expected in October 2005, and a final report in March 2006.

Maternal Fish Consumption, Hair Mercury, and Infant Cognition in a U.S. Cohort

Emily Oken, Harvard Medical School

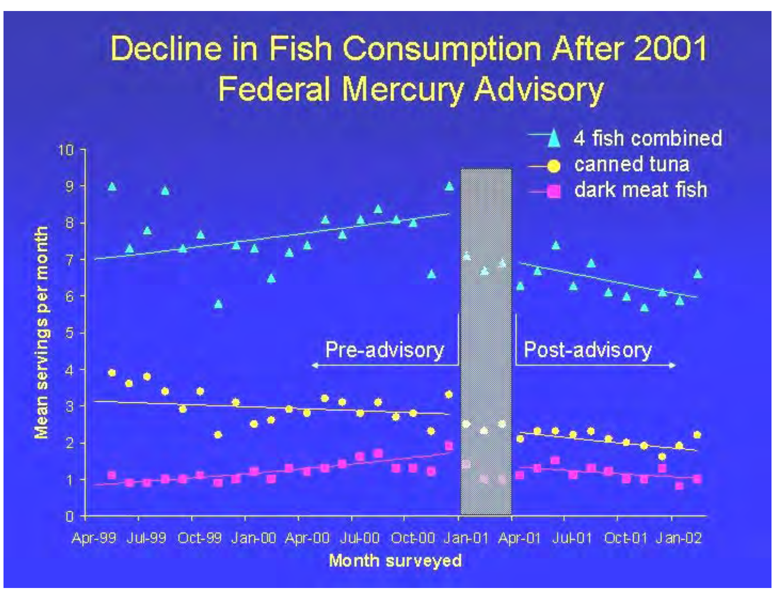
Fish and seafood are a primary source of elongated omega-3 fatty acids (EPA [eicosapentaenoic acid] and DHA [docosahexaenoic acid]). Fatty fish in particular have the highest levels of omega-3 fatty acids. People who eat more fish have higher levels of EPA and DHA. Some studies have shown how omega-3 fatty acids may influence pregnancy. Some studies suggest that omega-3 fatty acids prolong gestation and reduce the risk of preterm birth. Higher fish intake in pregnancy is associated with high birth weights, likely from longer gestation periods.

We were interested in whether maternal fish consumption during pregnancy harms or benefits fetal brain development. We examined the associations of maternal fish intake during pregnancy and maternal hair mercury at delivery with infant cognition among 135 mother-infant pairs in Project Viva, a prospective U.S. pregnancy and child cohort study.

Various analyses of Viva data show the following:

- There is no association between maternal omega-3 fatty acid intake and preeclampsia or gestational hypertension.
- There is no association with gestation length or risk of preterm.
- Maternal omega-3 fatty acid intake is inversely associated with fetal growth.

Prenatal data on omega-3 fatty acid and infant cognition show that DHA is an essential component of eye and brain cell membranes and that most fetal brain uptake occurs in late pregnancy and early infancy. One randomized controlled trial (RCT) showed higher intelligence at age 4 among children of mothers given prenatal cod liver oil (2.0 mg/day DHA+EPA) versus corn oil (n-6 fatty acids) (Helland, *Pediatrics*, 2003).



Postnatal data on omega-3 fatty acids and infant cognition show that breast-fed babies were "smarter" in a number of studies. (Note that breast milk contains DHA, and the formula did not.)

However, mercury, which may contaminate fish, may harm brain development. Prenatal mercury exposure in high levels is toxic. Moderate mercury exposure from fish and whale consumption in Faroe Islands was inversely associated with cognition. But there was no association of mercury levels and cognition among children in the Seychelle Islands (which had similar exposure levels to those of children in the Faroe Islands study).

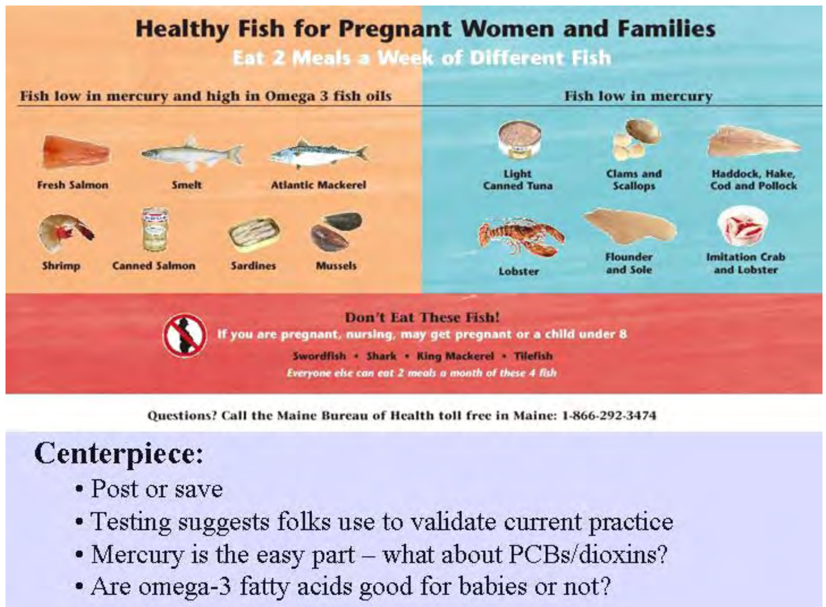
We assessed infant cognition by the percent novelty preference on visual recognition memory (VRM) testing at 6 months of age. In the study population, mothers consumed an average of 1.2 fish servings per week during the second trimester. Mean maternal hair mercury was 0.55 ppm, with 10 percent of samples greater than 1.2 ppm. The mean VRM score was 59.8 (range 10.9 to 92.5). After adjusting for participant characteristics using linear regression, higher fish intake was associated with higher infant cognition. This association strengthened after adjustment for hair mercury level. For each additional weekly fish serving, the offspring VRM score was 4.0 points higher (95% confidence interval [CI]: 1.3, 6.7). However, an increase of 1 ppm in mercury was associated with a decrement in the VRM score of 7.5 (95% CI: -13.7, -1.2) points. VRM scores were highest among infants of women who consumed more than two weekly fish servings, but who had mercury levels less than or equal to 1.2 ppm.

In this small sample of pregnant women from Massachusetts, higher fish consumption in pregnancy was associated with better infant cognition, but higher mercury levels with lower cognition. The implications are that women should continue to eat fish during pregnancy but should choose varieties with lower mercury contamination.

"Eating Fish for Good Health": A Brochure Balancing Risks and Benefits

Eric Frohmberg, Maine Bureau of Health

The state of Maine is in the process of revising its risk communication materials in an effort both to communicate fish advisories and to encourage consumption of low-mercury, high-omega-3-fatty-acid fish. Focus groups and key informant testing have identified a series of significant barriers to fish consumption. Significant concerns include balancing the benefits of omega-3 fish oils with lipophilic contaminants such as dioxin-like compounds and polychlorinated biphenyls (PCBs) and the quality of the benefits data for the developing fetus.



The motivation for developing a new brochure was that previous brochures focused only on sport-caught fish. In addition, Maine wanted to combine messages from multiple brochures into one. Through a series of multiple key informant and focus group tests, it was learned that: (1) people wanted information on sport-caught and commercial fish in one place; (2) people were aware of both mercury and omega-3 fatty acids; (3) there were some strong barriers to eating fish; and (4) everyone in the family needs to be addressed. Maine decided the new brochure should focus on commercial health, discuss health benefits, focus on what to do, address barriers, and address conflicting information.

The brochure:

- Identifies fish high in omega-3 fatty acids and low in mercury
- Includes advice on fish to avoid and fish to limit
- Provides advice to women of child-bearing age, children, as well as others
- Lists sport-caught fish that are low in mercury, and those to limit and avoid
- Discusses behavioral issues, such as how to buy, store, and cook fish, as well as what to eat at restaurants
- Provides a sample fish-eating schedule
- Discusses cost and sizes of fish meals

- Identifies issues for commonly eaten fish like fish sticks, tuna, farm-raised fish, and salmon.

The brochure centerpiece provides an illustration of various fish that are high in omega-3 fatty acids and low in mercury. Maine hopes that people will post this centerpiece in a visible place and refer to it.

The Use of Human Biomonitoring as a Risk Management Tool for Deriving Fish Consumption Advice

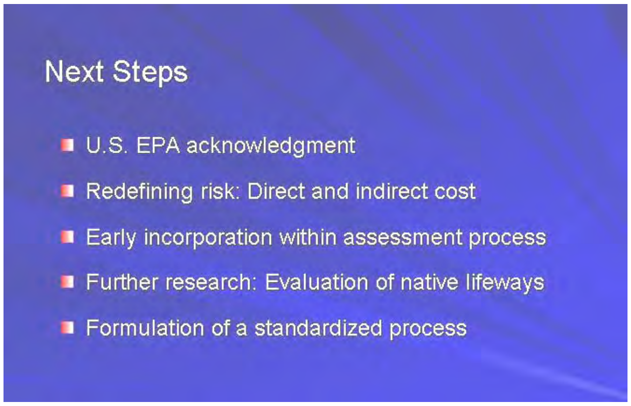
Scott M. Arnold, Alaska Division of Public Health

Fish is a healthy and readily available food item that is high in protein, low in saturated fat, and a rich source of omega-3 fatty acids and selenium. Broad, untargeted national advisories that recommend limiting the consumption of fish result in reduced fish consumption, causing unintended negative health consequences. The current national epidemic of obesity and diabetes underscores the need to balance the nutrient and public health benefits of fish consumption with the potential harm due to methylmercury and other anthropogenic contaminants in fish. New technology enables public health officials to directly measure actual methylmercury and contaminant exposures in populations that consume fish. The incorporation of human exposure information enables targeted, local advisories that include the consideration of the health benefits of fish consumption (e.g., nutritional, health, cultural, societal, and economic impacts) as well as the potential health risks.

A Comprehensive Risk Framework Presented to the Mohawks of Akwesasne

Anthony M. David, Environment Division, St. Regis Mohawk Tribe

The purpose of this comprehensive risk framework is to revise the various ways in which local industrial pollution—primarily polychlorinated biphenyls (PCBs) from three Superfund sites in the St. Lawrence River of northern New York—is evaluated and ultimately effectuated in terms of health and community wellness within the Mohawk territory of Akwesasne (St. Regis Indian Reservation) directly and/or as a consequence of management of the attendant risks. The contamination of fish, a staple of the Mohawk diet, has resulted in a number of **risk cascades** of direct and indirect health effects by removing a traditionally viable means of sustenance, and has contributed to socioeconomic and cultural impairment of the *Onkwehonwehneh* (Mohawk way-of life).



The identification of these endpoints reveals the limitations of the conventional federal paradigm for risk solely driven by direct exposure-effect relationships. The goal of this effort is to expand the framework of risk assessment used in Superfund remediation and other endeavors and thus to facilitate the construction of Applicable or Relevant and Appropriate Requirements (ARARs) suitable for the protection of Mohawk people and the *Onkwehonwehneh*.

Communicating the Nutritional Benefits and Risks of Fish Consumption

Charles R. Santerre, Purdue University

From environmental pollutants (mercury, polychlorinated biphenyls [PCBs], dioxins, furans, and flame retardants) to carotenoid pigments (astaxanthin and canthaxanthin), commercial seafood has been criticized by some as being highly toxic and dangerous for women of childbearing age and young children. Some researchers have recommended that intake of some popular species be limited to one meal per month or less. Some consumers ignore fish consumption advisories because they contend that the advice that is provided for recreationally caught fish is much more restrictive than that provided by federal agencies to regulate commercial fish products. In contrast to the risks associated with fish consumption is an increasing body of scientific evidence regarding the benefits from eating fish. This has confused many consumers and healthcare professionals in the United States as they question whether fish products are safe and whether the risks from consuming fish outweigh the benefits.

This presentation describes efforts to develop a simplified fish consumption advisory that incorporates advice based both upon contaminant residues and the nutritional benefits of commercial and recreationally caught fish.

As background information, around 38 percent of Indiana anglers do no follow fish advisories. This could impact 5,876 fetuses and close to 111,000 people 1–18 years of age. Healthy fats in fish include docosahexaenoic acid (DHA), important for brain and eye development. While 250,000 Americans die each year from sudden cardiac death, consuming omega-3 fatty acids may reduce the risk of coronary heart disease.

Several entities provide dietary guidelines for eicosapentaenoic acid (EPA) and DHA, including the National Academy of Sciences, the Dietary Guidelines Advisory Committee, and the American Heart Association (AHA). If one consumes 8 ounces of fish per week, one may meet the recommended levels, but this depends on the type of fish.

An advisory was developed based on several sources, including the AHA, local agencies, the Food and Drug Administration Food Code, et cetera. Mercury advice set a maximum of one meal every 2 weeks and 12 ounces of fish per week, but provided an exception for tuna.

Efforts to deliver this information to low-income women living in Indiana were discussed. Seven hundred twenty-one (721) women in Indiana received a 1-hour, face-to-face meeting. They were given pre- and post-tests. It was found that 39 percent had not eaten fish in the past 30 days and 10 percent had eaten higher mercury fish. Before the training, 33 percent of the women understood that omega-3 fatty acids were important for the fetus/infant. After the training, 87 percent understood the importance of omega-3s. Before training, 6–7 percent used the Indiana fish consumption advisory. After training, 69–79 percent intended to use it.

Finally, the following recommendations were suggested:

- Encourage fish consumption.
- Use rapid, low-cost methods to measure PCBs and mercury.
- Provide consumer and health profession education.
- Focus education efforts on at-risk populations.
- Replace albacore/white tuna in Women, Infants, and Children (WIC) and School Lunch Programs with Kid Healthy tuna.

Implementation of the FDA/U.S. EPA Joint Advisory

David W.K. Acheson, Food and Drug Administration

The Food and Drug Administration (FDA) regulates 80 percent of the food supply, which includes dietary supplements and bottled water. The mission of FDA is to protect public health. It has a variety of tools (such as regulations, guidance, and risk communication) to achieve its mission. FDA provides the correct interpretation of science to offer optimal public health protection.

The traditional approach has been to look only at the risk related to consumption of a particular product. In many instances, the risk is clear: food is contaminated with an agent; the agent causes harm to consumers; and there is a risk from consuming the food. When risks are clear, a clear risk message can be generated. However, while some risks from consumption are clear (e.g., exposure to food-borne pathogens, chemical agents, or physical agents), there are an increasing number of situations where there is a need to consider a balanced message. Sometimes there is a risk from consuming a food that contains an agent of concern, but there are also benefits associated with consuming the food. In this case, the risk message needs to be balanced between the degree of risk and the degree of benefit.

There are risks associated with mercury in fish. Mercury is a neurotoxin, and the developing brain is the most susceptible organ. There may also be negative cardiovascular effects. Simultaneously, fish is high in protein and nutrients, low in fat, and affordable.

It is important to note that virtually all fish have some level of mercury present. The risk of exposure depends on the amount and type of fish consumed. The risk will also vary with age. Methylmercury has a half-life of about 70 days; therefore, exposure prior to conception is important.

The 2004 Joint Advisory has three main elements: a risk/benefit message, consumer advice, and additional information. The risk benefit message lists who is at risk, namely “women who might become pregnant, women who are pregnant, nursing mothers, and young children.” The benefits and risks are stated along with this summary: “If you follow advice given by the FDA and U.S. EPA, women and children will receive the benefits of eating fish and shellfish and be confident that they have reduced their exposure to the harmful effects of mercury.”

The consumer advice portion of the advisory contains the following recommendations:

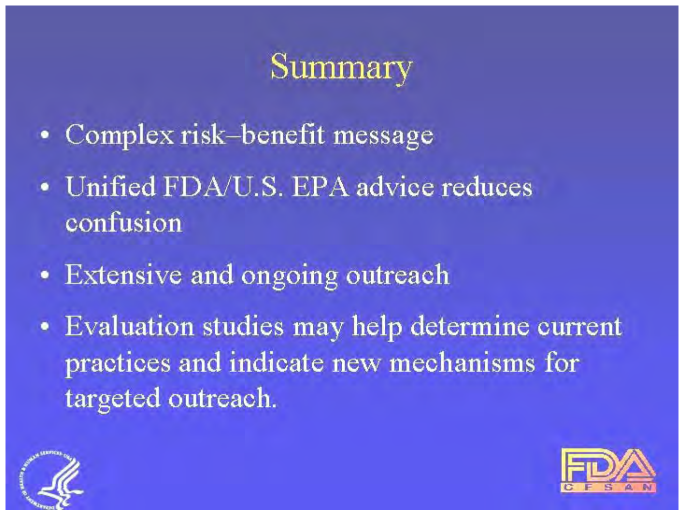
- Do not eat shark, swordfish, king mackerel, or tilefish because they contain high levels of mercury.
- Eat up to 12 oz (2 average meals) a week of a variety of fish and shellfish that are lower in mercury.
- Five of the most commonly eaten fish, low in mercury: shrimp, canned light tuna, salmon, pollock, catfish.

- Another commonly eaten fish, albacore ("white") tuna, has more mercury than canned light tuna. So, when choosing your two meals, you may eat up to 6 oz (one average meal) of albacore tuna per week.

The joint advisory also offered additional information, including the definition of mercury, whether women of child-bearing age should be concerned, information about fish sticks, and where one can get more information.

For education and outreach for the advisory, more than 9,000 electronic and print outlets were contacted, with information reaching millions of women. Editors of pregnancy books were urged to include information about the advisory in next editions. Over 50 organizations of health care providers to women and their families were contacted.

Over 4 million brochures were distributed through medical offices in English and Spanish. The MOMS TO BE food-safety education program for pregnant women was launched in September 2005. Funding was also provided for outreach to special populations.



In summary, the joint advisory clarifies a complex risk-benefit message. The unified FDA/U.S. Environmental Protection Agency (U.S. EPA) advice reduces confusion. There is extensive and ongoing outreach. In addition, evaluation studies are planned to determine current practices and indicate new mechanisms for targeted outreach.

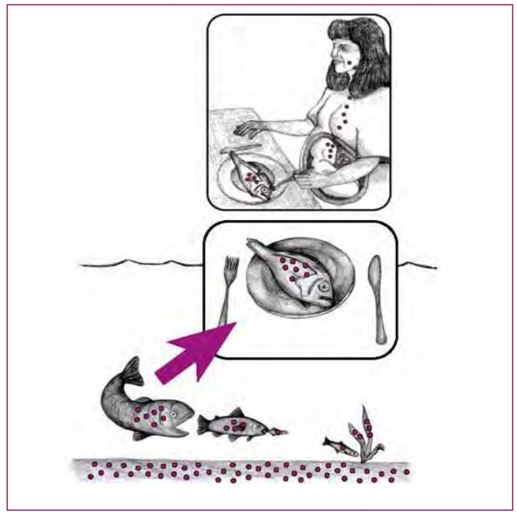
Risk Communication: Lessons Learned About Message Development and Dissemination

Joanna Burger, Rutgers University

Governmental agencies deal with the potential risk from consuming fish contaminated with toxic chemicals by issuing fish consumption advisories. Such advisories are often ignored by the general public, who continue to fish and consume fish from contaminated waters. Further, there are few studies that examine the efficacy of fish consumption advisories in detail, nor evaluate other fish consumption communication tools (such as brochures).

We suggest that attitudes (trust, risk aversion, environmental concerns, sources of information), behavior (sources of information, cultural mores, personal preferences), exposure (physical proximity, ingestion rates, bioavailability, target tissues), and hazards (levels of contaminants) all shape risk as much as hazard concentrations, and that all of these factors must be considered in risk management. Management includes evaluating how these factors interact, as well as evaluating the risk communication tools themselves (advisories, brochures, lessons).

We found that a fish fact sheet, a fish consumption brochure, and lesson plans developed for pregnancy/child care clinics (WIC—Women Infants and Children) were all most effective when the target audience was involved in creating them, and when they were developed especially for that audience. Brochures and plans were developed in both English and Spanish, and Spanish-speaking women noted that no one had ever given them this information in their native language and that they appreciated it. While some fish advisory signs appear in multiple languages, these do not provide enough detailed information to be persuasive, nor to explain why certain species of fish should not be eaten.



Maine's Moms Survey – Evaluation of Risk Communication Efforts

Eric Frohmberg, Maine Bureau of Health

Maine developed an easy-to-read brochure entitled "Protect Your Family: Eat Fish Low in Mercury." The brochure targeted pregnant women and was distributed through Women, Infants, and Children (WIC); obstetrician/gynecologists (OB/GYNs); family practitioners/obstetricians; certified nurse midwives; and mailings to sport-fishing households. A baseline survey was completed in 1999, an evaluation survey in 2000, and a survey of mothers in 2004.

The survey of mothers was 24 pages and had 75 questions. It was a pre-tested, mail survey. The sample was drawn from the Birth Certificate Registry. The response rate was around 60 percent (n = 768). Hair samples were provided by approximately 112 women.

2004 New Moms: Hair Samples

Hair Mercury – ppm	Got Brochure	Did Not Get Brochure	p Value
Mean	0.39 (0.31–0.47)	0.42 (0.35–0.61)	0.22
90th Percentile	0.75 (0.59–[?])	0.99 (0.60–1.18)	

	Of Those Requesting Hair Test		
	Supplied Hair	Did Not Supply Hair	p Value
Ate Fish While Pregnant	93% (87–96)	84% (82–87)	<0.01

Maine DHHS Public Health · Environmental and Occupational Health Program

Thirty-one (31) percent of the total sample reported receiving the brochure. Four (4) percent received it in the mail; 24 percent from a doctor or certified nurse midwife; and 9 percent from WIC. Forty-one (41) percent of the sample were on WIC, and 29 percent of those on WIC remembered getting the brochure from WIC. Of the moms who reported receiving the brochure, 93 percent read it, 46 percent kept it, and 91 percent reported trying to follow the advice.

As far as behavioral change is concerned, one of the main goals of the brochure was to encourage mothers to eat healthy fish. It is interesting to note that around 38 percent of women who got the brochure ate less fish, and the rest ate the same amount of fish. No women who got the brochure reported eating more fish as a result.

The brochure contained specific guidelines about sportfish. Three (3) percent of the women who received the brochure ate sportfish, and 5 percent of women who did not get the brochure ate sportfish. The brochure stated that pregnant and nursing women, women who might get pregnant, and children could eat one can of white tuna, or two cans of light tuna, per week. Of the women who received the brochure, 54 percent ate white tuna and 39 percent ate light tuna. Of those who did not get the brochure, 64 percent ate white tuna and 30 percent ate light tuna. Interestingly, the same percentage (8 percent) of women ate forbidden fish, whether or not they received the brochure. Of the total surveyed population, only 2 percent ate swordfish, less than 1 percent ate shark, and 1 percent ate tilefish.

Of the 112 women who provided hair samples, hair mercury was slightly higher in women who did not get the brochure. Ninety-three (93) percent of the women who supplied hair said they ate fish while pregnant.

Communication of Fish Consumption Associated Risks to Fishermen in the Baltimore Harbor & Patapsco River Area: Perspectives and Lessons Learned

Joseph R. Beaman, Maryland Department of the Environment

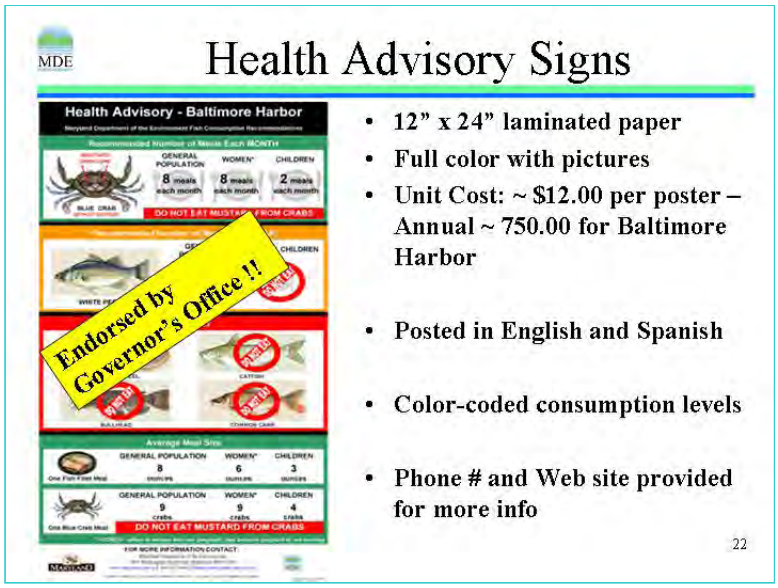
Polychlorinated biphenyls (PCBs) drive fish consumption advisories in the Chesapeake Bay. The highest levels of PCBs are in urban areas (Baltimore Harbor; Potomac River below Washington DC), and in Northeast Bay tributaries—Elk River, C&D Canal, et cetera. In Patapsco River Baltimore Harbor, the Maryland Department of the Environment (MDE) has mapped the distribution of PCBs. The Department has used risk assessment procedures and set fish consumption advisories for white perch, blue crab, and catfish.

The first advisory was issued in the Patapsco River in 1988 due to chlordane. In 1995, the Baltimore Urban Environmental Risk Initiative (BUERI) study was completed. In 2001, the first updates to advisories for PCBs were made, including the first advisories issued for crabs. In 2004, MDE revised the recommendations due to PCBs; they added new recommendations for carp, eel, catfish, crabs, and white perch. Separate recommendations were also made for crab meat and mustard.

For the 1988 advisory, a press release was issued for advisory communication purposes. The BUERI Study included the first release of brochures to fishermen and their families. In 2001, there was limited advisory communication via a Web site and a press release. There was more public interest in 2001 because it was the first time advisories were issued for crabs. In 2004, there was an expanded effort to communicate advisories. This effort included:

- Press release (resulting in a story in the *Baltimore Sun*)
- Signs posted at 11 fishing locations
- 5,000 brochures for health locations
- Weekly outreach to fishermen at fishing access points
- Survey by Virginia Tech
- Press release from the Baltimore County Department.

The survey found that 83 percent of fishermen who answered the interview were aware of fish consumption advisories. Fifty-three (53) percent of respondents said they ate at least some of the fish they caught. Seventy-eight (78) percent consumed more than the recommended amount.



In 2004, a workgroup on fish consumption guidelines was convened. The workgroup included representatives of health providers and citizens' groups. It expressed the need for effective and sustainable outreach; identified appropriate places to distribute materials; and noted there was a need for a clear understandable message.

MDE developed new brochures in English and Spanish and ensured language consistency and readability with state WIC programs. Brochures were distributed to both WIC clinics and Environmental Health Offices. MDE plans to develop partnerships with community clinics, managed-care organizations, community groups, and doctors' offices (e.g., obstetrics/gynecology, pediatrics, and family practice offices). Health advisory signs were also created in English and Spanish, and included contact information.

In conclusion, it appears that MDE outreach and communication techniques were effective based on the 80 percent awareness rate in the Virginia Tech survey. However, the survey indicated limited behavioral change. MDE hypothesizes that the limited behavioral change is due to the newness of the message, lack of outreach on previous advisories, and lack of understanding by the population at risk. MDE plans to continue the expanded outreach program, and to re-evaluate behavior change in 3 to5 years.

Fish Consumption Patterns and Advisory Awareness Among Baltimore Harbor Anglers

Karen S. Hockett, Conservation Management Institute,
Virginia Polytechnic Institute and State University

The Conservation Management Institute at Virginia Tech received a grant from the Chesapeake Bay Program (CBP): (1) to identify populations at risk for consuming contaminated self-caught fish, and (2) to examine the fish consumption advisories and protocols to identify possible improvements. We conducted 8 weeks of onsite angler interviews in the three regions of concern: Baltimore, MD; Washington, DC; and the Tidewater area of Virginia. This presentation focuses on the results from the Baltimore Harbor and adjacent waterways, where we conducted a total of 135 interviews between early June and mid-August 2004.

The Baltimore region was unique among our study areas in that local officials had released a new set of advisories approximately 1 month before our interviews began. This release was accompanied by an aggressive multimedia outreach campaign, which was reflected in the relatively high proportion of Baltimore anglers that were aware of the advisories (84 percent, of which 74 percent had heard about them within the past month). Of the anglers we interviewed, 53 percent reported that they consumed their catch at least sometimes, and 62 percent (including some who do not eat the fish themselves) stated they give their fish to others. Unfortunately, of the anglers who consume their catch, the most popular species for consumption are still those under advisory, including white perch, striped bass, catfish (a no-consumption species), and blue crab. In fact, 78 percent of the consumption instances reported exceeded advisory recommendations, even though anglers overwhelmingly indicated that they believed advisories were important to follow. The one socio-demographic factor that stood out as a critical risk factor was race. African Americans appear to be at an increased risk because they more often consumed their catch, more often provided their catch to their families, placed a higher importance on the reduction of food expenses as a motivation to fish, and were less likely to prepare their fish using risk-reducing techniques than other races, primarily white anglers.

Baltimore's current fish advisory dissemination protocol clearly has both benefits and challenges. Anglers in the Baltimore area were found to be relatively knowledgeable about advisories and placed a high level of importance on them, so it would seem that one objective is being addressed. However, compliance—the real crux of the issue—is still a challenge. We offer some suggestions for addressing this problem that emerged from our research, including additional research avenues as well as possible shifts in message format (simplification) and communication modes (onsite and interpersonal).

Great Lakes Indian Fish and Wildlife Commission Risk Management and Communication Program: "Reducing Health Risks to the Anishinaabe from Methylmercury"

Barbara A. Knuth, Department of Natural Resources, Cornell University

(Note: Funding provided by the U.S. Environmental Protection Agency STAR grant program to the Great Lakes Indian Fish and Wildlife Commission.)

The goal of this project is to develop, implement, evaluate, and document a comprehensive, systematic, and culturally sensitive intervention program to reduce risks associated with subsistence-based consumption of walleye contaminated with methyl mercury. The project includes several elements: (1) reconfiguring geographic information system (GIS) maps consistent with the U.S. Environmental Protection Agency approach; (2) implementing a systematic intervention program; (3) evaluating program efficacy; and (4) expanding the program to other states/tribes. Communication programs components were developed in dialogue with community members, and include a two-sided, color-coded map, the Ojibwe language, specific advice for sensitive and general populations, an alphabetical lake list, information about risks and benefits, advice for labeling freezer bags, and contact information. The next steps of the project include continuing the intervention, revising as appropriate, and a post-intervention evaluation.

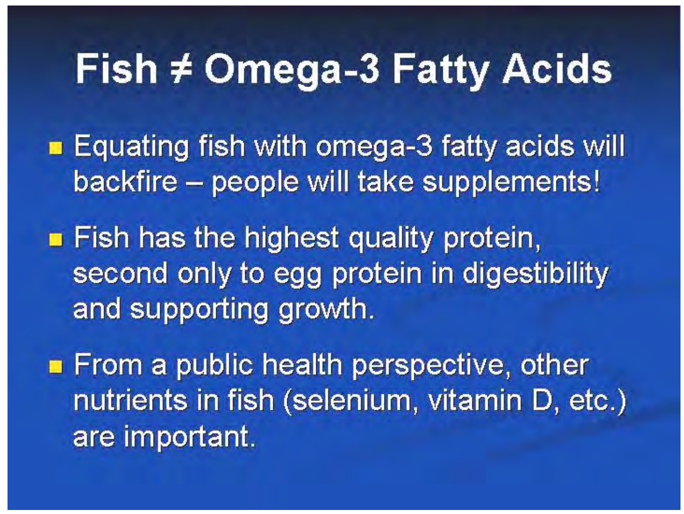
Problems with Media Reports of Fish-Contaminant Studies: Implications for Risk Communication

Barbara A. Knuth for Judy D. Sheeshka
Department of Family Relations and Applied Nutrition, University of Guelph

Published studies comparing the contaminant levels in wild versus farmed salmon (e.g., Hites et al., *Science* v. 303, January 2004) have received intensive media coverage in Canada. The Canadian Broadcasting Corporation (CBC), which is Canada's national radio and television, had the following headline: "Study Confirms Farmed Salmon More Toxic Than Wild Fish." The report included a quote from David Carpenter, stating: "We are certainly not telling people not to eat fish….We're telling them to eat less farmed salmon." This message quickly got lost. On the CBC's Web site, it carried this headline: "Something Fishy about Farmed Salmon?" The article stated that "farmed salmon should be eaten only infrequently—a meal a month, perhaps every two months—because the fish pose serious risks of cancer." It went on to say, "Officials at Health Canada and the Canadian Food Inspection Agency say the dangers of eating contaminated farmed salmon are overstated, as is the suggestion that intake of farmed salmon be severely restricted." Another CBC broadcast, later the same day, suggested that not all scientists are in agreement about the risks.

Consumers who had heard the message that fish is a healthy food became confused by these new media reports, and fish sales plummeted. Consumers stopped buying all types of fish. The estimates for salmon were that sales had dropped 20 to 50 percent in the 2 months following the media reports. This all happened at the same time that a Canadian Holstein cow tested positive for mad-cow disease in Washington State. As the following quote states, "public perception is everything." The 700-million-dollar salmon farming industry was reeling, and some small mom-and-pop salmon farms on the Atlantic coast reported that they were facing bankruptcy. The important point is that consumers were reporting that, since there were also contaminants in the wild fish, they thought it prudent just to stop eating fish.

What went wrong, and can we learn anything from this experience? First, different populations react differently. In Britain, consumers appeared to largely ignore the reports. In Canada, people seemed to decide that if fish was not a safe food, they would just take omega-3 fatty acid supplements and eat something else. Second, we need to give people simple and practical information on how they can reduce their risks, so that they are better positioned to make informed choices. Third, environmental scientists and toxicologists might consider greater efforts to educate dietitians, the medical community, and nutrition researchers about the chemical contaminant risks associated with eating fish. For the most part, these groups are not informed about the issue of chemical contaminants in fish, yet they are expected to answer consumers' questions. Last, from a public health perspective, fish is an excellent source of very high quality protein. This is particularly important for populations that catch their own fish. It is also an important source of some nutrients that are scarce in other foods, such as vitamin D and selenium. Focusing on omega-3 fatty acids as the main reason to eat fish is risky, because people can simply buy omega-3 fatty acid supplements.



We need to broaden our message about the health benefits of eating fish and ensure that consumers are informed about practical strategies to reduce their risks of ingesting too many chemical contaminants.

The Presentation of Fish in Everyday Life: Seeing Culture Through Signs in the Upper Peninsula of Michigan

Melanie Barbier, Departments of Fisheries and Wildlife and Sociology, Michigan State University

Fish consumption advisories often fail to effectively help communities adequately address the benefits and risks of eating potentially contaminated fish. The social aspect of a risk framework suggests that the impact of any risk communication strategy depends on sound understanding of the informational symbols, imagery, and signals that appear and on how people interpret and respond to them. The Agency for Toxic Substances and Disease Registry

(ATSDR) identifies the Upper Peninsula of Michigan as a particular region of concern regarding the uncertain effectiveness of fish advisories due to the vast rural and isolated nature of the area as well as the relatively large presence of Native American populations who may consume larger amounts of fish (ATSDR, 2003). Fish advisories exist in the Upper Peninsula that apply to Great Lakes waters of Lake Huron, Lake Michigan, Lake Superior, and St. Mary's River as well as to inland lakes, reservoirs, and streams (MDCH, 2003). In the Michigan Great Lakes, polychlorinated biphenyls (PCBs) comprise the predominant contaminant of concern, followed by chlordane, dioxin, and mercury. For inland lakes, fish advisories encompass mercury, PCBs, chlordane, and dioxin, in decreasing order of frequency.

The counties with the highest number of specific inland lake and stream advisories include Marquette (9), Gogebic (6), Iron (5), Alger (3), and Houghton (3). In addition, a general advisory applies to all inland lakes in the Upper Peninsula, as well as the rest of Michigan. In 2004–2005 we collected data in four counties in Michigan's Upper Peninsula through focus groups, community dinners, public meetings, and photographs. Photographs were taken of fish advisories, and restaurants advertising fresh fish.

Residents expressed a strong affinity toward eating Great Lakes fish, although a minority of participants had read the official fish advisory. We attribute part of our findings to the role of eating fish in the cultural fabric of the Upper Peninsula, which emerges through a visual analysis of road signs and other cues. The singular use of technical solutions, such as uniformly delivered fish consumption advisories, emerges as inadequate without acknowledging the role of culture.

Promoting Fish Advisories on the Web: WebMD Case Study

Michael Hatcher for Susan Robinson, Centers for Disease Control and Prevention

A case study was presented for a pilot project that the Agency for Toxic Substances and Disease Registry (ATSDR) did in collaboration with the U.S. Environmental Protection Agency (U.S. EPA) this past summer (summer 2005) to see how consumers of fish could be reached directly. Traditional methods to reach target audiences are carried out through infomediaries such as health care providers, conferences, presentations, brochures in multiple languages, and direct mail. This project was designed to look at how the Web could be used to reach the target audience (i.e., the consumer). The objective of the project was to educate users about the potential risks of mercury in fish. The target audience was:

- Women who are trying to become pregnant
- Women who are already pregnant or nursing
- Parents of young children.

The key was to select the right partner. Selection criteria included: the partner needed to have the capacity to reach the desired demographic and to provide content focusing on health. MedMD, the partner chosen, typically builds "Health Zones" around different topics. In this case, the content was not deep enough to merit a full health zone, thus it was designed to be a mini-health zone. In addition, the typical ads displayed around the content on WebMD were "turned off" to avoid any conflicts in messaging. The content zone consisted of:

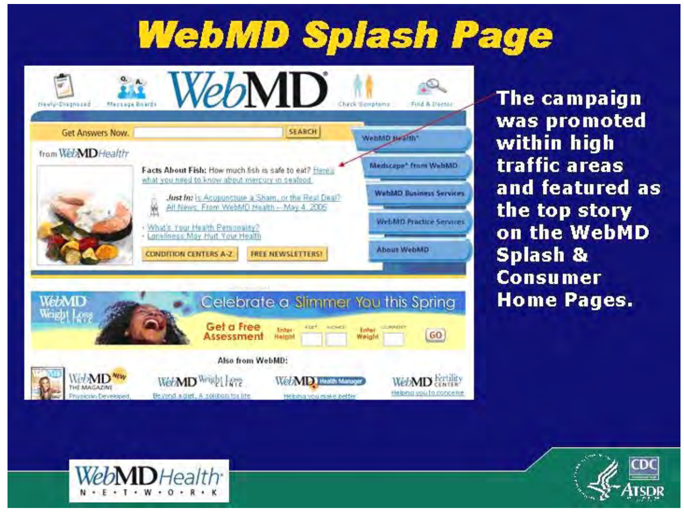
- Four timely WebMD articles reflecting the latest U.S. EPA/Food and Drug Administration (FDA) guidelines
- A new WebMD article based on a recent U.S. EPA/FDA brochure
- A "More Information" area with links to the U.S. EPA and FDA Web sites
- Links to related WebMD message boards.

An important aspect of the project was to work with WebMD editorial staff to assist them in translating the materials into the formats they use, which are articles. WebMD retained full editorial independence, so part of the work involved educating their editorial staff on details such as the difference between groundwater and surface water as it related to how mercury travels through fish. The resulting articles were strongly based on the language of the fish advisory. A major benefit of the project to WebMD is that it was able to ensure all its content was entirely up to date and it was able to add content. An entirely new piece (a Web page) was created based on the latest guidelines. This page was highly promoted and was the highest performing piece in terms of unique visitors. It was second highest in terms of overall page views. The links to the U.S. EPA and FDA sites took viewers to the actual advisory, in the case of the U.S. EPA, and to the Center for Food Safety and Applied Nutrition, in the case of the FDA.

An important takeaway for this presentation is that all the good content in the world will not ensure people read it. It must be promoted. This is where the WebMD system of programming content was very helpful. WebMD promoted the fish advisory information across the WebMD Consumer Network and in its e-mailed consumer newsletters. Individuals sign up for these newsletters on the site. Secondly, WebMD promoted the content using links on different high-trafficked pages, including:

- WebMD Splash/Home Page
- WebMD Consumer Home Page
- Channels
- Pregnancy Center, Parenting Center, Diet and Nutrition, Healthy Women, and Healthy Men
- eNewsletters
- Pregnancy and Family, Trying to Conceive, Diet and Nutrition, Women's Health, Men's Health, and Living Better.

The WebMD Splash Page is the first page you see when you go to the WebMD Web site. The editorial department decides what will be featured each day. They decide after being "pitched" by the programming directors. ATSDR and U.S. EPA worked both with those who created content and with the programming directors. To be worthy of a Home Page slot, the content must be good and timely. On the Web, position is everything, and to get a link front and center ("above the fold") where the user does not have to scroll down, is the best. The campaign was promoted within high-traffic areas and featured as the top story on the WebMD Splash and Consumer Home pages. The content was also featured in one of the rotating contextual link pages. Getting this slot depends on what is going on with the programming and news in general. This link stayed up for a few days and was intermittently rotated out for few days over months. The content was also featured in a top position (upper right hand top corner) of the WebMD Consumer Home page. It was up for a few days off and on through the period of the campaign. It was not rotated in June. The content was also featured in other areas of the page on different days.



Another area on the site where the content was promoted was the Pregnancy Health Center. WebMD has over 60 health centers for conditions, wellness, and other special topics of interest, and include the Parenting Center, Diet and Nutrition, Healthy Women, and Healthy Men. The content was promoted in each of these centers. Many women use the Parenting Center channel to look for information on taking care of their children, so the message about fish consumption guidelines for young children was appropriately promoted there.

WebMD also sends out an HTML media-rich e-mail to about 10,000 subscribers. These are highly targeted users who give WebMD information on what they are interested in. The HTML e-mail gets a high click-through rate. The fish advisory content was featured in two spots. The producer for this project reported to ATSDR that they saw a spike in traffic on a daily basis from each of these promotions.

Overall, the performance of this mini-zone exceeded expectations, and people were quite engaged with the content. The campaign ran about 5 months (mid-April to the end of August 2005), garnering a total of 155,508 unique visitors and about three times that many page views. This translates to an overall 3:1 ratio of page views to unique visitors, where the ratio is usually closer to 2:1. The most viewed article was the new WebMD article based on the U.S. EPA/FDA brochure.

Page views held steady until June (April and May had 125,000+ page views while June had only 25,823). This is typical for content, in that during a promotion time you get new people looking at the content, who are more engaged with it because it is new. A similar pattern was observed with unique visitors. In April and May, the ratio of page views was over 3:1. It then declined in the following 2 months, ending with a slight rise. Note that the most visitors were also in the first 2 months. Thus, you had the most people reading the most content when it was highly promoted and also when it was new information.

Programming plays a large role in page view numbers. Pregnancy: Eating Healthy for Two was promoted in April. Facts About Fish – Home Page was promoted in May. These two pages were the core content of the mini-health zone. Pregnancy: Eating Healthy for Two was the most general article into which the fish information was embedded. It had the highest 1 month volume, because obviously it had more appeal than a title focused just on fish advisories. Something to consider is getting more readership by combining your messages with other content that appeals to a wide base of readers. A number of WebMD readers also visited the U.S. EPA and FDA sites as a result (about 12,000 people). These were likely women in the demographic that both organizations would like to reach.

In summary, think beyond your destination site (.gov) to achieve reach into desired audiences. Another project that would be useful to undertake would be online promotion to physicians, perhaps through the WebMD Physician Channel or another Web site. Also, good content is key, but promotion is crucial. Match your needs with the needs of your potential Web outlet partners. Understand your partners' constraints (e.g., editorial, policy, etc.), and work out the details of the promotion strategy with them, because this makes or breaks whether or not people actually see your great content. ATSDR and the U.S. EPA would consider purchasing sponsored space at WebMD where they could control the content completely. Also, it would be good to create Web public service announcements (PSAs) to run in the Web site's advertising space.

Seafood Safe Case Study: Voluntary Seafood Contaminant Testing and Labeling Program

Henry W. Lovejoy, Seafood Safe
Barbara A. Knuth, Department of Natural Resources, Cornell University

Seafood Safe is an industry-initiated voluntary testing and labeling program for contaminants in seafood. EcoFish is a national distributor of seafood, exclusively from environmentally sustainable fisheries. EcoFish has 11 retail branded items that are sold in 1,500 retail grocery stores nationwide and a full line of fresh seafood products that are sold in over 125 restaurants nationwide.

The EcoFish demographic is a well-educated affluent consumer who researches their food and cares about the healthfulness of what they consume. Starting a few years ago, EcoFish began receiving an increased number of consumer questions inquiring if they tested their seafood for contaminants. Over the past 2 years the Seafood Safe model has been developed through collaborative efforts with academics, consumer advocacy organizations, independent laboratories, and seafood industry quality assurance and sampling specialists. The result is a pilot program with EcoFish's retail prepackaged products.

The consumer receives conflicting and confusing messages on seafood. The medical community and revised food pyramid recommend seafood, especially those species high in omega-3 fatty acids, as part of a healthy diet. However, consumers are being warned about the presence of dangerous contaminants in some types of seafood. What is a consumer to do, especially mothers of childbearing age? A vast majority of seafood is healthy to consume regularly; however, some species can be dangerous if too much is consumed.

Consumers require a credible, user-friendly, and simple system at the point of purchase. The industry needs to confront this public relations challenge head on. Seafood Safe provides an industry-wide testing and labeling program that would exemplify that the vast majority of seafood is safe, and increase consumption of healthy species.

The Seafood Safe business model is a collaborative effort, leveraging the collective strengths of academics, industry consultants, laboratories, and independent organizations. An independent advisory panel was assembled consisting of two of the country's leading academics on the subject of contaminants in seafood to advise on the structure, methodology, and messaging of the program. Dr. Barbara Knuth of Cornell University and Dr. David Carpenter of the University at Albany (State University of New York) are Seafood Safe's advisors. Seafood Safe partnered with an independent international seafood industry consulting firm to develop company-, species-and fishery-specific guidelines, as well as chain-of-custody and sampling protocol. The testing is performed by independent laboratories specific to mercury and polychlorinated biphenyls. Seafood Safe has also partnered with Environmental Defense as a consumer advocate, providing an information clearinghouse for consumer education on the subject.

The seafood industry is facing a significant public relations challenge regarding contaminants in seafood. Seafood Safe not only has the ability to help eliminate consumer confusion, but also to portray a much more positive image of seafood. In an environment of full disclosure, consumers will learn that the vast majority of seafood available is safe to consume regularly.

Seafood Safe has received a tremendous amount of positive media attention. As consumers become progressively aware of Seafood Safe, they will come to expect the program in the marketplace, which will drive expansion. Also, recent legal activity in California indicates that individual states can drive the need for more disclosure on seafood.

Seafood Safe will be an industry-sponsored program. Those companies that want to participate and to be evaluated will pay for the services. Once products are successfully tested, a company will pay a minimal licensing fee to use the Seafood Safe label on their products, and to cover Seafood Safe's operating costs. Mercury and PCBs are currently the contaminants that are tested for. Additional contaminants may be added (e.g., flame retardants).

Test results are applied to the U.S. EPA Guidance and Risk-Based Consumption Tables, and the results are converted into the number of 4-ounce portions a woman of childbearing age can consume per month. The Seafood Safe Web site will provide a table that consumers can download that will allow them to keep track of their cumulative multispecies consumption by subpopulation.

Risk perception constructs include:

- Volition, choice
- Control
- Seriousness
- Dread
- Certainty
- Causality – natural or not
- Distribution of risks and benefits
- Responsiveness
- Trust, credibility.

The Seafood Safe risk communication strategy focuses on behavior (addresses choice and volition) of the consumer and industry/markets. It provides "control." The focus of the message is to women of childbearing age. The risk communication strategy addresses concerns about distribution of benefits and risks. The supporting information addresses dread, seriousness, and causality. A consistent message reduces uncertainty. Calculations are personalized and cumulative consumption charts are under development. Providing the testing details (use of independent laboratories and advisory panel) builds credibility, confidence, and trust.

Future considerations of the Seafood Safe program include weighing the risks and benefits of contaminants versus omega-3s; evaluating consumer response (purchasing, consumption, environmental advocacy, food safety advocacy); and evaluating industry participation.

Proceedings of the 2005 National Forum on Contaminants in Fish

Section III

Presentations

Please note that three presentations are not included at the request of the authors due to pending publication. These are: Krabbenhoft's "Mapping Sensitivity of Aquatic Ecosystems to Mercury Inputs across the Contiguous United States" (Sampling and Analysis session), Arnold's "The Use of Human Biomonitoring as a Risk Management Tool for Deriving Fish Consumption Advice" (State and Tribal Approaches to Risk Management session), and Knuth's "Great Lakes Indian Fish and Wildlife Commission Risk Management and Communication Program: 'Reducing Health Risks to the Anishinaabe from Methylmercury'" (Risk Communication session).

Joint Federal Mercury Advisory: EPA's Choice of the One Meal/Week Limit for Freshwater Fish Consumption

James Pendergast, Office of Science and Technology, U.S. Environmental Protection Agency

Joint Federal Mercury Advisory

EPA's Choice of the One Meal/Week Limit for Freshwater Fish Consumption

2005 National Forum on Contaminants in Fish
September 18-21, 2005
Baltimore Marriott Inner Harbor, Baltimore, MD

James Pendergast, Chief
Fish, Shellfish, Beach and Outreach Branch
Office of Science and Technology
Office of Water
U.S. EPA

Our Goals in Developing the Limit

- Maintain consistency with state advisories
- Protect the majority of consumers
- Keep the message simple

Consistency with State Advisories

- Most *statewide* advisories are 1 meal/week
- Use of 2 meals/month category is inconsistent across United States

Protect the Majority of Consumers

Table 4-3. Monthly Fish Consumption Limits for Noncarcinogenic Health Endpoint - Methylmercury

Risk Based Consumption Limit[a]	Noncancer Health Endpoints[b]
Fish Meals/Month	Fish Tissue Concentrations (ppm, wet weight)
Unrestricted (>16)	0 - 0.029
16	>0.029 - 0.059
12	>0.059 - 0.078
8	>0.078 - 0.12
4 (= 1 meal/week)	>0.12 - 0.23
3	>0.23 - 0.31
2	>0.31 - 0.47
1	>0.47 - 0.94
0.5	>0.94 - 1.9
None (<0.5)	>1.9

Examine existing fish tissue data against this full range, rather than just the 1 meal/week rate

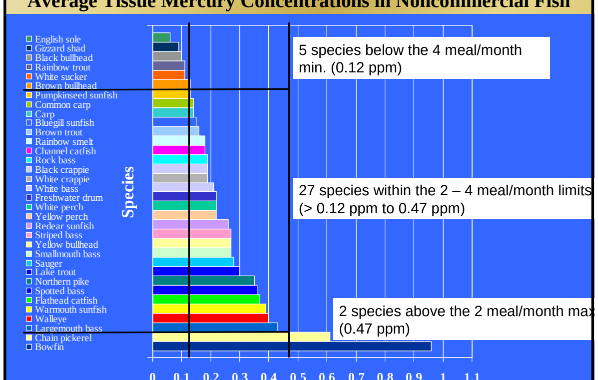
US EPA, 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Volume 2. Risk Assessment and Fish Consumption Limits, Third Edition. EPA 823-B-00-008.

Protect the Majority of Consumers

Approach: Compare available fish data against the 2, 3, and 4 meals/month concentration limits

- Existing fish tissue data
  - EPA National Listing of Fish Advisory (NLFA) fish tissue database
  - State and tribe submitted data, 1987–2003
  - Represents noncommercial fish
- Calculation of species averages
  - Mean of species means at each monitoring station
  - Only species with data from >100 stations
  - Only edible-size filets, all lengths and weights
  - Not a national *statistical average*

Average Tissue Mercury Concentrations in Noncommercial Fish



Caution: Mercury concentrations in fish vary considerably from region to region and waterbody to waterbody. Consumers should, first and foremost, consider any local advisories.

EPA National Fish and Wildlife Contamination Program www.epa.gov/waterscience/fish

Joint Federal Mercury Advisory: EPA's Choice of the One Meal/Week Limit for Freshwater Fish Consumption

James Pendergast, Office of Science and Technology, U.S. Environmental Protection Agency

Keep the Message Simple

Risk communication approach: A *simplified message to inform consumers without scaring them away*

- Original 4-page message failed in early focus groups; many subjects said they would avoid eating fish entirely

- EPA and FDA trimmed the message to 1 1/2 pages
- Recreational freshwater catch a small component of overall consumption, so a small component of the national advisory
- Shortened advisory does not cover species, location variability
- Advisory encourages consumers to first check local advisories; federal advisory backstops for areas with no state advisory

Additional Analyses

Analyses performed since advisory's release further justifies the 1 meal/week limit

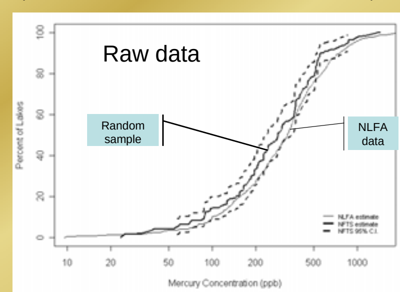
- Additional risk assessment analyses
- Conservative bias in the data

Additional Risk Assessment Analyses

- Consuming a variety of freshwater fish species is < RfD
  - Overall average of 0.25 ppm vs. one meal/week limit of 0.23 ppm
  - This 0.25 ppm average is simple average of means for all species *http://www.epa.gov/waterscience/fishadvice/1-meal-per-week.pdf*
- Consuming a preferred species < RfD for 60% of species
  - 20 of 34 species have means < one meal/week limit of 0.23 ppm
  - 12 of 34 species (35%) result in exposure at up to twice the RfD
  - 2 remaining species (5%) result in exposure at 3-4 times the RfD (bowfin and chain pickerel)

A Conservative Bias in the Data

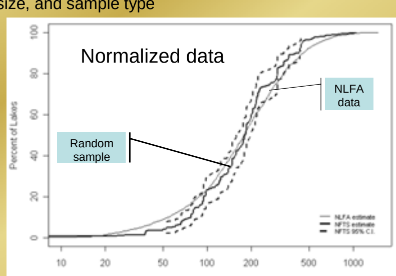
- Comparison of NLFA data with national random sample



- The NLFA data is clearly biased high relative to the national random sample.

A Conservative Bias in the Data

- Comparison of 2 data sets after normalizing to standard species, size, and sample type



- This inherent NLFA bias means the above risk assessment is conservative

Consistent Advice for Striped Bass and Bluefish along the Atlantic Coast

Eric Frohmberg, Maine Bureau of Health

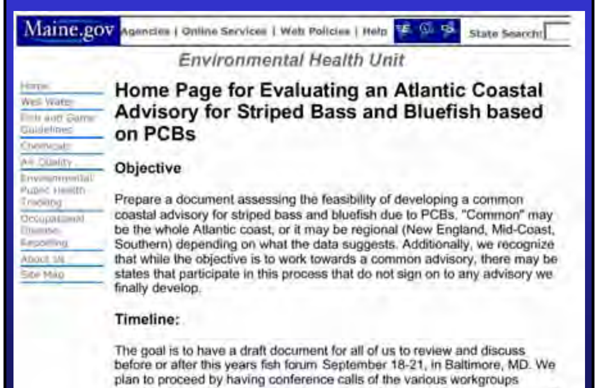
Consistent Advice for Striped Bass and Bluefish along the Atlantic Coast

Eric Frohmberg

Maine Environmental and Occupational Health Program

Background

- 3-10 fold increase in PCB levels in year 2000 striped bass in Maine
- This resulted in a discussion about consistent advisories for migratory species



Environmental Health Unit

Home Page for Evaluating an Atlantic Coastal Advisory for Striped Bass and Bluefish based on PCBs

Objective

Prepare a document assessing the feasibility of developing a common coastal advisory for striped bass and bluefish due to PCBs. "Common" may be the whole Atlantic coast, or it may be regional (New England, Mid-Coast, Southern) depending on what the data suggests. Additionally, we recognize that while the objective is to work towards a common advisory, there may be states that participate in this process that do not sign on to any advisory we finally develop.

Timeline:

The goal is to have a draft document for all of us to review and discuss before or after this years fish forum September 18-21, in Baltimore, MD. We plan to proceed by having conference calls of the various workgroups

Organization

- Data Workgroup
- Biology Workgroup
- Toxicology Workgroup
- Advisory Workgroup
- Organization Workgroup

Data: Goals

- Compile and describe the PCB data for these species along the coast.
- Are these data comparable, should we recommend consistency of sampling methods?
- How should we measure PCBs?

Biology: Goals

- Summarize migratory patterns of these fish.
- What are these fish eating?
- What do we know about the regulations and catch of these species?

Consistent Advice for Striped Bass and Bluefish along the Atlantic Coast

Eric Frohmberg, Maine Bureau of Health

Toxicology: Goals

- Review the basis of the existing toxicology numbers used to set advisories.
- Briefly review any new literature.
- Evaluate feasibility of developing new toxicology number.

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Advisories: Goals

- Summarize how states vary in their advice.
- Summarize how states vary in their procedures.

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Data: Issues of Interest

- Lots of state-to-state variation
- PCB levels in striped bass appear to be going down over time.
- A new coastal-wide study of PCBs in striped bass and bluefish would be helpful.
- Unlikely to recommend consistency of methods

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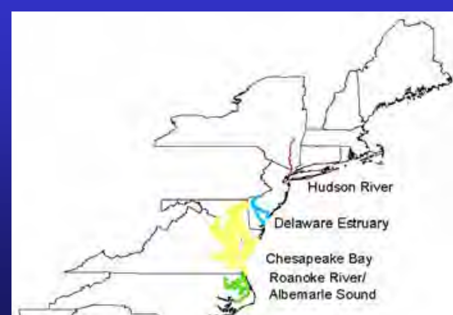
Biology Workgroup

Figure 1: Major spawning stocks of Atlantic striped bass



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Biology Workgroup

Figure 2: Summer distribution of adult female striped bass

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Biology Workgroup

Figure 3: Winter distribution of all stocks adult female striped bass

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Consistent Advice for Striped Bass and Bluefish along the Atlantic Coast

Eric Frohmberg, Maine Bureau of Health

Biology: Issues of Interest

- Migratory striped bass are large adult females.
- Diet variable for both species, but not a lot of overlap.
- Can't predict arrival times for populations of striped bass.
- Draft chapter online

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Toxicology: Issues of Interest

- Toxicology estimates need to be updated.
- Goal should be not increasing body burden in young women.
- Quality of omega-3 benefits data to babies is not compelling.
- Draft chapter online

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Advisories: Issues of Interest

- Procedures variable from state to state; advisories aren't that different
- Unlikely to recommend common procedures
- Think about age breakdowns to specify who you want to protect and to simplify communication.

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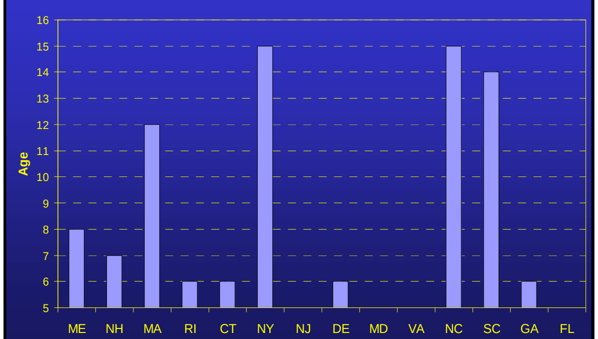
State-by-State Variations in Age Definitions of a "Child"



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Eric's Draft Thoughts

- Bluefish – Not a lot of data, but conceptually, a regional advisory may make sense.
- Striped bass – Local spawning location-based advice + consistent advice for migratory fish?
- Toxicology estimates for PCBs need to be updated.
- Need a survey of PCBs in these fish up and down the coast.

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Thanks

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- George Henderson (FL)
- Rich McBride (FL)
- Byron Young (NY)
- Victor Crecco (CT)
- Paul Caruso (MA)
- Sharee Rusnak (CT)
- Tony Forti (NY)

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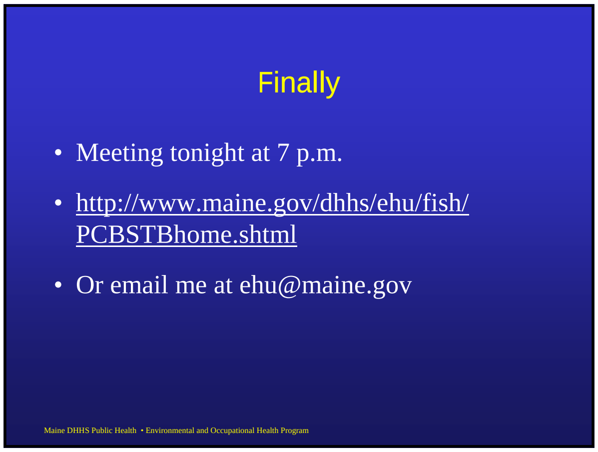
Finally
• Meeting tonight at 7 p.m.
• http://www.maine.gov/dhhs/ehu/fish/PCBSTBhome.shtml
• Or email me at ehu@maine.gov
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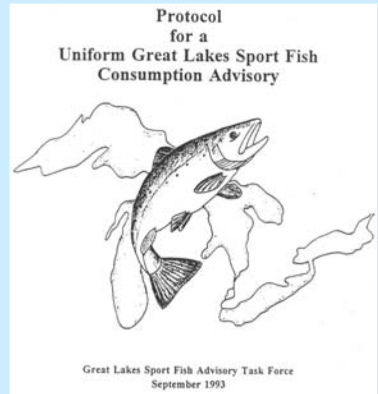
Great Lakes Mercury Protocol

Pat McCann, Minnesota Department of Health

Great Lakes Mercury Protocol

Pat McCann

September 18, 2005



Protocol Components

Advisory Introduction Components
1. General statement about contaminants, benefits, and hazards
2. Statement on cancer risk
3. Statement on benefits of fish consumption
4. Preparation and cooking advice

Consumption Advice Components

5. Meal unit dose reduction
6. Uniform meal size
7. Easily understood meal frequency advisory groups

Hazard Identification Components

8. Fish flesh sample collection protocol for residue analysis
9. Uniform limits of detection
10. Fish size and contaminant concentration based consumption categories

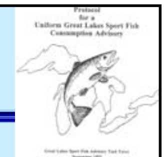
Risk Assessment Components

11. RA for assigning fish to consumption frequency groups
12. Multiple contaminants

Prospective Advisory Items

13. Uniform method for deciding when to shift size/species class into another advisory category
14. Coordinate release of annual advisory

Assumptions for PCB Protocol Calculations



1. Health protection value = 0.05 ug PCB/kg/day
2. Average meal = 227 g (1/2 lb) uncooked fish
3. Representative target consumer is a 70 kg adult
4. Five advisory groups – Meal rates
5. Assume skinning/trimming/cooking reduces residues 50% from raw, skin-on filet used to assess PCB residue level.

Great Lakes Protocol Advice Categories – PCBs

Fish meals	Fish tissue concentrations (ppm)
Unrestricted (225 meals/yr = 18.75/mo)	0 - 0.05
1 meal/week (52 meals/yr)	0.06 - 0.2
1 meal/mo (12 meals/yr)	0.21 - 1.0
6 meals/yr	1.1 - 1.9
No consumption	> 1.9

Mercury

- Each Great Lakes state has mercury-based fish consumption advice
  - Both site-specific and statewide

Great Lakes Mercury Protocol

Pat McCann, Minnesota Department of Health

"Health Protection Values"

- **IL, IN*, WI, MN** (two-tier advice)
  - Sensitive population RfD = 0.1 μg/kg/day
  - General population RfD = 0.3 μg/kg/day
- **PA, OH** (same advice for all populations)
  - RfD = 0.1 μg/kg/day
- **NY, MI** (two-tier advice)
  - FDA/modified FDA action level

* IN sensitive population RfD = 0.3/(30.4 days per month/7 days per week) = 0.07

Definition – Sensitive Population

- NY, MI, IN, IL, WI, MN
  - Women of childbearing age
  - Children < 15 YOA
- PA, OH
  - Not specified, same advice given to everyone

Meal Categories – Sensitive Population

Fish meals	NY	PA	OH	MI	IN	IL	WI	MN
Unrestricted		0-0.12			0-0.05	<= 0.06		<= 0.05
1 meal/week		0.13-0.25	0.05-0.219		0.06-0.2	>0.06-0.23	0.05-0.22	> 0.05-0.2
2 meals/month		0.26-0.50						
1 meal/month	1.0 - 2.0	0.51-1.0	0.220-.999	> 0.5	0.2-1.0	>0.23-0.94	0.22-1	> 0.2-1.0
6 meals/year		1.1-1.90	1.0-1.99		1.1-1.9			
No consumption	> 2.0	> 1.9	>2	> 1.5	> 1.9	> 0.94	> 1.0	> 1.0

Meal Categories – Sensitive Population (cont.)

Fish meals	NY	PA	OH	MI	IN	IL	WI	MN
Unrestricted		0-0.12			0-0.05	<= 0.06		<= 0.05
1 meal/week		0.13-0.25	0.05-0.219		0.06-0.2	>0.06-0.23	0.05-0.22	> 0.05-0.2
2 meals/month		0.26-0.50						
1 meal/month	1.0 - 2.0	0.51	0.22	> 0.5	0.2	>0.23	0.22	> 0.2
6 meals/year		1.1-1.90	1.0-1.99		1.1-1.9			
No consumption	> 2.0	> 1.9	>2	> 1.5	> 1.9	> 0.94	> 1.0	> 1.0

Meal Categories – General Population

Fish meals	NY	MI	IN	IL	WI	MN
Unrestricted			< 0.16	<= 0.18	<0.16	<= 0.16
1 meal/week		> 0.5	0.16-0.65	>0.18-0.69	0.16-0.65	>0.16-0.65
1 meal/month			0.66-2.8	>0.69-2.82	>0.65	>0.65-2.8
6 meals/year			2.81-5.6			
No consumption	>= 1.0	> 1.5	> 5.6	>2.82		> 2.8

General – Statewide Advice

State	Sensitive Population Advice	General Population Advice	Waterbodies Included	Basis
New York	One meal/week all fish species and sizes	Same as SP	Fresh waters and some marine waters at mouth of Hudson	Some chemicals are commonly found in New York State fish (mercury and PCBs for example), fish from all waters have not been tested and fish may contain unidentified contaminants.
Pennsylvania	One meal/week all fish species and sizes	Same as SP	All waters including Great Lakes	Officially based on mercury but includes BJP for all contaminants
Ohio	One meal/week all fish species and sizes	Same as SP	All waters including Great Lakes	Based on Hg national guidance of 1 meal/ week and increasing number of site-specific 1 meal/wk Hg advisories (current means analysis supportive, 90% of samples since 1988 are > 0.05ppm)

Great Lakes Mercury Protocol

Pat McCann, Minnesota Department of Health

State	Sensitive Population Advice	General Population Advice	Waterbodies Included	Basis
Michigan	One meal/month for crappie, rock bass or perch over 9 inches in length and any size largemouth bass, smallmouth bass, walleye, northern pike, or muskie	One meal/week for crappie, rock bass or perch over 9 inches in length and any size largemouth bass, smallmouth bass, walleye, northern pike, or muskie	Inland lakes only	Established about 15 years ago based on Hg, regression analysis, about 2/3 of lakes had samples exceding 0.5ppm Hg
Illinois	One meal/wk for all predators	Unlimited for all species and sizes	All waterbodies except Great Lakes	Means analysis across years and sizes, limited data for regression analysis, distribution within meal advice category (2/3 to 3/4 of predator fish sampled required 1/wk advice for SP), BPJ
Wisconsin	1 meal/wk: panfish, bullhead, perch; 1 meal/mo: all other species; Do not eat: muskie	Unlimited: panfish, bullhead, perch; 1 meal/wk: all other species	All waterbodies except Great Lakes	Hg, means analysis, frequency distribution within meal category
Minnesota	1 meal/wk: panfish, bullhead, perch; 1 meal/mo: all other species, walleye < 20", northern < 30"; Do not eat: muskie and large northern and walleye	Unlimited: panfish, bullhead, perch; 1 meal/wk: all other species	All waters including Great Lakes	Hg and PCBs, means analysis, frequency distribution within meal category, length cut-offs considered regression analysis and harvest rates

State	Sensitive Population Advice	General Population Advice	Waterbodies Included	Basis
Indiana	Limit to 1 meal per month: All black bass (smallmouth, largemouth, and spotted), channel catfish, flathead catfish shorter than 38 inches, walleye or sauger shorter than 24 inches, northern pike, white bass, striped bass shorter than 28 inches, rock bass	Limit to 1 meal per week: All black bass (smallmouth, largemouth, and spotted), channel catfish, flathead catfish shorter than 38 inches, walleye or sauger shorter than 24 inches, northern pike, white bass, striped bass shorter than 28 inches, rock bass	All waters including Great Lakes	Predominance of data for PCBs and Hg, BPJ (few samples of same species and size)

States that list site-specific advice if it is more restrictive than statewide advice

State	Site-specific data analysis/logic
New York	Regression analysis if supported by data, otherwise arithmetic mean. GP: listed if concentration warrants either 1/mo or eat none. SP: if advice for GP is more restrictive than statewide advice for any species then SP = eat none for all species and size
Pennsylvania	About 60 samples per year are analyzed, generally one composite sample per species maybe two sizes. Two years of data in same advice category are needed to list advice.
Ohio	Regression analysis if enough data, otherwise means analysis.
Illinois	Listed if mean of panfish > 0.06 ppm or predator > 0.23 ppm (need 2 yrs of data). Currently 10 waters are listed for Hg advice.
Wisconsin	Screen first to ID high fish mercury waters using 1 ppm for game fish and 0.5 ppm for panfish as screen. For high waters do regression for gamefish and frequency distribution within meal advice categories for panfish. BPJ. If panfish are listed at 1/mo
Michigan	Regression analysis if r2 > 0.6 otherwise use median within size classes

States that list site-specific advice if different than statewide advice – list both less & more restrictive

State	Site-specific data analysis/logic
Indiana	Generally not enough data for statistical analysis. Predominance of data – BPJ. Use composite samples w/focus on variety of species, sizes, and waterbodies. Will use one composite sample for advice.
Michigan	Use regression analysis if enough data, otherwise, medians within a length group. If advisory is more or less stringent, list it in the book.

States that list site-specific advice for all tested waters

State	Site-specific data analysis/logic
Minnesota	Means analysis by species and size class and within five years of most recent sampling. Composites for bottom feeders and panfish. Individual fish samples for predator species.

"And" vs. "Or"

	And vs. Or
New York	Silent, probably would choose "and"
Pennsylvania	Or
Ohio	Silent on web/verbal 'Or'
Michigan	Not specified, some language on spacing meals impies "or"
Indiana	Silent
Illinois	Not specified, some language on spacing meals
Wisconsin	And
Minnesota	Or

Purchased Fish Consumption Advice

- Four states currently (or are working towards it) provide quantitative advice
- Four states have no plans to provide quantitative advice

Great Lakes Mercury Protocol

Pat McCann, Minnesota Department of Health

Issues for Discussion

- Selection of HPV
  - Two-tiered advice
  - Meal advice category calculation assumptions and significant figures
- And vs. Or
- Consistency between statewide and site-specific listing methods (important for border waters)
- Data analysis
- Statewide advice methodology
- Commercial fish advice

Moving Forward

- Agreed to work towards consistent advice
- Integrated advice for commercial and locally caught fish
  - Consistent methodology
- Focus on which fish to eat and promoting consumption of 2 meals per week

Addendum

- Covers sensitive population
- Updated benefits statement
- HPV selection
- Meal size/body weight ratio
- Meal frequency categories
- Data analysis
- Purchased fish advice

Benefits Statement

- Discussion paper
- Draft statement written
  - Use an approach that outlines risks and benefits to different populations
  - Include information on omega-3 fatty acids content
    - For both commercial and locally caught fish
- Complete after forum

HPV Selection

- U.S. EPA RfD for Sensitive Population
- Text in addendum
  - Rationale for choice of RfD vs. MRL
  - Include discussion about differences between results from Seychelles and Faroes

Meal Size/Body Weight Ratio

- Emphasize ratio

Meal Frequency Categories

- Considered many options
- Considered benefits,
  - Added 2 meals/week option
- “Do not eat” consistent with FDA
  - Dropped 6 meals/year

Data analysis

- More options beyond regression
- Include guidelines for general advice (statewide advice), as well as site-specific

Purchased Fish Consumption Advice

- Optional
  - Follow Hg protocol
  - Use published data, such as FDA

Draft Addendum

- Welcome review comments
- Complete benefits statement
- And vs. Or
- Discuss implementation

Dealing with Interstate Inconsistencies in Fish Consumption Advisory Protocols in the Upper Mississippi River Basin

John R. Olson, Iowa Department of Natural Resources

Dealing with Interstate Inconsistencies in Fish Consumption Advisory Protocols in the Upper Mississippi River Basin

John Olson

Iowa Department of Natural Resources

DNR

2005 National Forum on Contaminants in Fish

Overview:

- Background
- The Upper Mississippi River Basin Association (UMBRA) & the UMRBA Water Quality Task Force
- Levels of inconsistency
- UMRBA coordination effort
- Recommendations
- Show-stoppers

DNR

The Upper Mississippi River Basin

DNR

Background of This Fight. . .

- Interstate inconsistency on fish consumption advisory (FCA) protocols, advisory methodologies, and consumption advice is a nationwide issue
- Involves the five states of the Upper Mississippi River basin (IA, IL, MN, MO, & WI) (also, EPA Regions 5 and 7)
- Inconsistencies in FCA protocols is but one of several interstate issues for the Upper Mississippi River and the UMR basin

DNR

Background (continued)

- IL, MN, & WI [Great Lake States]
  - Have consistent Rfds for PCBs, chlordane, Hg [Great Lakes Protocol(s)]
  - From there, states use slightly different methods, but the end product is similar:
    - Predator fish: 1 meal/mo
    - Other species: 1 meal/wk
- IA & MO: Continue to use an FDA action level-based approach

DNR

Comparison of Advisory Levels (ppm) for PCBs in the Upper Mississippi River Basin

State	Un-restricted	1 meal/wk	1 meal/mo	1 meal/2 mo	Do not eat
Illinois	0 – 0.05	0.06-0.22	0.23 – 0.95	0.96 – 1.89	> 1.9
Iowa	**NA**	**NA**	**NA**	**NA**	**> 2.0**
Minnesota	0 – 0.05	> 0.05 – 0.2	> 0. 2 – 1.0	>1.0 – 1.9	> 1.9
Missouri	**NA**	**NA**	**NA**	**NA**	**> 2.0**
Wisconsin	0 – 0.05	> 0.05 – 0.2	> 0. 2 – 1.0	>1.0 – 1.9	> 1.9

DNR

Dealing with Interstate Inconsistencies in Fish Consumption Advisory Protocols in the Upper Mississippi River Basin

John R. Olson, Iowa Department of Natural Resources

Comparison of Advisory Levels for Mercury (Sensitive Populations) in the UMR Basin

State	Un-restricted	1 meal/wk	1 meal/mo	1 meal/2 mo	Do Not Eat
Illinois	0 – 0.05	0.06 – 0.22	0.23 – 0.95	0.96 – 1.89	> 1.9
Iowa*	**NA**	**NA**	**NA**	**NA**	**> 1.0 (all pops.)**
Minnesota	0 – 0.05	> 0.05 – 0.2	> 0.2 – 1.0	NA	> 1.0
Missouri	**NA**	**NA**	**NA**	**NA**	**> 0.3 (sensitive pops. only)**
Wisconsin	0 – 0.05	> 0.05 – 0.2	> 0.2 – 1.0	>1.0 – 1.9	> 1.9

* In 2004, Iowa issued 1 meal/wk consumption advice to warn sensitive populations about levels of mercury in IA fish; the advisory level remains at 1.0 ppm.

DNR

UMRBA

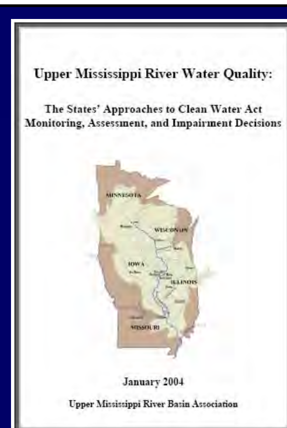
- The Upper Mississippi River Basin Association:
  - A 501[c](3) nonprofit organization est. in 1981 by the governors of the 5 UMR states, with each state having a governor-appointed representative
  - Located in St. Paul, MN
  - Goal: To facilitate dialogue and cooperative action among the 5 UMR states and to work with federal agencies on inter jurisdictional programs and policies
  - http://www.umrba.org/

DNR

The UMRBA's Water Quality Task Force

- Formed in 1998 due to a lack of interstate consultation on WQ-related issues involving the UMR
- Includes representatives from the relevant water quality agencies of the 5 UMR states and EPA Regions 5 and 7
- Issues addressed (but not solved) thus far:
  - Section 305(b) WQ assessments & 303(d) listings
  - Fish consumption advisory protocols
- Next issue:
  - Assessing siltation/sedimentation/turbidity impacts

DNR



DNR

UMRBA's Interest in FCA Protocols

- Identified in the January 2004 UMRBA report on CWA Monitoring & Assessment as an area where progress in consistency could be made in the short term
  - i.e., FCAs are used by states to assess support of the "fish consumption use" for the UMR for Section 305(b) reporting & 303(d) listing & **inconsistent listings exist**
- Identified as an achievable goal by the WQTF (including a certain now-retired biologist from EPA Region 5) in 2004 during a "brainstorming" session
- The Great Lakes states in the UMR basin (IL, MN, WI) all use the GLP for PCBs (1993), and these states saw an opportunity to extend the GLP westward

DNR

DNR

Dealing with Interstate Inconsistencies in Fish Consumption Advisory Protocols in the Upper Mississippi River Basin

John R. Olson, Iowa Department of Natural Resources

The Levels of Inconsistency. . .

- FDA vs. risk-based approaches (e.g., GLP)
- Different approaches for issuing and rescinding FCAs
- Different FCA approaches exist in the states to the west of IA and MO
- Different approaches for assessing support of fish consumption uses [for Section 305(b)]
- Different approaches for identifying Section 303(d)-impaired waters

DNR

The Levels of Inconsistency (cont.)

- Irrespective of FCA protocols, approaches for issuing and rescinding FCAs differ:
  - IL & IA: Need 2 consecutive samples showing levels < criteria before rescinding
  - MN & WI: Use a mean contaminant level
    - MN: Uses a 5-year mean
    - WI: Uses a 5-10 year mean and maximum value
  - MO: Uses the % of samples > action level
    - <10%, unlimited; 11 to 49%, limited; >50%, no consumption.

DNR

UMRBA's Coordination Effort

- Made possible with a grant from U.S. EPA
- Contractor: FTN Associates, Little Rock, AR
- Surveys of state approaches conducted in early 2005
- FCA consistency workshop in March 2005:
  - In addition to UMRBA & contractor, attended by U.S. EPA & state water quality, health, & fisheries agencies
  - Discussed: Monitoring & analysis, guidance & issuance, assessment & listing
- FCA Background report summarized state approaches and discussions from the March workshop

DNR

UPPER MISSISSIPPI RIVER
WATER QUALITY

STATE APPROACHES TO FISH CONSUMPTION ADVISORIES AND THEIR USE IN DESIGNATING WATER QUALITY IMPAIRMENTS FOR THE UPPER MISSISSIPPI RIVER

March 4, 2005

DNR

UMRBA's Coordination Effort (cont.)

- Draft FCA options paper
- May 2005 meeting in St. Paul, MN
- Final report in August 2005:

  Upper Mississippi River Fish Consumption Advisories: State approaches to issuing and using fish consumption advisories on the Upper Mississippi River

  [available at: http://www.umrba.org/reports.htm]

DNR

Upper Mississippi River
Fish Consumption Advisories:

State Approaches to Issuing and Using
Fish Consumption Advisories
on the Upper Mississippi River

August 2005

Upper Mississippi River Basin Association

DNR

Dealing with Interstate Inconsistencies in Fish Consumption Advisory Protocols in the Upper Mississippi River Basin

John R. Olson, Iowa Department of Natural Resources

Five-state Data Comparison

- Suggested at the March 2005 meeting by MN Dept. of Health to better determine the degree of inconsistency
- All states supplied data for Hg & PCBs in fish filet samples for the last 10 years
- Data were compiled by MN Dept. of Health and presented to the UMRBA Water Quality Task Force at the May 2005 meeting

Five-state data comparison (cont.)

- For the Iowa reach of the UMR (sensitive & general populations):
  - PCBs are the driver for bottom-feeding fish:
    - CCAT & common carp <20": 1 meal/wk; >20": 1 meal/mo.
  - Mercury is the driver for predator fish:
    - Range from unlimited consumption (BLG) to 1 meal/wk for smaller predator fish to 1 meal/mo for larger predator fish
- For the Iowa reach of the UMR:
  - With FDA action levels: No advisories
  - IF the GLP were used: Would have some type of advisory in every one of the 11 UMR pools; thus, would be placed on Iowa's list of Section 303(d) waters

UMRBA's Coordination Effort: Recommendations

- There should be consistent FCAs for the UMR (FCA=guidance & issuance) because
  - The UMR is a shared waterbody
  - Inconsistency generates unfavorable public perception
  - Currently have different messages coming from the UMR states
- For monitoring and analysis
  - Establish a minimum set of contaminants, fish species, sizes, sampling locations, sample frequency, sample preparation methods, etc., for all states

UMRBA's Coordination Effort: Recommendations (cont.)

- All UMR states should participate in EPA's national fish contaminant forum
- If necessary, hold a meeting after the 2005 Fish Contaminant Forum to specifically address protocols for consistent FCA guidance & issuance
- CWA Section 305(b) & 303(d) processes should be revisited after obtaining consistency in data and FCAs

"Show-Stoppers"

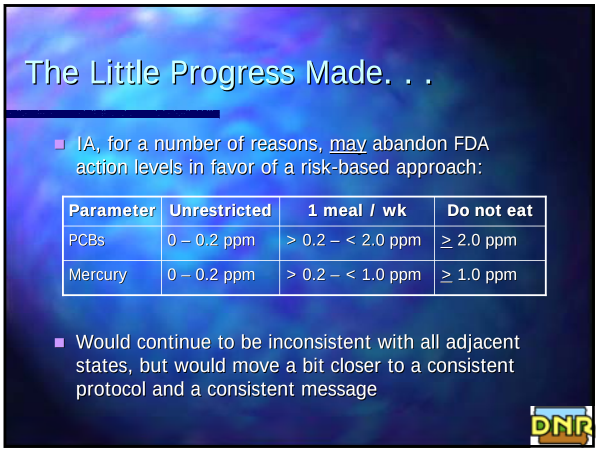
- In the discussion about risk-based (GLP) vs. FDA:
  - Primary issue is whether risk-based FCA approaches overstate the risk to human health from Hg & PCBs, thus diverting people away from consuming fish and recreational fishing
- Other issues:
  - "Skin-on" vs. "skin-off" filet
  - Use of different laboratories to analyze samples
  - Different approaches in issuing & rescinding advisories
  - Little communication and sharing of information between the states regarding monitoring protocols and advisory protocols

Summary

- Information exchange was very useful
- Both the background report and options paper serve as excellent references
- However, little progress in achieving consistency in FCAs was made
  - Each state feels that it has a good approach
  - No consequences of continuing the inconsistency, other than public confusion
  - This outcome was not unexpected & is typical of attempts to resolve interstate inconsistencies

Dealing with Interstate Inconsistencies in Fish Consumption Advisory Protocols in the Upper Mississippi River Basin

John R. Olson, Iowa Department of Natural Resources



Gulf Coast State Fish Consumption Advisory for King Mackerel

Joseph Sekerke, Florida Department of Health

Gulf Coast State Fish Consumption Advisory for King Mackerel

Participating States

- Texas
- Louisiana
- Mississippi
- Alabama
- Florida

Criteria/Assumptions in 1999

State	Do not eat	Adults	Women of childbearing	Children
FL	>39 FkL	1/w 33-39	1/m 33-39	<10 1/m 33-39
AL	>39 FkL	1/m < 39	No < 39	<15 No < 39
MS	>39 FkL	2/m 33-39	1 q 2M 33-39	<7 1 q 2m 33-39
LA	>39 FkL	1/w < 39	1/m < 39	<7 1/m 33-39
TX	>43 TL	1/w 37-43	1/m 37-43	1/m 37-43 (age?)

Issues to Resolve

- Fork length or total length
- Age of child
- Size criteria
- RfD (Hg ppm to break)

Proposed Advisory

- Women of childbearing age and children under 15 should not consume king mackerel
- All others may consume two 2-oz meals per month of king mackerel < 31 inches fork length. Do not consume king mackerel ≥ 31 inches.

Status in Each State

Texas	Katrina
Louisiana	Katrina
Mississippi	Katrina
Alabama	Katrina
Florida	Action in October 2005

Advisories in Shared Waters—Two States Achieve Consistent Advice

Gary A. Buchanan, New Jersey Department of Environmental Protection

Advisories in Shared Waters – Two States Achieve Consistent Advice

Gary A. Buchanan, Ph.D., NJDEP
Richard Greene, DNREC

Acknowledgments

- NJDEP: Alan Stern and Bruce Ruppel
- DE DNREC: Roy Miller
- DE DPH: Jerry Llewellyn

Are State Boundaries Barriers?

Can Fish Swim?

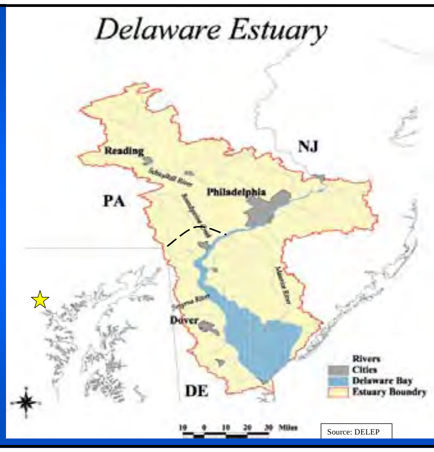
- Fish (and crabs) don't obey state boundaries
- Anglers consuming the "same" fish
- Public confused by different or conflicting advisories
- Concern from health and outreach perspective
- Many rivers are state boundaries (e.g., Mississippi, Ohio, and Colorado rivers)

Consistent Advisories – Potential Problems & Barriers

- Inconsistency – Intrastate water bodies; multiple interstate boundaries
- Unwillingness or inability to compromise
- Assumption that current advisory is protective/adequate
- Policy of current administration
- Current intrastate agency agreements
- Recognition of shared resources

Advisories in Shared Waters—Two States Achieve Consistent Advice

Gary A. Buchanan, New Jersey Department of Environmental Protection



Prior to Consistent Advisory

Waterbody	Species	NJ PCB Advisory using 10^{-5} Cancer Risk	NJ PCB Advisory using 10^{-4} Cancer Risk	Delaware
Delaware Bay (C&D Canal to mouth of bay)	Striped bass	Do not eat	4 meals per year	1 meal per year
	Bluefish	Do not eat (>24") 1 meal/year (<24")	4 meals per year (>24") 1 meal/month (<24")	No advisory
	American eel	1 meal per year	4 meals per year	1 meal per year
	Channel catfish White catfish White perch	1 meal per year (DE advisory)		1 meal per year
Delaware River (DE/PA border to C&D canal)	All finfish	Do not eat (DE)		Do not eat

???

Key to Success

- NJDEP Commissioner Campbell and DNREC Secretary Hughes *requested* the development of consistent fish consumption advisories in the shared waters of Delaware and New Jersey

History of Past Advisories

- NJ since 1982 (1989 in DE Estuary)
- DE since 1986 (1994 in DE Estuary)
- Developed separately
- NJ adopted some DE advisories in 1990s
- DE, NJ, PA, U.S. EPA, and DRBC: Fish Consumption Advisory Team (FCAT) under Delaware Estuary Program

May 2003 Meeting

- Delaware DNREC:
  - Division of Water Resources
  - Division of Fish and Wildlife
- Delaware DHSS:
  - Division of Public Health
- New Jersey DEP:
  - Division of Science, Research, and Technology

Reasons for Differences

- DE: Multiple contaminants
- NJ: Individual contaminants (PCBs)
- DE: 10-5 cancer risk (mandated by Delaware's waste clean-up law)

Reasons for Differences (cont.)

- NJ: "Range approach" (10^{-5} and 10^{-4})
- Different datasets
- Differences in risk assumptions (e.g., 30-yr vs. 70-yr exposure)

Advisory Differences in Delaware Bay (10^{-5} cancer risk)

- Striped bass: DE = 1 meal per year; NJ = Do not eat
- Bluefish – DE = no advisory; NJ = statewide advisory
- American eel

Similarities in Advisories

- Delaware Bay: Channel catfish, white catfish, white perch – NJ lists DE advisory
- Delaware River: NJ lists DE advisory of "Do not eat" for all species
- High-risk population: both states recommend "do not eat"
- Build on consistencies!!

Resolution for Consistent Advisories in Shared Waters

- DE agreed to add bluefish to state's advisories (NJ data)
- NJ agreed to use 10^{-5} cancer risk
- DE/NJ agreed to use DE 2002 striped bass data and NJ assumptions for advisory

NJ and DE Issue Consistent Advisories March 2004

Advisories in Shared Waters—Two States Achieve Consistent Advice

Gary A. Buchanan, New Jersey Department of Environmental Protection

Prior to Consistent Advisory

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	American eel	1 meal per year	4 meals per year	1 meal per year
	Channel catfish White catfish White perch	1 meal per year (DE advisory)		1 meal per year
Delaware River (DE/PA border to C&D canal)	All finfish	Do not eat (DE)		Do not eat

2004 New Jersey and Delaware Fish Consumption Advisories for Shared Waters of the Delaware Estuary/Delaware Bay

Area	Species	Advisory	Contaminants of Concern**
DE/NJ/PA Border to the Chesapeake & Delaware Canal	All finfish	Do not eat	PCBs, dioxin, chlorinated pesticides, mercury
Chesapeake & Delaware Canal to the mouth of the Delaware Bay	Bluefish	Do not eat fish larger than 6 lbs or 24 inches	PCBs, mercury
		No more than 1 meal per year for fish less than 6 lbs or less than 24 inches*	
	Striped bass White perch American eel Channel catfish White catfish	No more than 1 meal per year*	PCBs, mercury

Notes:
- * Women of childbearing age and children should not consume these fish.
- ** Proper trimming and cooking of fish can reduce but not eliminate the risk associated with PCBs, dioxins, and chlorinated pesticides. Trimming and cooking does not reduce the risk associated with mercury.

Benefits of Consistent Advisories

- Uniform and more effective message to anglers and fish consumers in both states
- Improved comprehension by the public
- Increase public health protection

Benefits of Consistent Advisories (cont.)

- Coordinated state outreach efforts
- Sharing of resources and data
- Meets the DE/NJ and Delaware Estuary Program's goal of consistent advisories
- Consistent basis for 303(d) listing and TMDL development (leading to clean up)

Lessons Learned

- Need (simple) consistent advisories.
- Public has difficulty understanding the advisory even without conflicting and complex messages for the same fish in the same waterbody.
- Clear message to the public (risk communication) is more important than differences in technical procedures (risk assessment assumptions).

Conclusions

- Share data
- Compromise
- Management mandate
- Public better informed
- Benefits – Reach more of the public and leverage cleanups


Heineken

Akwesasne Mohawk Fish Advisory Communication

Anthony M. David, Environment Division, St. Regis Mohawk Tribe

Akwesasne Mohawk Fish Advisory Communication

Tony David, Environment Division
St. Regis Mohawk Tribe

2005 National Forum on Contaminants in Fish
Marriott Inner Harbor
Baltimore, MD

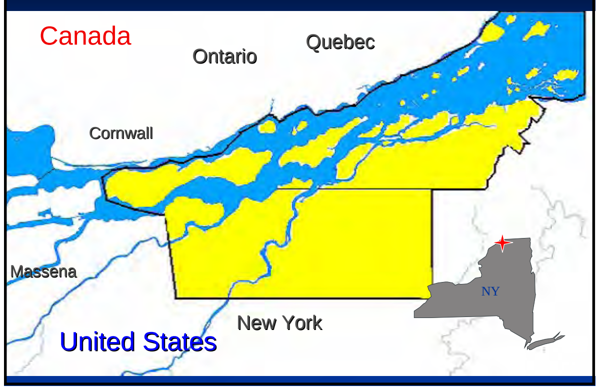
Mohawks of Akwesasne

- 40,000-ac
- U.S. and Canadian
- St. Lawrence River
- Fish-consuming community
- 10,000–12,000 people
- Fish and agriculturally based traditional culture

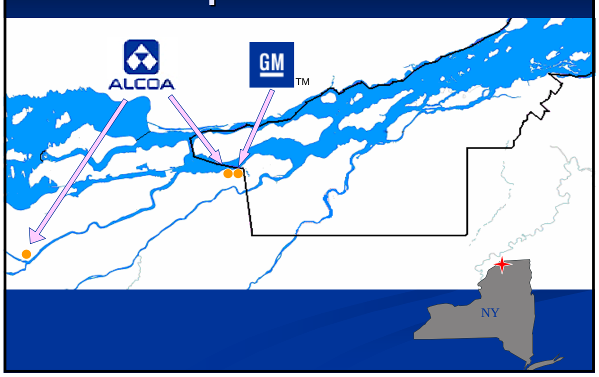
St. Regis Mohawk Tribe

- Tribal government established circa 1934
- Environment division
- 15,000-ac

Mohawks of Akwesasne



Superfund Sites



Public Health Studies

- 1980s, Ward Stone, NYS wildlife pathologist
- 1986, Selikoff and Hammond, Mt. Sinai
- 1992, Chemical contaminants in breast milk
- 1999, NYS DOH/ATSDR, public health assessment
- 2000, SUNY Albany, blood serum PCBs
- 2006? update

Akwesasne Mohawk Fish Advisory Communication

Anthony M. David, Environment Division, St. Regis Mohawk Tribe

Non-Government Efforts

- The Women's Dance
  - Katsi Cook, Midwife to the Six Nations
  - Breast milk exposure concern
  - Risk vs. benefit

©Scott Hess

Cleaning and Cooking Fish to Reduce Contaminants

A Presentation of State and Tribal fish advisories

The Advisories

- SRMT Health Service (1986)
  - Women: Consume no fish
  - Children: Consume no fish
  - Men: 1 meal per week
- NYS DOH (2005)
  - Specific advisories
    - Grasse River: Consume no fish, all species
    - Bay at General Motors: Consume no fish, all species
  - Other general advisories

Contaminant-Reducing Preparation

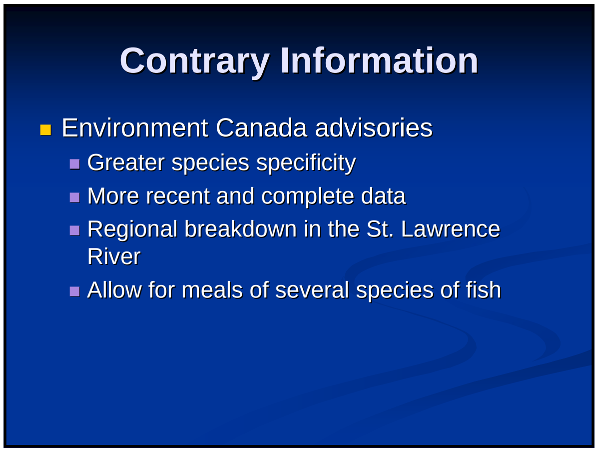
Other Recommendations

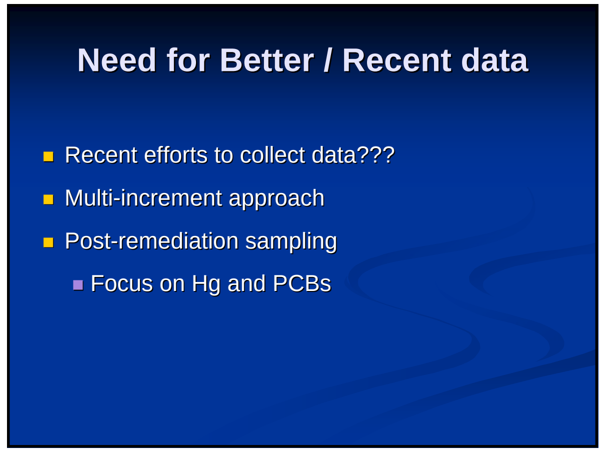
Cooking techniques

- Avoid using fat in recipes
- Don't deep or fat fry
- Filet off when cooking and smoking

General Advisories

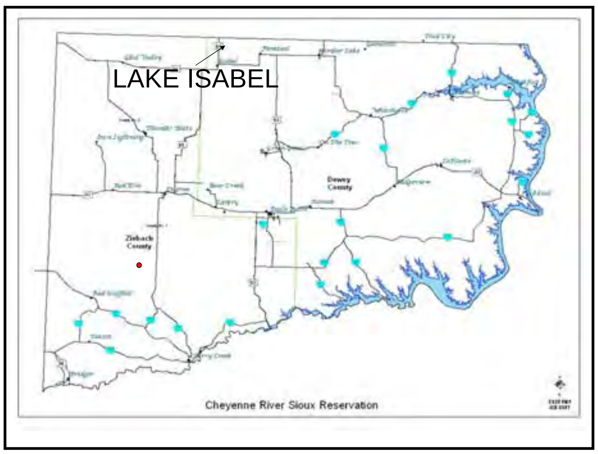
- Select for generally cleaner species
- Harvest from "clean" locations
- Select for smaller size fish

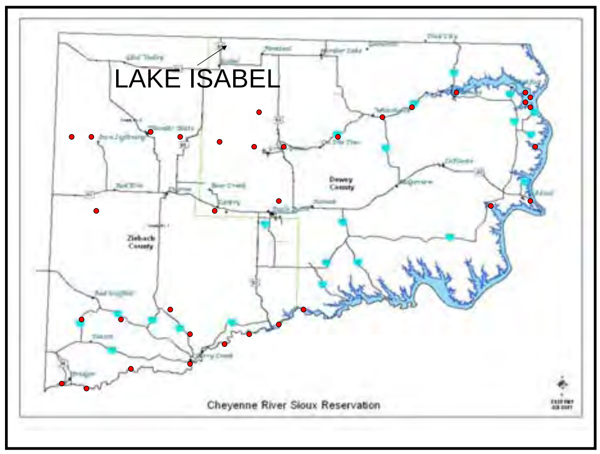

Contrary Information
Environment Canada advisories
Greater species specificity
More recent and complete data
Regional breakdown in the St. Lawrence River
Allow for meals of several species of fish


Need for Better / Recent data
Recent efforts to collect data???
Multi-increment approach
Post-remediation sampling
Focus on Hg and PCBs

Development Processes of Consumption Advisories for the Cheyenne River Sioux Indian Reservation

Jerry BigEagle, Environmental Protection Department, Cheyenne River Sioux Tribe





- Two advisories for the same area
  - The state of South Dakota (SD)
  - The Tribe
- Maintain interest level in recreational angling – focus on individual lakes.
- Reservation-wide advisory – address issues where fish consumption is also for subsistence and supplement of other wild game.

Current South Dakota Advisory

- Lake Roosevelt, Tripp County
  - Species: Largemouth bass (fish > 18 inches)
  - Contaminant: Mercury
  - Healthy adults: No more than one 7-oz. meal per week (52 meals/year)
  - High risk groups: No more than one 7-oz. meal per month (12 meals/year)
  - Children under age 7: No more than one 4-oz. meal per month (12 meals/year)
- Lake Hurley, Potter County
  - Species: Largemouth bass (fish > 18 inches)
  - Contaminant: Mercury
  - Healthy adults: No more than one 7-oz. meal per week (52 meals/year)
  - High risk groups: No more than one 7-oz. meal per month (12 meals/year)
  - Children under age 7: No more than one 4-oz. meal per month (12 meals/year)
- Lake Isabel, Dewey County
  - Species: Northern pike (fish >25 inches), Largemouth bass (fish >17 inches)
  - Contaminant: Mercury
  - Healthy adults: No more than one 7-oz. meal per week (52 meals/year)
  - High risk groups: No more than one 7-oz. meal per month (12 meals/year)
  - Children under age 7: No more than one 4-oz. meal per month (12 meals/year)

Healthy adults – Healthy adults should limit consumption of this fish to no more than one 7 oz. meal per week (7 oz. is equal to two medium-size portions or roughly the size of two decks of playing cards). High risk groups - women who plan to become pregnant, are pregnant, or are breast-feeding should eat no more than one 7-oz. meal of this fish per month. Children under age 7 should eat no more than one 4-oz. meal of this fish per month. (4oz. is equal to one medium-size portion or roughly the size of one deck of playing cards)

Development Processes of Consumption Advisories for the Cheyenne River Sioux Indian Reservation

Jerry BigEagle, Environmental Protection Department, Cheyenne River Sioux Tribe

Current Cheyenne River Sioux Tribal Advisory

REVISED FISH CONSUMPTION ADVISORY
July 15, 2002

The Cheyenne River Sioux Tribe is concerned about the levels of mercury found in the fish of the Cheyenne River, Moreau River, Lake Oahe, and all surface waters of the Cheyenne River Sioux Reservation, especially when those fish are consumed in large quantities, eaten by children, elderly, women of childbearing age, women that are pregnant and women that are breast-feeding. Based upon samples taken by the Cheyenne River Sioux Tribe's Environmental Protection Department in cooperation with the Environmental Protection Agency, the Tribe is expanding the coverage of its original fish consumption advisory beyond the three largest water bodies to include all surface waters reservation-wide (including but not limited to stock ponds, dams, lakes, reservoirs, rivers, creeks, etc.).

IF YOU DO FISH HERE REDUCE YOUR HEALTH RISK BY:

- DO NOT KEEP AND EAT LARGE, OLDER FISH (greater than 4 pounds). Keep smaller fish for eating. In addition to tasting better, younger, smaller fish have had less time to accumulate contaminants than older, larger fish. Selecting smaller fish for consumption reduces risk to your health.
- Eat smaller meals when you eat big fish and eat them less often. Freeze part of your catch to space the meals out over time.
- Eat those that are less contaminated. Contaminants build up in large predatory fish. LIMIT THE AMOUNT OF SMALLER FISH EATEN to one 4-ounce meal per week.

High-risk individuals' such as young children, nursing mothers, elderly and childbearing women are at greatest risk of adverse health effects. Such people should be especially concerned about fish eating habits. PREGNANT WOMEN, WOMEN THAT ARE BREAST-FEEDING AND CHILDREN LESS THAN 6 YEARS OF AGE SHOULD NOT EAT FISH CAUGHT HERE

FOR ADDITIONAL INFORMATION OR QUESTIONS PLEASE CALL THE CRST ENVIRONMENTAL PROTECTION DEPARTMENT AT 964-6568 OR THE CRST GAME, FISH AND PARKS AT 964-7812.

Factors Affecting Advisory Release

- Cheyenne River Sioux Tribe
  - Minority group where average annual income is $1,100/yr
  - Subsistence fishing is a broad practice (BigEagle 02)
  - Education level is a factor
  - Follows U.S. EPA guidelines
  - Recreational fishing not important
  - Species differentiation is not a greater factor
  - Tribe used grants for all efforts

Factors Affecting Advisory Release

- State of South Dakota
  - No harm to recreational fishing
  - Name specific lakes
  - Higher level of guidelines; above U.S. EPA?
  - Names specific species
  - Allows consumption of other unnamed species
- Overall is more specific, more detailed
- State has designated funding

Separate Advisory Efforts

- GF&P, CRST, Dept. Health completes sampling.
- Each agency sent samples to various places for results and compared to EPA GL
- Each agency then made a set of recommendation to the S.D. Dept. of Health
- Series of press releases regarding results
- U.S. EPA Guidelines: U.S. EPA vs. CRST Tribe and U.S. EPA vs. State of S.D.
- The SD GF&P worked off action level 1, FDA standards, and U.S. EPA guidelines
- The Tribe used guidelines closer to standard U.S. EPA recommendations
- May or may not be higher level than U.S. EPA (i.e., ppb vs. ppm)
- State of SD has action syntax similar to FDA or half of FDA standards
- Results?
  - State advisory – no more than 7 oz. per week
  - Tribe advisory – no more than 4 oz per week
  - State = more for adults, same as Tribe for children
  - Tribe = same for both groups; little less confusing when trying to interpret
  - Tribal anglers may not follow advisory

Summary of Coordination

- Coordinated protocol of sampling?
- Coordinated sampling methodology?
- Coordinated information to the public?
- Shared recommendations from T to S
- Have warnings in same jurisdictions?
- Advisories are similar, 7 oz and 4 oz vs. 4 oz and 4 oz
- Overall public safety and risk assessment is homogeneous between ENR and Tribe.

Future of Our Advisory Actions

- National Indian Health Service Grant
- Gather more samples and sample annually
- Funding through permanent source (not a casino Tribe)
- Include arsenic and other dioxins
- Test drinking water

Development Processes of Consumption Advisories for the Cheyenne River Sioux Indian Reservation

Jerry BigEagle, Environmental Protection Department, Cheyenne River Sioux Tribe

Acknowledgments

- Mr. Pat Snyder, SD Environment & Natural Resources
- Mr. Carlyle Ducheneaux, Cheyenne River Sioux Tribe
- Mr. Stuart Surma, History of Lake Isabel
- U.S. EPA, ENR, DOH, CRST

Question: If a tree falls in the forest and no one's around, and it hits a toxicologist, does anyone care?

EPA Advisory Program Update

James Pendergast for Denise Keehner, Office of Science and Technology, U.S. Environmental Protection Agency

EPA Advisory Program Update

James Pendergast, Chief
Fish, Shellfish, Beach, and Outreach Branch
Office of Science and Technology
Office of Water
U.S. EPA

EPA

A Measure of National Interest

Thanks to Mort Walter

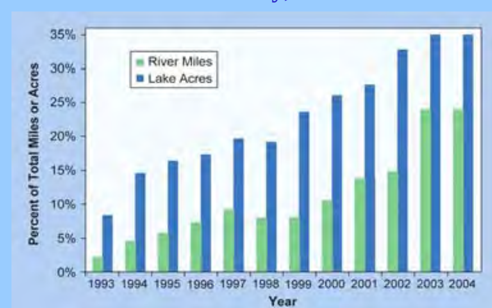
EPA 2

What Is the EPA Program?

- Provides technical assistance to state, federal, and tribal agencies on matters related to health risks associated with exposure to chemical contaminants in fish and wildlife.
  - National guidance documents and outreach
  - National databases
  - Assistance in issuing advisories
  - National conferences and workshops
  - Grants for sampling and analysis
  - Conduct special studies
- Also issues advisories when necessary

EPA 3

Percentage of River Miles and Lake Acres Under Advisory, 1993-2004



EPA 4

Number of Safe-Eating Guidelines by State (2004)

EPA 5

Outreach at Conferences

EPA 6

EPA Advisory Program Update

James Pendergast for Denise Keehner, Office of Science and Technology,
U.S. Environmental Protection Agency

Joint Federal Advisory

- Published advisory for methylmercury in commercial and non-commercial fish in March 2004.
- To improve our outreach, we plan to conduct various surveys about the public's perception of, and sources of information about, the benefits and risks of fish consumption.

7

MOU with FDA

- In June 2005, U.S. EPA's Office of Water and FDA CFSAN signed a memorandum of understanding (MOU) regarding greater collaboration between U.S. EPA and FDA regarding contaminants in fish and shellfish and safety for consumption.
- The MOU lays out goals and objectives and describes how they will be achieved by:
  - Promoting the use of the best available science and public health policies
  - Promoting the sharing and availability of appropriate information among the agencies' health and environmental professionals and the public
  - Encouraging environmental monitoring efforts by FDA/CFSAN and U.S. EPA/OW and stakeholders
  - Encouraging the development of public health advice that considers both risks and benefits of consumption of commercial and noncommercial fish and shellfish, and
  - Promoting uniformity where appropriate in public health messages regarding consumption of commercial and noncommercial fish and shellfish.

8

What Are the Future Directions?

- Look at emerging contaminants:
  - PBDEs and PFOA
- Look at relevance of existing advisories:
  - Have tissue levels changed enough to warrant revising advisories?
  - How do advisories really change people's behavior?
- Continue ongoing work with states to identify safe-eating guidelines
- React & respond to NAS report on risks and benefits related to eating fish
- Continue work with FDA about environmental contaminants in fish and shellfish and the safety of fish and shellfish for consumption by U.S. consumers
- Look at advisories in interstate waters
- Work with U.S. EPA programs on using advisories to leverage clean-ups
- Plan for the 2007 forum

9

U.S. Food & Drug Administration

SEAFOOD SAFETY PROGRAM

Donald W. Kraemer
Acting Director
Office of Seafood

Food Safety by Design

- FDA Published "Seafood HACCP Regulation" in 1995
- Effective 1997
- Requires processors to:
  - Assess potential food safety hazards to determine if they are "reasonably likely to occur"
  - Develop and implement a HACCP plan to control those hazards

Seafood Safety Hazards

- Natural toxins
  - Histamine formation in tuna, mahi mahi, and bluefish
  - Paralytic shellfish poisoning (saxitoxin) and amnesic shellfish poisoning (domoic acid) in colder temperate zone oysters, clams, and mussels
  - Neurotoxic shellfish poisoning (brevetoxin) in warmer temperate zone and subtropical oysters, clams, and mussels
  - Ciguatera toxin in subtropical and tropical barracuda, grouper, and snapper

Seafood Safety Hazards

- Parasites in many species of near-shore fish consumed raw
- Drug residues
  - Chloramphenicol in aquacultured shrimp and crabmeat
  - Fluoroquinolones in aquacultured basa (catfish)
  - Malachite green in salmon
- Unapproved use of food and color additives
  - Unlabeled sulfites in warm water shrimp

Seafood Safety Hazards

- Microbiological contamination:
  - *Vibrio vulnificus* and *Vibrio parahaemolyticus* in Gulf Coast oysters
  - *Listeria monocytogenes* in smoked and pickled fish
  - Norovirus, Hepatitis A virus, and *Vibrio cholerae* in oysters, clams, and mussels
  - *Clostridium botulinum* toxin in vacuum-packaged seafood
  - *Staphylococcus aureus* toxin in stuffed seafood
  - *Salmonella* in many seafood products

Seafood Safety Hazards

- Allergens:
  - Unlabeled milk, eggs, and peanuts in seafood products
- Physical hazards:
  - Metal fragments in breaded fish
  - Glass fragments in packaged fishery products
- Environmental chemicals and pesticides:
  - Industrial chemicals, pesticides, and toxic elements in near-shore fish
  - Methyl mercury in shark, swordfish, king mackerel, tilefish, and albacore tuna

Chemical Contaminants

- Total Diet Study:
  - Tuna, salmon, pollack, shrimp, and catfish
  - Radionuclides, pesticides, PCBs, VOCs, toxic and nutritional elementals, and folic acid
- Chemical Contaminants Field Assignments:
  - Pesticide program
  - Toxic elements program
  - Dioxin program
  - Perchlorate assignment
  - Mercury assignments

FY'05 Pesticide Program

- 175 domestic, 300 import samples
- Pesticides and PCBs
- Domestic: locally caught, commercial, non-migratory, and bottom feeders
- Import: salmon from Canada and Norway, aquacultured catfish, crayfish, tilapia, Nile perch, basa, shellfish, and crustaceans

FY'05 Toxic Elements Program

- 10 domestic, 160 import samples
- Lead, cadmium, arsenic, and mercury
- Fresh or frozen striped bass, salmon, flounder, herring, sardine, cod, bluefish, halibut, Alaska pollack, crab, oyster, squid, scallop, and American lobster

FY'05 Dioxin Program

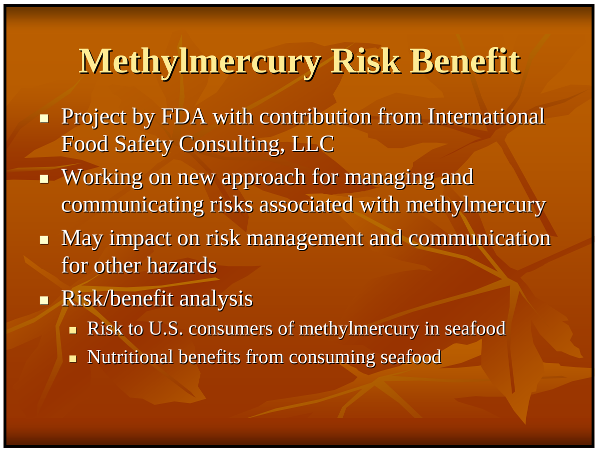
- 520 domestic and import samples, 85 feed samples
- Dioxins and dioxin-like PCBs
- Domestic: Aquacultured catfish, striped bass, tilapia, and salmon
- Import: Salmon, bluefish, flounder, halibut, sole, striped bass, wild salmon, scallop, shrimp, clam, oyster, crab, mussel, lobster, Alaska pollack, cod, sardines, swordfish, ocean perch, tuna, haddock , crayfish, mackerel, croaker, sablefish, orange roughy, shark, weakfish, and pogy

FY'05 Perchlorate Assignment

- 35 domestic and import samples
- Perchlorate
- Aquacultured catfish and salmon, wild-caught salmon, and shrimp

FY'05 Mercury Assignments

- Domestic and import
- 470 samples fresh/frozen fish – 29 species
- 100 fresh/frozen tuna, 50 samples canned tuna
- Total mercury

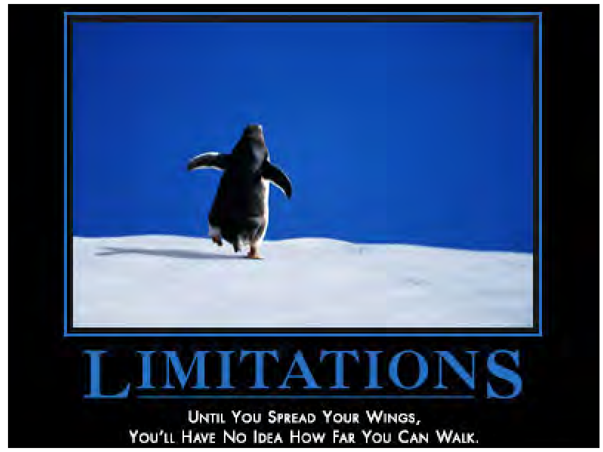

Methylmercury Risk Benefit
Project by FDA with contribution from International Food Safety Consulting, LLC
Working on new approach for managing and communicating risks associated with methylmercury
May impact on risk management and communication for other hazards
Risk/benefit analysis
Risk to U.S. consumers of methylmercury in seafood
Nutritional benefits from consuming seafood

Key Considerations in Fish Tissue Sampling Design

Lyle Cowles, Region 7, U.S. Environmental Protection Agency

Key Considerations in Fish Tissue Sampling Design

Lyle Cowles, U.S. EPA Region 7



Main Discussion Areas

- Preparation is required to design a sampling program that meets your needs.
- Understanding and choosing sampling designs appropriate to your questions, resources, and needs.
- Considerations in balancing, integrating, and implementing multiple sampling designs.

Key Consideration 1 – Preparation

- Primary question: How to design and implement a monitoring system to meet your needs?
- Be very thorough and methodical in developing a complete understanding of (a) the questions, (b) the resources to be monitored, and (c) design options (strengths & limitations).
- Design based on what you need to accomplish, not on what you're currently doing and/or the resources you have to do it (i.e., don't limit your thinking).
- Be open-minded and creative about solutions, looking for efficiencies, asking for more, doing more.

Key Consideration 1 – Preparation

For a Thorough and Methodical Understanding

- Know all the questions. For states, tribes, and EPA, the Clean Water Act asks two basic questions:
  1. **What is the condition of all the waters, what % are impaired?** = 305(b) question (requires an unbiased probability-based or representative-type design)
  2. **Which ones are impaired and why (by what pollutant)?** = 303(d) question (requires a targeted, determinative-type monitoring approach)

Key Consideration 1 – Preparation

For a Thorough and Methodical Understanding

- Know all the questions (inc. pollutants of interest)
- Know all the resource classes and any distinct sub-classes to be monitored and their size.
- Have good rationale and data to support your monitoring program design decisions.
- Identify the level of monitoring coverage needed for each class and sub-class to be monitored.

Key Considerations in Fish Tissue Sampling Design

Lyle Cowles, Region 7, U.S. Environmental Protection Agency

303(d)/305(b) Monitoring Network Design Table

Resource class	Population Size	Significant Public Profile / Use	Significant Fishing Pressure	Monitoring Coverage Needed	Monitoring Design	Year to Sample
Big Rivers	500 miles 50 segmts	Y	Y	Represent all segments	Targeted-Represent	annual
Non-wade	25 streams 2,500 miles	Y	Y	Census of streams	Census	annual
Wadeable Streams	25,000 miles	N	Y	Represent all miles	Probability	2007
Small/int. streams	100,000 miles	N	N	None	N/A	N/A
Urban lakes/ small streams	hundreds	Y/N	Y/N	Represent/ None	Probability/ None	2009
Large public lakes (A)	75	Y	Y	Census	Annual census	annual
Medium public lakes (B)	300	Y	Y	Census	Rotating census	2008
Small public, private (C)	10,000	N	Y	Represent	probability	2008

Recap of Consideration 1 – Preparation

- *You need all these in order to be able to choose monitoring designs that meet your needs*.
  - Know the questions (seek to balance them).
  - Know the resources, sub-classes, and size.
  - Know your coverage needs for each class.
  - Have supportable design rationale and data.
  - Don't limit your thinking.

Key Consideration 2 – Design Pros & Cons

Design	Pros	Cons
Census – All sites are sampled	Answers both 305 and 303	Expensive and not practical if large number of water bodies to sample
Probability – Sites are selected at random to represent a population	• Efficient to represent a large population with a small sample (305b) • Known confidence for results • Predicts size of 303d & provides some of the 303(d) sites	• Does not ID all impaired waterbodies for 303(d) • Sites require inventory and recon • Logistical problems accessing remote sites
Targeted-Representa-tive – Sites are selected by BPJ or other means to represent an area or population	• Can usually be implemented simply and efficiently	• Assumptions are necessary • No guarantee sites are representative • Work required to develop and implement targeting methodology • Does not ID all impaired waterbodies for 303d
Targeted – Sites are selected via determinative methods usually to investigate known or suspected problems/areas	• Well suited to 303(d) • Can provide some 303(d) sites if targeting methods work	• Does not provide 305(b) answer • Work required to develop and implement targeting methodology • Used alone, does not provide data to validate the targeting method

Consideration 3 – Balancing and Integrating Designs

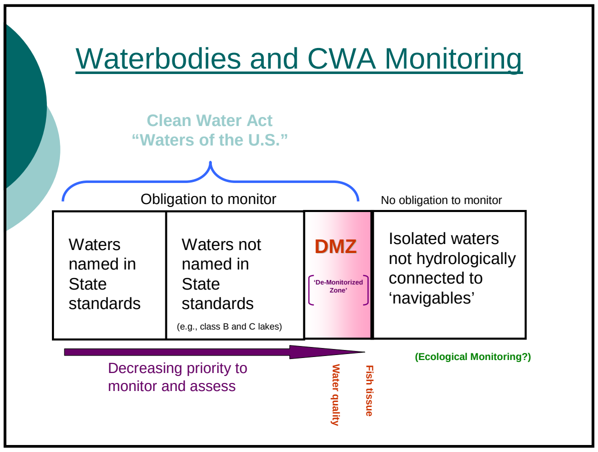
1. The designs for 305(b) and 303(d) can provide complementary assessment results, but the data are not readily integrated. Integration is often misused to describe coordination of sampling.
2. In a perfect 305(b)/303(d) world, I would implement an "educational" probability-based design first followed by an "educated" targeted design that considered the most important factors driving impairment (e.g., land use, point and non-point sources).
3. Adequate resources, planning, and coordination are the keys to balancing and implementing multiple designs.
4. Resources can be created! How?
   - Have good rationale
   - Eliminate existing program inefficiencies
   - Look at what your data is telling you

Key Considerations in Sampling Design

- Balancing the CWA Questions:
  - We should seek through state strategies to balance the monitoring needed to answer both 305(b) and 303(d) questions.
  - Some state and EPA programs have prioritized the monitoring for 303(d) without providing for 305(b). Worse, targeted 303(d) data has been used for 305(b), producing negatively biased assessments.

Challenges in Sampling Design

- Knowing the questions, resources, and your needs are not as easy as they may seem. They may require
  - GIS work: ID of populations and areas of interest
  - Agreement on definitions and sub-classes
  - Agreement on coverage needs
  - Obtaining the required information and making design decisions may be compounded by the number of collaborators, old program considerations, and thinking.


Waterbodies and CWA Monitoring
Clean Water Act
"Waters of the U.S."
Obligation to monitor
No obligation to monitor
Waters named in State standards
Waters not named in State standards
(e.g., class B and C lakes)
DMZ
'De-Monitorized Zone'
Isolated waters not hydrologically connected to 'navigables'
(Ecological Monitoring?)
Decreasing priority to monitor and assess
Water quality
Fish tissue

How Many Fish DO We Need? Protocol for Calculating Sample Size for Developing Fish Consumption Advice

Jim VanDerslice, Washington State Department of Health

How Many Fish DO We Need?

Protocol for Calculating Sample Size for Developing Fish Consumption Advice

Jim VanDerslice, Ph.D.
David McBride, M.S.
Rob Duff, M.S.

Office of Environmental Health Assessments
Washington State Department of Health

How Many Fish Do You Need?

- Precision of estimate of mean concentration
  - Relative (e.g. +/- 15%)
  - Absolute (e.g. +/- 50 ppb)
- Fish populations
  - Species that are consumed
  - Size classes that may have different levels of contamination
- Response: HOW many?
- Alternate: n=($$ available)/(cost per sample)

WA Approach For Fish Consumption Advice

- Goal is to develop and communicate defensible, consistent advice about healthy consumption of fish
- Assessment ➔ Meal recommendations

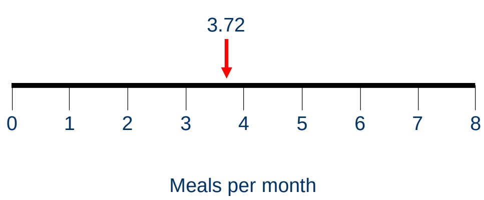
Meal Recommendations

- Meal recommendation (meals per month) =

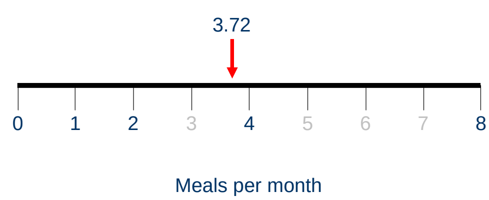
(noncancer endpoints) $\frac{\text{Rfd} * 30.4 * \text{BW}}{\text{meal size} * \text{Conc.}}$

(cancer endpoints) $\frac{\text{Risk level} * 30.4 * \text{BW}}{\text{CSF} * \text{meal size} * \text{Conc.}}$

Meal Recommendations

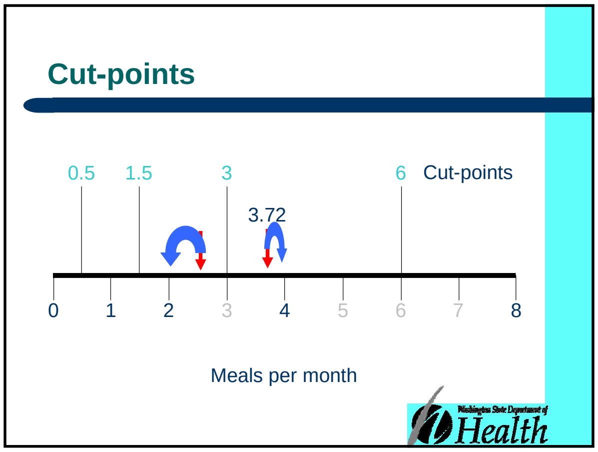


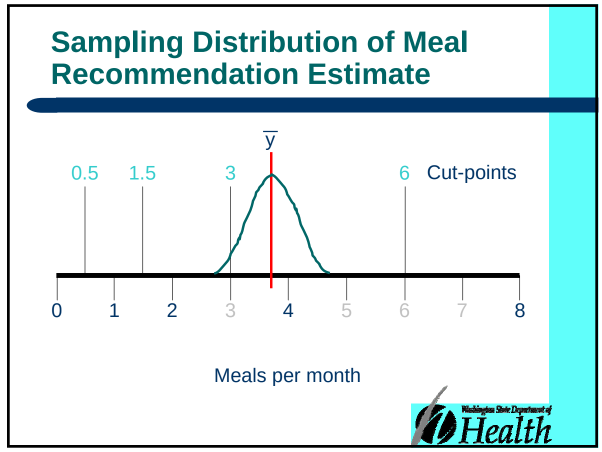
Standard Meal Recommendations

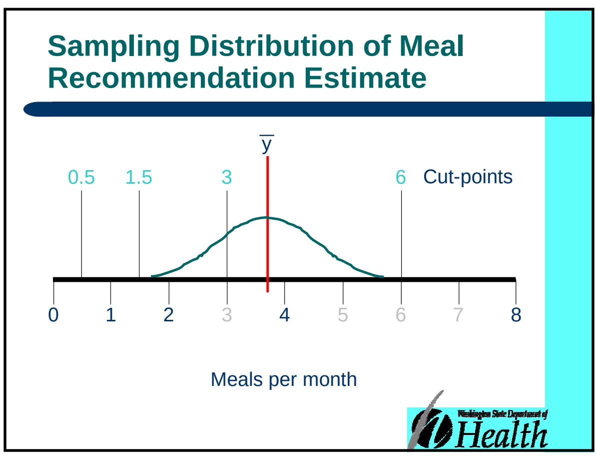


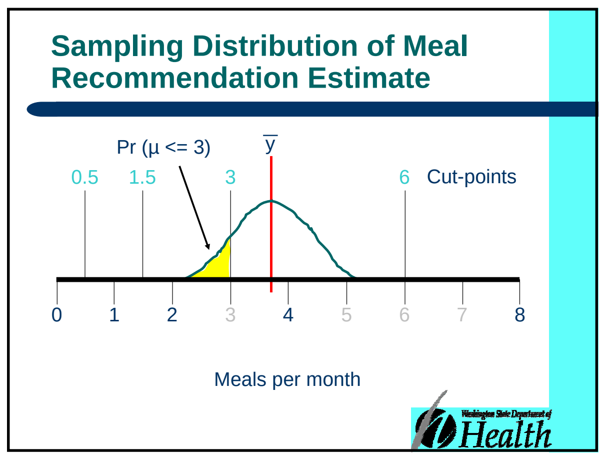
How Many Fish DO We Need? Protocol for Calculating Sample Size for Developing Fish Consumption Advice

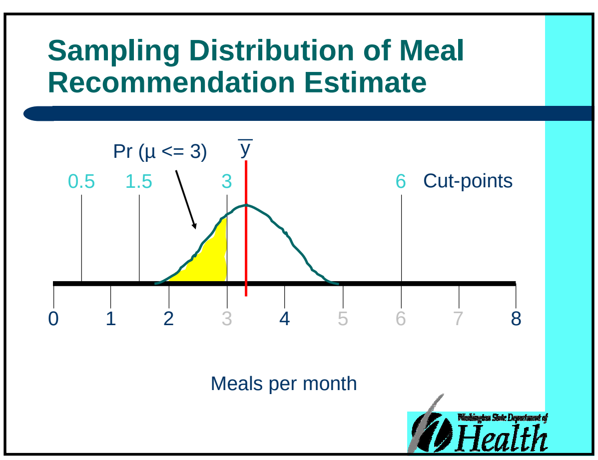
Jim VanDerslice, Washington State Department of Health

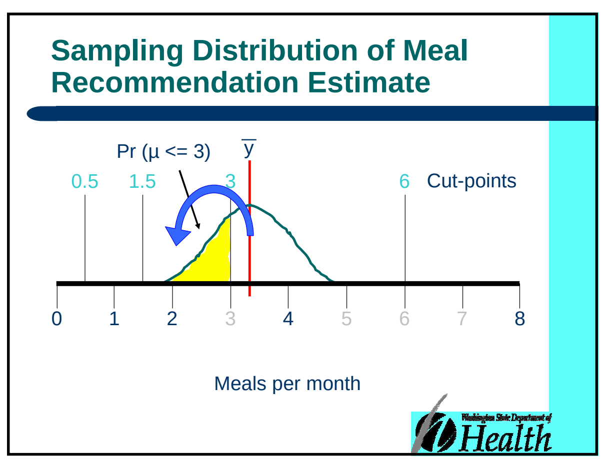












How Many Fish DO We Need? Protocol for Calculating Sample Size for Developing Fish Consumption Advice

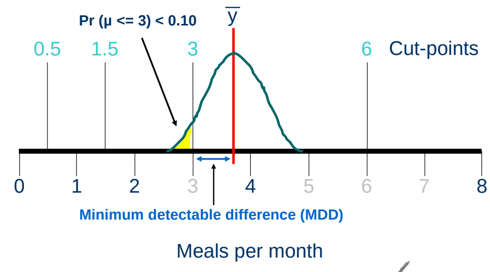
Jim VanDerslice, Washington State Department of Health

Decision Rule

- If Pr (μ <= cut-point) > 0.10 then consider using lower standard meal recommendation (10% is arbitrary)
- Provides basis for sampling objective
  - Have an 80% chance of
    - Detecting the difference between the expected meal recommendation and the lower cut-point (i.e., minimum detectable difference)
    - At a significance of 0.10 (one-sided)

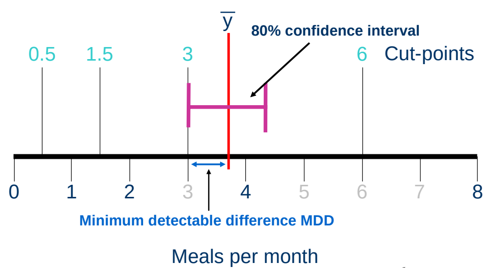
Washington State Department of Health

Minimum Detectable Difference of Meal Frequency



Washington State Department of Health

Estimated Meal Recommendation and 80% Confidence Interval



Washington State Department of Health

But We're Sampling Fish…

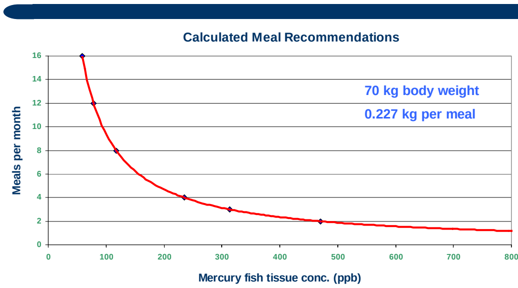
- For a given contaminant and target population:

Meal recommendation =

$$\frac{\text{Rfd} * 30.4 * \text{BW}}{\text{meal size} * \text{Conc.}} = \frac{\text{A}}{\text{Conc.}}$$

Washington State Department of Health

Hg Concentration vs. Recommended Meals



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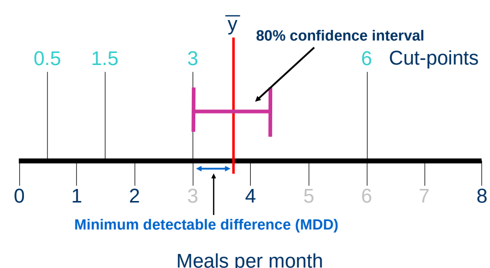
Minimum Detectable Difference of Meal Frequency



Washington State Department of Health

How Many Fish DO We Need? Protocol for Calculating Sample Size for Developing Fish Consumption Advice

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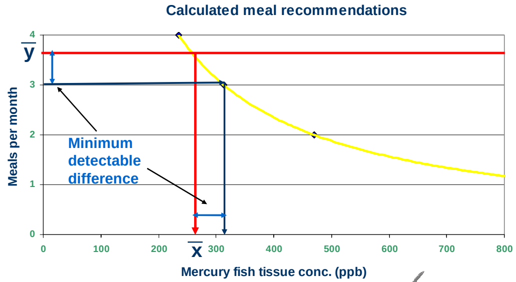
Minimum Detectable Difference of Contaminant Concentration



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Summary

1. Estimate mean and s.d. of contaminant concentration
2. Determine meal frequency associated with mean contaminant concentration
3. Determine difference between cut-point and mean meal frequency (MDD)
4. Determine MDD of fish tissue concentration needed
5. Calculate sample size needed
6. Conduct sensitivity analyses

Washington State Department of Health

Optimal Sampling

Rolfe, F.J., H.R. Akcakaya, and S.P. Ferraro, 1996. Optimizing composite sampling protocols. *ES&T* 30(10):2899–2902.

- Calculation of sample size for given MDD
- Iterative solution of optimum number of fish per composite
- Based on variability of contaminant concentrations, variability of lab analyses, cost of additional fish samples, and cost of additional lab analyses

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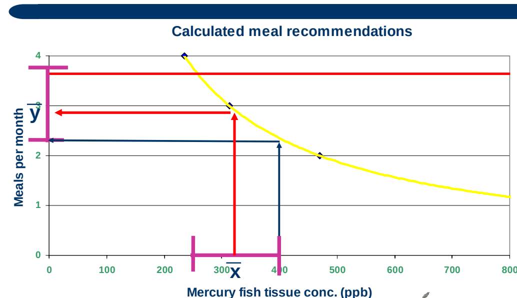
Minimum Detectable Difference of Contaminant Concentration



Washington State Department of Health

Acknowledgments

- This work was supported in part by the Washington Environmental Public Health Tracking Network grant from the National Centers for Environmental Health, Centers for Disease Control and Prevention (U50/CCU022438-01,02)

Washington State Department of Health

US FDA's Total Diet Study

Katie Egan, Food and Drug Administration

US FDA's Total Diet Study

Katie Egan
U.S. FDA/CFSAN

Presented at the
National Forum on Contaminants in Fish
September 18-21, 2005, Baltimore, MD

Introduction

- What is a Total Diet Study (TDS)?
- Brief history of FDA's TDS
- Review of study design
- Brief discussion of TDS results

Total Diet Studies

- Purpose is to
  - Measure levels of various substances in foods
  - Estimate dietary intakes of the substances
- Involves purchase and analysis of foods representing all components of the diet
- Focus is the average diet rather than extreme or atypical consumers

Total Diet Studies (cont.)

- Conducted by many countries
- Study design depends on specific
  - Health/safety concerns
  - Resources
- Model can be adapted to meet specific needs (e.g., selected foods, regions)

FDA's Total Diet Study

- Initiated in 1961 due to concern about radioactive fallout
- Conducted continuously since then
- Over time has evolved to include
  - More analytes
  - More foods
  - Improved analytical methods
  - Intakes for more population groups

Current TDS Design

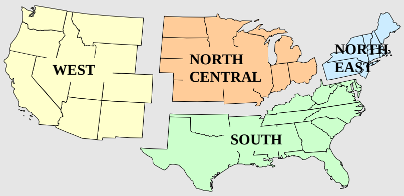
- ~ 280 foods & beverages
- ~ 500 analytes
  - Pesticides, elements, industrial chemicals, nutrients
- Estimated dietary intakes for
  - Total United States
  - 14 age/gender groups

US FDA's Total Diet Study

Katie Egan, Food and Drug Administration

Current TDS Design

4 regional market baskets each year
~ 280 foods collected in 3 cities per region
– 3 samples are composited for analysis



TDS Design Components

- TDS food list
- Sample collections
- Sample preparation/compositing
- Sample analyses
- Estimation of dietary intakes

TDS Food List

- Includes major components of the average American diet
- Is based on national food consumption survey results
- Limited to foods available nationwide
- Is revised periodically to reflect changing dietary patterns

Selecting TDS Foods

TDS food: Applesauce
Survey codes and consumption amounts

Survey code	Survey Food Description	
62101200	Apple, dried, cooked	0.001
62101230	Apple, dried, cooked, with sugar	0.009
63101110	Applesauce/stewed apples, NS as to added sweetener	0.694
63101120	Applesauce/stewed apples, unsweetened	1.252
63101130	Applesauce/stewed apples, with sugar	1.290
63101140	Applesauce/stewed apples, with low calorie sweetener	0.063
63101150	Applesauce with other fruits	0.028
63101210	Apple, cooked or canned, with syrup	0.039
63101310	Apple, baked, NS as to added sweetener	0.030
63101320	Apple, baked, unsweetened	0.081
63101330	Apple, baked, with sugar	0.132
63101420	Apple, pickled	0.008
63101500	Apple, fried	0.095
	Total consumption:	3.7

Fish/Seafood in TDS

- Species consumed nationwide by most Americans
- Includes:
  - Canned tuna
  - Fish sticks
  - Fish sandwich (fast food)
  - Shrimp
  - Haddock (through 1997)
  - Salmon (added in 1997)
  - Catfish (added in 2003)

Foods are "table ready"

- Fresh orange, peeled
- Green beans, cooked
- Salmon, baked
- Microwaved popcorn
- Taco/tostada, carry-out

Sample Collection Sites

- Selected from Standard Metropolitan Statistical Areas (SMSAs) close to FDA district or field offices
- 3 cities selected per region
- Cities vary from year to year

TDS Analytes

Each food is analyzed separately for

- Pesticide residues (>150)
- Industrial chemicals (43)
- Radionuclides (13)
- Elements (4 toxic, 14 nutrient)
- Folate
- Dioxin (since 1999); acrylamide (since 2003); perchlorate, furan (since 2004)

Analytical Results

- Results for TDS analytes posted on TDS Web site:
  - Individual data (as .txt files)
  - Data summaries by analyte and/or food
- Current Web site includes data from 1991 through 2001/2002
- Results for additional analytes posted elsewhere on CFSAN Internet

Results for Fish/Seafood: Mercury (total)

TDS Food	n (detected)	Hg concentrations (mg/kg)	
		Average	Range
Canned tuna	40	0.163	0.06 – 0.322
Fish sticks	39	0.004	0 – 0.030
Shrimp	39	0.027	0 – 0.071
Salmon	17	0.030	0 – 0.060

TDS Intake Estimates

- Dietary intake =
  Analyte concentration x amount of foods consumed
- TDS "diets" developed for 14 age-gender groups + total U.S. population
- Each diet = Consumption amount for each TDS food

Dietary Intake of Mercury from Fish/Seafood

TDS Food	Hg conc (mg/kg)	Intake (µg/day)		
		Total US	MF 2 yrs	F 25-30 yrs
Canned tuna	0.163	0.541	0.186	0.490
Fish sticks	0.004	0.008	0.005	0.005
Shrimp	0.027	0.091	0.013	0.212
Salmon	0.030	0.085	0.025	0.058

TDS Intake Estimates

- Provide reasonable estimates of
  - Background intakes/exposure
  - Average intake over time
- Are not appropriate for assessing
  - Acute intakes
  - Upper percentile intakes
  - Intakes from very specific foods or specific population subgroups

Web Sites

More information and analytical results are posted on CFSAN's Web site: http://www.cfsan.fda.gov

Program Areas:
Chemical Contaminants
- Total Diet Study

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

David McBride, Washington State Department of Health

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

Dave McBride, M.S.
Jim VanDerslice, Ph.D.
Denise Laflamme, M.S., M.P.H.
Asnake Hailu, D.P.H.
Liz Carr, M.S.

Washington State Department of Health
Division of Environmental Health
Olympia, WA

Study Objectives

- To characterize levels of mercury and PCBs in canned tuna and fresh fish sold in grocery stores
  - To estimate contaminant levels in the most frequently consumed fish in Washington State
  - To identify fish with lower levels for making recommendations to consumers
- Expanded analysis to include PBDEs

Sampling Fresh and Frozen Fish

- Species chosen based on frequency of consumption and expected contaminant levels
  - Catfish
  - Cod
  - Flounder
  - Halibut
  - Red snapper
  - Pollack
  - Salmon
  - Tuna (canned white and light)
  - Tuna steaks, carp

U.S, EPA, 1996; U.S. FDA, 1994

Study Design

- Sampling objective:
  - Obtain a probability sample of fish available for retail sale in Washington State
- Target:
  - 60 of white/light canned tuna
  - Follow up to 2003 study
  - 20 of each species of fresh/frozen fish
- Two-stage sampling:
  - Store
  - Fish sample

Fish Collection – Selecting Stores

- Primary sampling unit:
  - Retail outlets (small and large grocery stores)
- Obtained listing of all retail food outlets from WA Dept. of Revenue
  - Includes data on food sales ($)
  - Used total sales as proxy for sales of fish
  - Random selection of stores; probability of selection proportional to sales
- Fish bought from 40 stores

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

David McBride, Washington State Department of Health

Location of Grocery Stores

Sampling Fresh and Frozen Fish

- Collected samples between October 2004 and February 2005
- Collected one sample of each available fish type (fresh/frozen) from each store
  - Medium-sized fillet of counter fish
  - Top package of packaged fish
  - Relied on sales person regarding "species"
- Total of 390 fish samples collected (118 cans, 172 fillets)

Store Labeling of Fish

- Fish labels on store packages or signs can include different species:
  - Red snapper
    - Includes rock fish and red snapper
  - Cod
    - Includes Pacific and Alaskan cod
  - Flounder
    - Includes sole, Dover sole, and flounder
  - Chinook salmon "worst case"

Sampling Canned Tuna

- Listed all available "products" of canned tuna on the shelf:
  - 6-oz cans
  - No specialty products
- Randomly selected:
  - 2 cans from all albacore types
  - 2 cans from all light tuna types

Preparation and Analysis

- Individual fish samples analyzed
- Homogenized and frozen
- Lab analysis – WA Dept. of Ecology Manchester lab
  - Mercury analyzed by CVAA, U.S. EPA Method 245.6
  - PCB Aroclors analyzed by GC/ECD, U.S. EPA Method 8082 (1016, 1221, 1232,1242, 1248, 1254,1260, 1262, 1268)
  - PBDE Analyzed by GC/MS/MS, U.S. EPA Method 8270
    - Analyzed for BDE-47, 66, 71, 99, 100, 138, 153, 154, 183, 190, and 209
    - Estimated quantitation limits:
      - 0.12-0.52 ng/g (ppb) for all congeners except BDE-209
      - 0.41-6.5 ng/g for BDE-209

Mercury Results

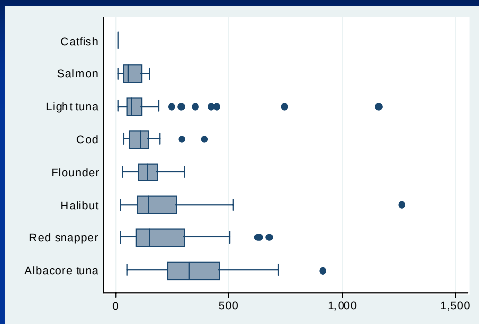
Species	Mean (ppb)	Range (ppb)	N	Det. Freq. (%)
Catfish	8.5	8.5 – 8.5	23	0
Pollack	9.1	8.5 – 22	24	4
Salmon	71	8.5 – 150	17	94
Cod	115	34 – 391	33	100
Tuna – light	126	8.5 – 1160	55	96
Flounder	147	28 – 303	18	100
Halibut	215	20 – 1260	30	100
Red snapper	223	21 – 674	27	100
Tuna – white	357	52 – 912	63	100

ND = ½ DL

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

David McBride, Washington State Department of Health

Mercury Concentrations



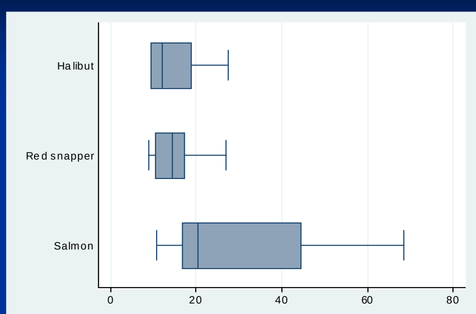
Total Mercury (ppb)

PCB Results

Species	Mean (ppb)	Range (ppb)	N	Det. Freq. (%)
Flounder	9.6	9.0 – 10.7	19	5
Cod	9.8	9.0 – 18.5	33	0
Pollack	9.9	9.0 – 18.5	23	0
Tuna - light	12.6	8.6 – 31.4	20	5
Tuna – white	12.6	9.0 – 18.9	20	0
Halibut	14.6	9.5 – 27.4	29	62
Red snapper	14.7	9.0 – 27.0	27	74
Catfish	15.1	9.0 – 45.4	24	8
Salmon	31.5	10.9 – 68.4	17	76

ND = ½ DL

PCB Concentrations



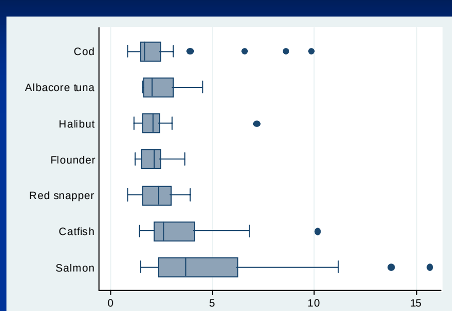
Total PCBs (ppb)

PBDE Results

Species	Mean (ppb)	Range (ppb)	N	Det. Freq. (%)
Pollack	2.0	1.4 – 3.8	23	0
Flounder	2.0	1.2 – 3.7	19	16
Halibut	2.1	1.2 – 7.2	29	41
Red snapper	2.3	0.8 – 3.9	27	56
Tuna – light	2.4	1.5 – 6.5	20	5
Tuna – white	2.4	1.6 – 4.5	20	15
Cod	2.5	0.8 – 9.8	33	12
Catfish	3.3	1.4 – 10.1	24	25
Salmon	5.3	1.5 – 15.7	17	88

ND = ½ DL

PBDE Concentrations



Total PBDEs (ppb)

PBDE Congeners

	% of Samples with Detected Congeners										
Species	47	66	71	99	100	138	153	154	183	190	209
Catfish	17	0	4	4	0	0	0	0	0	0	8
Cod	6	0	0	0	0	0	0	0	0	0	9
Flounder	11	0	5	0	0	0	0	0	0	0	0
Halibut	20	3	10	0	3	0	0	0	0	0	7
Pollack	0	0	0	0	0	0	0	0	0	0	0
Red snapper	50	0	4	0	4	0	4	4	0	0	8
Salmon	82	0	29	41	41	0	24	24	0	0	12
Tuna – light	0	0	0	0	0	5	0	0	5	5	5
Tuna – white	5	0	0	0	0	0	0	5	5	0	0

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

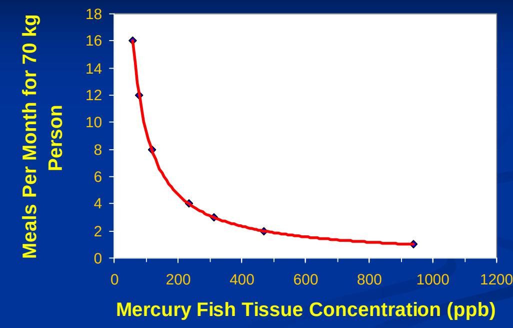
David McBride, Washington State Department of Health

Calculating Concentration As a Function of CR

- Concentration in fish $= \frac{RfD \times BW \times CF}{MS \times CR}$

Parameter	Value	Units
RfD – Reference Dose		
PCBs	2.0E-5	mg/kg-day
Mercury	1.0E-4	
PBDEs	NA	
CF – Conversion Factor	30.4	days/month
BW – Body Weight	70 (adult)	kg
MS – Meal Size	0.227 (8 oz)	kg/meal
CR – Consumption Rate	0 - 16	meals/month

Calculated Meal Recommendations Based on Hg Concentration

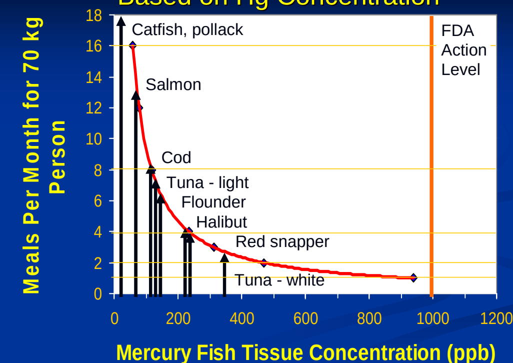


Meal Recommendation Calculations

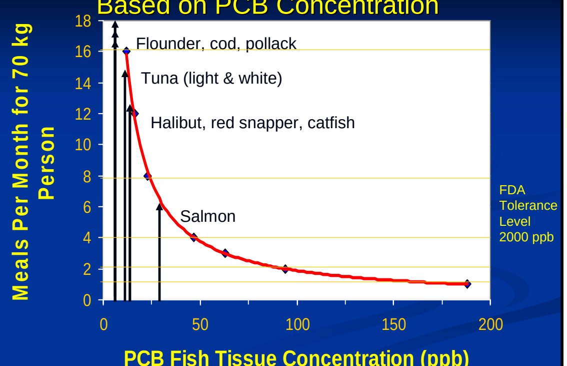
- Meals per month $= \frac{RfD \times BW \times CF}{MS \times Concentration}$

Parameter	Value	Units
RfD – Reference Dose		
PCBs	2.0E-5	mg/kg-day
Mercury	1.0E-4	
PBDEs	NA	
CF – Conversion Factor	30.4	days/month
BW – Body Weight	70 (adult)	kg
MS – Meal Size	0.227	kg/meal
Conc. – Concentration	mean	mg/kg

Calculated Meal Recommendations Based on Hg Concentration



Calculated Meal Recommendations Based on PCB Concentration



Drivers of Meal Recommendations

Species	Hg meals per month	PCB meals per month
Catfish	unlimited	16
Cod	8	unlimited
Flounder	8	unlimited
Halibut	4	16
Pollack	unlimited	unlimited
Red snapper	4	16
Salmon	16	8
Tuna – light	8	16 (unlimited)
Tune – white	2 (4)	16 (unlimited)

Value in parenthesis based on 6-oz (1 can) meal size.

Conclusions

- Mercury was most frequently detected
  - 7 out of 9 species had detected frequency > 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, and salmon had detected frequency >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

Acknowledgments

- Washington State Department of Ecology, Manchester lab:
  - Stuart Magoon
  - Dolores Montgomery (Principal chemist)
  - Jeff Westerlund
  - Cherlyn Milne
  - Kelly Donegan
  - Daniel Baker
  - Danette Hanttula
  - Dickey Huntamer
  - Pamela Covey

Acknowledgments

- Washington State Department of Ecology, Headquarters:
  - Keith Seiders, Cheri Peele (PBDE lead policy analyst)
- Washington State Department of Health:
  - Judy Bardin, Nancy West, Glen Patrick, Helen Murphy, Milo Straus, Rob Banes, Marnie Boardman
- Funded by:
  - Washington State Department of Health, and
  - Washington Environmental Public Health Tracking Network grant from the National Centers for Environmental Health, Centers for Disease Control and Prevention (U50/CCU022438-01,02)

BRFSS Fish Consumption Questions

- How often do you eat canned tuna?
- In the past 30 days, how often did you eat either fresh or frozen store bought fish, including fish items, such as fish sticks?
- Not counting shellfish, please tell me all the types of FRESH FISH you ate in the past 30 days (*purchased at a grocery store or fish market*).

Meals Per Month
(mean, 95% CI) BRFSS 2002

	Canned tuna	Store-bought
All adults (N=4756)	7.4 (6.6 – 8.1)	2.8 (2.6 – 3.0)
Men (N=1917)	8.2 (7.0 – 9.5)	2.8 (2.6 – 3.0)
Women (N=2839)	6.5 (5.8 – 7.3)	2.8 (2.6 – 3.0)
Women (18-44 years old) (N=1270)	7.3 (6.1 – 8.4)	2.4 (2.1 – 2.7)
Pregnant women (N=61)	5.0 (1.5 – 8.5)	4.7 (0.5 – 9.4)

Types of Fish Eaten in Last Month
(preliminary 2005)

- Salmon 27%
  - 27% of respondents reported eating salmon in the last month
- Halibut 12%
- Cod 9%
- Tuna 4%
- Sole 2%
- Catfish 2%
- Tilapia 1%
- Snapper 1%

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

David McBride, Washington State Department of Health

Mercury Results

Species	Sample Size	Det. Freq. (%)	Mean (ppb)
Catfish	23	0	8.5
Pollack	24	4	9.1
Salmon	17	94	71
Cod	33	100	114
Tuna – light	55	96	126
Flounder	18	100	147
Halibut	30	100	215
Red snapper	27	96	223
Tuna – white	63	100	357

PCB Results

Species	Sample Size	Det. Freq. (%)	Mean (ppb)
Flounder	19	5	9.6
Cod	33	0	9.8
Pollack	23	0	9.9
Tuna – light	20	5	12.6
Tuna – white	20	0	12.6
Halibut	29	62	14.6
Red snapper	27	74	14.7
Catfish	24	8	15.1
Salmon	17	76	31.5

PBDE Results

Species	Sample Size	Det. Freq. (%)	Mean (ppb)
Pollack	23	0	2.0
Flounder	19	16	2.0
Halibut	29	41	2.1
Red snapper	27	56	2.3
Tuna – light	20	5	2.4
Tuna – white	20	15	2.4
Cod	33	12	2.5
Catfish	24	25	3.3
Salmon	17	88	5.3

Seafood Safe Case Study: Voluntary Seafood Contaminant Testing and Labeling Program

Henry W. Lovejoy, Seafood Safe, LLC; John R. Cosgrove, AXYS Analytical Services, Ltd.;
and Colin Davies, Brooks Rand

Seafood Safe

Case Study:

Voluntary Seafood Contaminant Testing and Labeling Program

EcoFish as First Adopter:

Nationwide Sustainable Seafood Distributor:

- 1,500 grocery stores
- 125 restaurants

Evolution

- Media attention
- Consumer demographics
- Project research

Conflicting & Confusing Messages

seattlepi.com

"Sound's Salmon Carry High PCB Levels: But State Says Health Benefits of Eating the Fish Outweigh Risks"

San Francisco Chronicle

"Mercury Debate Gets Murkier – No Clear Choices on Which Fish are Best"

"Rich Folks Eating Fish Feed on Mercury too – 'Healthy Diet' Clearly Isn't"

The New York Times

"Study Finds Mercury Levels in Fish Exceed U.S. Standards"

"EPA Says Mercury Taints Fish Across United States"

"EPA Raises Estimate of Babies Affected by Mercury Exposure"

Consumers Are Confused

Something Fishy: The Salmon Debate

The Miami Herald
November 4, 2004

"Eat salmon, we're urged. It is rich in omega-3 fatty acids, which help our hearts, cholesterol and blood pressure, fights rheumatoid arthritis, and might even ease depression.

Eat salmon only sparingly, we're warned. The fish, especially when farm-raised — as is 65 percent of the salmon sold in U.S. supermarkets — contains PCBs and other toxins that may cause cancer.

What's a health-conscious consumer to do? Studies and counter-studies, alarms, and assurances, leave the public unsure, anxious."

Business Model

- Autonomous, independent structure
  - Advisory panel
  - Sampling
  - Labs (Axys Analytical, Brooks Rand)
  - Consumer Advocacy Organization (Environmental Defense)
- Precautionary principle
- EcoFish first adopter

Seafood Safe Case Study: Voluntary Seafood Contaminant Testing and Labeling Program

Henry W. Lovejoy, Seafood Safe, LLC; John R. Cosgrove, AXYS Analytical Services, Ltd.;
and Colin Davies, Brooks Rand

Marketing Strategy

- Positive industry message
- Consumer driven
- State agency driven (CA A.G.)
- Media follow through

Future Financial Model

- Industry pays
- Consultation with client
- Customized programs:
  - Species life history, regionality, size range, seasonality, historical data, etc.
- Testing
- Licensing

Future Participation

- Seafood industry (fisheries, processors, distributors, packers)
- Grocery store chains
- Restaurant chains

EcoFish Species Tested

- Wild Alaskan salmon – *Oncorhynchus keta*
- Wild Alaskan halibut – *Hippoglossus stenolepsis*
- Wild Peruvian mahi mahi – *Coryphaena hippurus*
- Wild Oregon/Washington albacore tuna – *Thunnus alalunga*
- Wild California squid – *Loligo opalescens*
- Farmed Chinese bay scallops – *Argopecten irradians*
- Farmed Florida white shrimp – *Penaeus vannamei*

Contaminants Tested

- Mercury
- PCBs
- Additional future contaminants?

Labeling

- How to read
- Guidance derivation
  - U.S. EPA's *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories*
  - U.S. EPA's risk-based consumption tables

Seafood Safe Case Study: Voluntary Seafood Contaminant Testing and Labeling Program

Henry W. Lovejoy, Seafood Safe, LLC; John R. Cosgrove, AXYS Analytical Services, Ltd.;
and Colin Davies, Brooks Rand

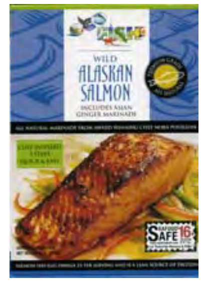
Recommendations

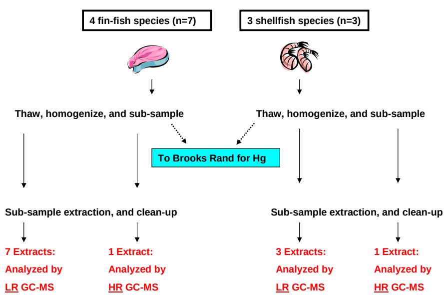
Assumptions

Sub-population	Age	Weight in kg	Weight in lbs
Women of childbearing age	16-45	64	141
Men	18-75	78.1	172
Average adult	18-75	70	154
Young children	0-6	14.5	32
Older children	6-12	30.5	67

Tested Species	Avg. ppm Hg	Hg Servings Women/Month	Avg. ppm PCB/HR	PCB Servings Women/Month	4 oz. Meals Per Month	8 oz. Meals Per Month
Calamari	0.022	77.9	0.002	57.1	16+	16+
Albacore Tuna	0.249	6.9	0.007	13.8	6	3
White Shrimp	0.007	255.9	0.001	71.4	16+	16+
Mahimahi	0.223	7.7	0.000	857.2	7	3.5
Bay Scallops	0.009	194.8	0.000	428.6	16+	16+
Halibut	0.169	10.1	0.001	94.2	10	5
Keta Salmon	0.028	60.4	0.001	57.9	16+	16+

Label in Use





Frozen samples received, homogenized, and sampled at:
AXYS Analytical Services Ltd., Sidney, B.C., Canada

Results: HR vs. LR Comparability

- PCB concentrations presented as sum of individual congeners measured (HR=209; LR=18)
- Detection limit differed by three orders of magnitude between LR and HR (0.1 ng/g versus 0.1 pg/g)
- No congeners reported >0.1 ng/g via HR were absent from the targeted LR analysis
- <0.10 ng/g = '0' for PCB congener summing purposes

Seafood PCB (ng/g, ww) by HR and LR GC-MS

	Total HR PCB (Total of 209 congeners, ng/g)	Range Total LR PCB (Total of 18 congeners ng/g)	Ratio of LR PCBs to Total HR PCBs
Albacore tuna	6.60	4.0 – 7.5	
Mahi mahi	0.10	<0.10 – <0.10	
Halibut	0.91	0.10 – 0.43	
Keta salmon	1.48	<0.10 – 0.95	
Calamari	1.50	0.76 – 0.90	
White shrimp	1.20	0.76 – 0.78	
Scallop	0.20	<0.10 – <0.10	

Seafood PCB (ng/g, ww) by HR and LR GC-MS

	Total HR PCB (Total of 209 congeners, ng/g)	Total LR PCB (Total of 18 congeners ng/g)	Ratio of LR PCBs to Total HR PCBs
Albacore tuna	6.60	4.80	0.72
Mahi mahi	0.10	<0.10 (0)	0
Halibut	0.91	0.43	0.47
Keta salmon	1.48	0. 51	0.34
Calamari	1.50	0.89	0.60
White shrimp	1.20	0.78	0.65
Scallop	0.20	<0.10 (0)	0

Seafood Safe Case Study: Voluntary Seafood Contaminant Testing and Labeling Program

Henry W. Lovejoy, Seafood Safe, LLC; John R. Cosgrove, AXYS Analytical Services, Ltd.;
and Colin Davies, Brooks Rand

Seafood PCB (ng/g, ww) by HR and LR GC-MS

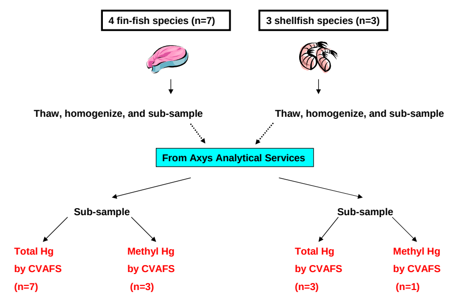
	Total HR PCB (Total of 209 congeners, ng/g)	Range LR PCB (Total of 18 congeners ng/g)	Ratio of LR PCBs to Total HR PCBs
Albacore tuna	6.60	4.0 – 7.5 (4.80)	0.72
Mahi mahi	0.10	nd** (0.00)	0
Halibut	0.91	0.10 – 0.43 (0.43)	0.47
Keta salmon	1.48	nd – 0.95 (0. 51)	0.34
Calamari	1.50	0.76 – 0.90 (0.89)	0.60
White shrimp	1.20	0.76 – 0.78 (0.78)	0.65
Scallop	0.20	nd (0.00)	0

* (bracketed value): LR PCB of paired HR PCB sample

** 'nd': below detection limit (0.1 ng/g) of LR analysis

Conclusions

- Highest [PCB] in albacore tuna; lowest in mahi mahi.
- $[PCB]_{HR} > [PCB]_{LR}$ in all species.
- Ratio of $[PCB]_{HR}$: $[PCB]_{LR}$ was variable and generally increased with increasing total PCB concentrations.
- "Short" LR PCB target list included all congeners > 0.1ng/g by HR.
- HR data provides more reliable Total PCB estimate than LR. (LR estimate may provide a contingency estimate approach for decision purposes, e.g., by doubling total LR values.)



Methodology:Total Hg and Methyl Hg

Total Hg – Appendix to U.S. EPA 1631

- HNO_3/H_2SO_4/BrCl digestion & oxidation
- $SnCl_2$ reduction, purge & gold amalgamation
- Cold Vapor Atomic Fluorescence Spectrometry (CVAFS)

Methyl Hg – U.S. EPA 1630 Modified

- KOH/Methanol digestion
- Ethylation, purge and trap, GC, pyrolysis
- CVAFS

Quality Assurance

Total Hg

- CRM average recovery 101.7%, RSD 7.6% (n=6)
- MS/MSD average recovery 101.5%, RSD 7.8% (n=10)
- MDL 0.07 ng/g

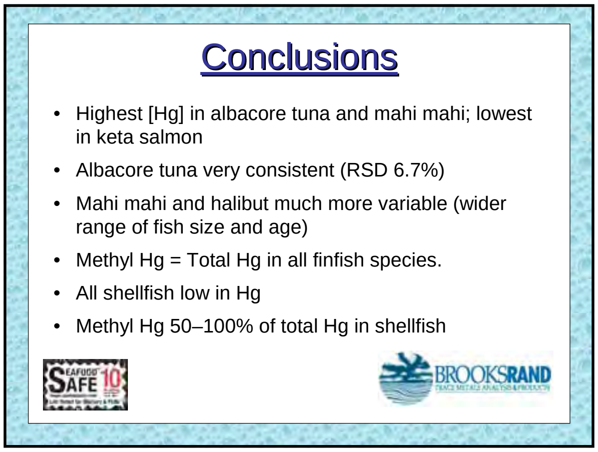
Methyl Hg

- CRM average recovery 111% (n=2)
- MS/MSD average recovery 105% (n=2)
- MDL 1.5 ng/g

Seafood Hg (ng/g, ww) by CVAFS

	Total Hg (ng/g)	Methyl Hg (ng/g)	Mean Ratio of Methyl Hg to Total Hg
Albacore tuna	226-275 (249)	214-258	95.1%
Mahi mahi	98.4-538 (223)	102-595	110.1%
Halibut	82.7-233 (169)	86.3-284	110.9%
Keta salmon	21.2-37.1 (28.4)	20.5-30.0	90.7%
Calamari	21.5-23.7 (22.3)	23.1	97.5%
White shrimp	5.47-11.0 (6.49)	5.67	51.5%
Scallop	8.45-9.35 (8.79)	7.38	78.9%

* (bracketed value) = mean


Conclusions
• Highest [Hg] in albacore tuna and mahi mahi; lowest in keta salmon
• Albacore tuna very consistent (RSD 6.7%)
• Mahi mahi and halibut much more variable (wider range of fish size and age)
• Methyl Hg = Total Hg in all finfish species.
• All shellfish low in Hg
• Methyl Hg 50–100% of total Hg in shellfish
SEAFOOD SAFE 10
BROOKSRAND

Strategy for Assessing and Managing Risks from Chemical Contamination of Fish from National Fish Hatcheries

George Noguchi, Linda L. Andreasen, and David Devault, U.S. Fish and Wildlife Service

Strategy for Assessing and Managing Risks from Chemical Contamination of Fish from National Fish Hatcheries

2005 National Forum on Contaminants in Fish
September 18 – 21
Baltimore, MD

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Global Assessment of Organic Contaminants in Farmed Salmon
Ronald A. Hites,[1*] Jeffery A. Foran,[2] David O. Carpenter,[3] M. Coreen Hamilton,[4] Barbara A. Knuth,[5] Steven J. Schwager[6]

High Levels of PCBs in Farmed Salmon. - *San Francisco Chronicle 30jul03*

EWG Advises Consumers to Choose Wild Not Farmed Salmon. - *EWG 2003*

Farmed salmon not so safe, report says. Toxins higher than EPA recommends in fish from wild
SEATTLE POST-INTELLIGENCER NEWS

Dangerous PCBs Found in Salmon *The Washington Post July 29, 2003*

Farmed Salmon Show High Levels of Cancer-Causing PCBs -- "U.S. Adults Eat Enough PCBs From Farmed Salmon to Exceed Allowable Lifetime Cancer Risk 100 Times Over" - *Prostate Cancer Newsletter*

Study Finds PCBs in Farmed Salmon. *Reuters – WIRED News*

What Is the Fish & Wildlife Service Doing?

- Sampling fish from national fish hatcheries (NFHs)
- Analyzing fish feeds
- Developing a strategy for assessing and managing risks

Hatchery Fish Sampling (2004)

- Screening-level sampling
- 3 FWS regions; 15 facilities overall
- Focus on "catchable size" fish
- Composite samples (5 or 6 fish/composite)
- 7 species

Facilities

Region 1 (Pacific)

Eagle Creek, Entiat, Dworshak, Hagerman, Winthrop, Lahontan (CNO)

Region 5 (Northeast)

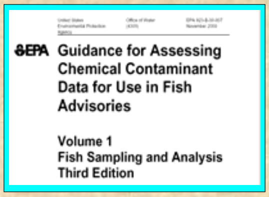
Allegheny, Green Lake, Nashua, White River, White Sulphur

Region 6 (Mountain-Prairie)

Bozeman, Ennis, Jackson, Saratoga

Strategy for Assessing and Managing Risks from Chemical Contamination of Fish from National Fish Hatcheries

George Noguchi, Linda L. Andreasen, and David Devault, U.S. Fish and Wildlife Service



Fisheries & Habitat Conservation 7

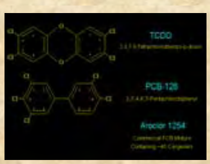
Sampling Summary

	R1	R5	R6	TOTAL
Atlantic salmon		14		*14*
Brook trout		1		*1*
Brown trout			1	*1*
Cutthroat trout	2		1	*3*
Lake trout		4	1	*5*
Rainbow trout	5	4	2	*11*
Steelhead	2			*2*
TOTAL Composites (fish)	9 *(47)*	23 *(144)*	5 *(30)*	*37* *(221)*

Fisheries & Habitat Conservation 8

Chemical Analysis

- PCB, dioxin, and furan congeners
- Dioxin total dioxin equivalents (TEQs)
- Organochlorine pesticides
- Mercury and other metals
- Trace elements



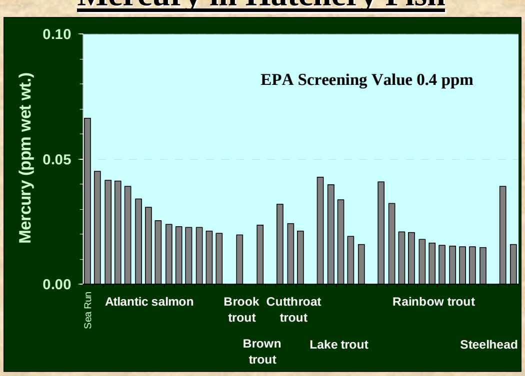
Fisheries & Habitat Conservation 9

Summary of 2004 Hatchery Fish Sampling

- PCBs were the only organic contaminant detected in all fish samples.
- Mercury was also detected in all samples, but concentrations were low.
- Concentrations of PCBs and dioxin TEQs in some samples were above U.S. EPA screening values.

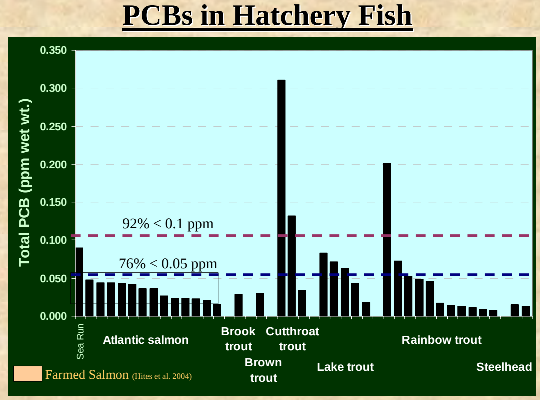
Fisheries & Habitat Conservation 10

Mercury in Hatchery Fish



Fisheries & Habitat Conservation 11

PCBs in Hatchery Fish



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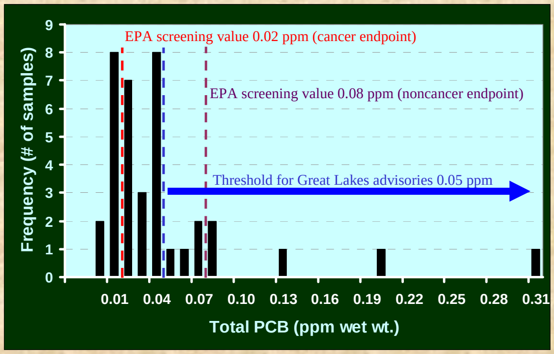
Strategy for Assessing and Managing Risks from Chemical Contamination of Fish from National Fish Hatcheries

George Noguchi, Linda L. Andreasen, and David Devault, U.S. Fish and Wildlife Service

PCBs in Hatchery Fish



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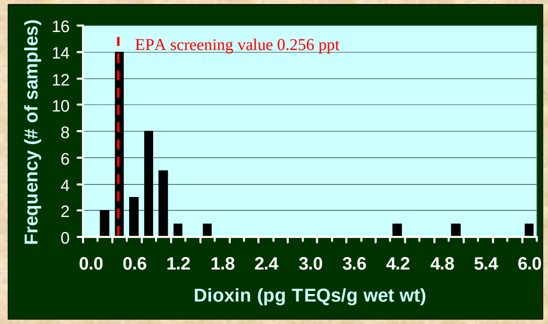
Dioxins (TEQs) in Hatchery Fish



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Analysis of Fish Feed

- Fish Feed Study*: Collaboration between U.S. FWS and USGS
- Analyzed fish feed used at 11 national fish hatcheries
- 6 different feed manufacturers
- Sampled multiple batches of feed from 2001–2003

* A Survey of Chemical Constituents in National Fish Hatchery Fish Food. Alec Maule (USGS), Ann Gannam (U.S. FWS), and Jay Davis (U.S. FWS).

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Chemical Analysis (Fish Feed)

14 PCB Congeners

PCB 77	PCB 118	PCB 157	PCB 180
PCB 81	PCB 123	PCB 167	PCB 189
PCB 105	PCB 126	PCB 169	
PCB 114	PCB 156	PCB 170	

Dioxin and furan congeners
Organochlorine pesticides
Mercury and other metals
Trace elements

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PCBs in Fish Feed (2001–2003)

Sum of 14 PCB Congeners (ppb)

Manufacturer	N	Mean (ppb)	CV
A	**6**	**2.56**	**42%**
B	**7**	**1.32**	**64%**
C	**4**	**1.02**	**56%**
D	**14**	**1.85**	**75%**
E	**12**	**0.41**	**127%**
F	**3**	**9.87**	**5%**

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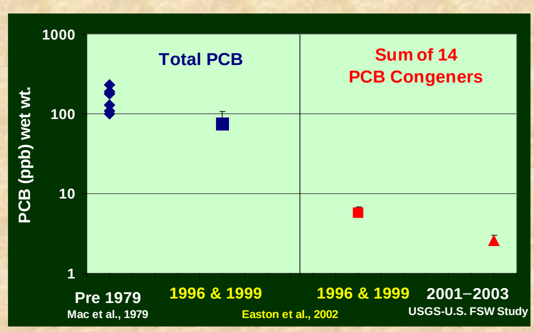
PCBs in Fish Feed (Manufacture A)



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Strategy for Assessing and Managing Risks from Chemical Contamination of Fish from National Fish Hatcheries

George Noguchi, Linda L. Andreasen, and David Devault, U.S. Fish and Wildlife Service

Now What?

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Hatchery Contaminants Workshop

February 2005

Strategy for assessing and managing risks from chemical contamination of fish from national fish hatcheries

1. NFHS "healthy fish" goal
2. Clean feeds
3. Monitoring
4. Guidance

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Strategy

1. NFHS "healthy fish" goal
   - Define "healthy fish" from a chemical contaminants perspective. Identify target concentrations as goals for protecting fish health and human health (i.e., no advisories)
   - Conduct studies to obtain necessary information
   - Work with partners to develop best management practices (e.g., diet, physical plant, facility management) to reach healthy fish goal
2. Clean feeds
   - Work with the aquaculture and feed industries to identify and meet feed contaminant limits for healthy fish production

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Strategy

3. NFHS monitoring
   - Continue monitoring of NFHs at "screening" level
   - Prioritize sampling based on hatchery information (e.g., species, diet, facility age, potential sources of contamination) *hatchery matrix*
   - Develop long-term monitoring plan
4. National policy
   - Develop interim and long-term guidance for making management decisions regarding transfer or stocking of hatchery fish to states and tribes, stocking on federal lands, and NFHS fishing events

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Interim Guidelines for Hatchery Fish Management Decisions Regarding Contaminants in Catchable-Size Fish Produced by the National Fish Hatchery System

When contaminant data are available for fish from the NFH:

- **If contaminant levels are below those that trigger "do not eat" state fish consumption advisory** – Provide contaminant information to state, tribe, or federal land management agency and provide fish if requested.
- **If contaminant levels are at or above levels that trigger "do not eat" state fish consumption advisory** – Fish should not be transferred or stocked.

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Interim Guidelines for Hatchery Fish Management Decisions Regarding Contaminants in Catchable-Size Fish Produced by the National Fish Hatchery System

When the NFH has not yet been sampled and no contaminant data are available:

- Make fish available unless the facility is considered potentially high risk according to the Hatchery Risk Assessment Matrix.
- High-risk facilities: consult with states, tribes, and federal land management agencies, as appropriate, to discuss potential risks. Applies to all activities (e.g., stocking/transfer to states, tribes, and federal lands; fishing events at NFHs).

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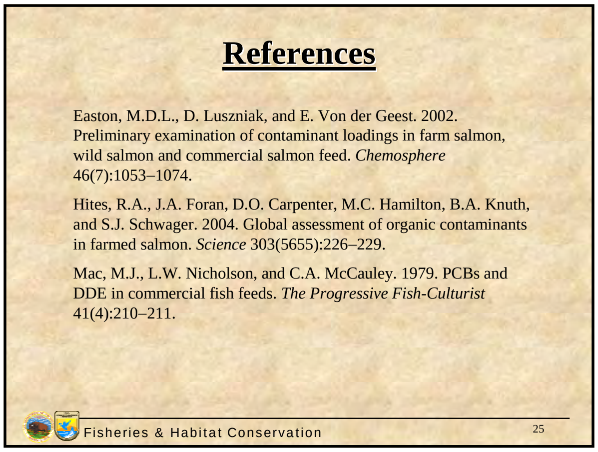
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Easton, M.D.L., D. Luszniak, and E. Von der Geest. 2002. Preliminary examination of contaminant loadings in farm salmon, wild salmon and commercial salmon feed. *Chemosphere* 46(7):1053–1074.
Hites, R.A., J.A. Foran, D.O. Carpenter, M.C. Hamilton, B.A. Knuth, and S.J. Schwager. 2004. Global assessment of organic contaminants in farmed salmon. *Science* 303(5655):226–229.
Mac, M.J., L.W. Nicholson, and C.A. McCauley. 1979. PCBs and DDE in commercial fish feeds. *The Progressive Fish-Culturist* 41(4):210–211.
Fisheries & Habitat Conservation
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Variability of Mercury Concentrations in Fish with Season, Year, and Body Condition

Paul Cocca, U.S. Environmental Protection Agency

Variability of Mercury Concentrations in Fish with Season, Year, and Body Condition

A Synthesis of the Literature
and Considerations for Advisory Programs

2005 National Forum on Contaminants in Fish
September 18–21, 2005
Baltimore Marriott Inner Harbor, Baltimore MD

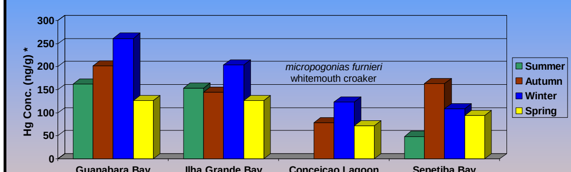
Paul Cocca
Office of Science and Technology
Office of Water
U.S. EPA

Overview

- Seasonal and interannual variability of fish mercury concentrations is significant
- Caused primarily by fluctuations in fish growth and nutrition
- Ideas for advisory programs to consider

Measured Seasonality in Fish Hg

- Whitemouth croaker in Brazilian estuaries (Kehrig et al., 1998)



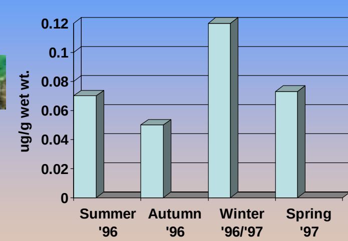
* All concentrations normalized to 700 g fish, wet wt.

- Explanatory hypotheses:
  - Concentrations increase when fish lose weight
  - Spring bioproduction dilutes the available mercury.

Measured Seasonality in Fish Hg

- Perch in the southern Baltic Sea (Szefer et al., 2003)
  - *Concentrations not normalized*

Perca fluviatilis
European Perch

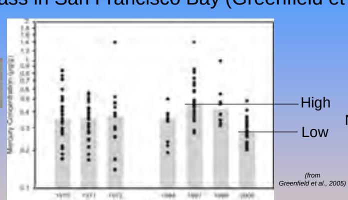


- Seasonal differences supported through factor analysis

Measured Interannual Variability in Fish Hg

- Striped bass in San Francisco Bay (Greenfield et al., 2005)

Morone Saxatilis
Striped Bass

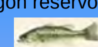


Note: *Vertical axis is log scale*

- 1997 statistically different from other years
- Explanatory hypotheses (Greenfield et al., 2005):
  - Higher Hg bioavailability from 1997 flood event
  - Different populations exposed to different MeHg concentrations
  - Variability in movement patterns or diets.

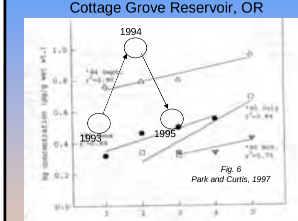
Measured Interannual Variability in Fish Hg

- Largemouth bass in Oregon reservoirs (Park and Curtis, 1997)

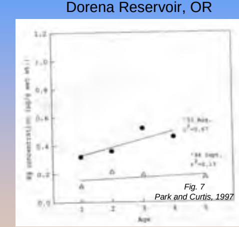


Micropterus salmonides
Largemouth Bass

Cottage Grove Reservoir, OR



Dorena Reservoir, OR



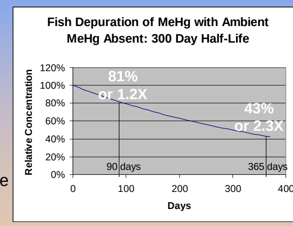
- Explanatory hypotheses
  - Environmental conditions influence MeHg production, bioavailability
  - Concentration decreases caused by *growth dilution.*

Measured Interannual Variability in Fish Hg

- Yellow perch yearlings in 16 Ontario lakes, *whole fish, unadjusted* (Suns and Hitchin, 1990)
- Monitored over 10-year period, ~7 sampling events per lake
- ***High concentration : Low concentration*** ratio ranges from 1.5 to 2.2 for most lakes

A Partial Cause: Depuration Loss During Reduced Hg Bioavailability

- Were depuration fast, fish MeHg would mirror ambient levels
- Instead MeHg depuration is slow, which dampens variability
- Fish MeHg depuration half-lives (Huckabee et al.,1979)
  - Northern pike: 100 days
  - Bullheads: 178 – 277 days
  - Ling: 433 – 707 days
  - Rainbow trout: 1,000 days
- ***Central tendency: 300 days***
- Depuration may account for some literature-reported variability.



More Important: Variable Fish Nutrition

- Fish Hg levels decrease during ***Growth Dilution***
  - Negative correlation with growth rate (r^2 = 0.92) (Simoneau et al., 2005)
  - Higher concentrations in dwarf fish than in normal fish (Doyon et al., 1998)
  - Faster growth reflects efficiency; flesh added with proportionally less food and mercury intake (Greenfield et al., 2001)
- Fish Hg levels increase during ***Starvation Concentration***
  - Higher concentrations in skinny fish than in robust fish (Hinners, 2004; Cizdziel et al., 2002, 2003)
  - Starved, non-starved lose MeHg same rate (Burrows and Krenkel, 1973)
  - Starving fish can lose muscle quicker than mercury.

Fish Body Condition

- How to quantify fish body condition
  - *Condition Factor*, K (Williams, 2000)
  - W/L^3 x 100; where
    - W is weight (g)
    - L is the standard length (cm)
    - Results in an index value close to 1
  - Online calculator: http://www.hac.org.nz/cf.htm

Brown trout, **K Factor: 0.78**

Brown trout, **K Factor: 1.66**
from: Barnham & Baxter 1998

- What the *condition factor* measures:
  - Relative robustness, degree of well-being, nutritional status
  - Reflects both seasonal and longer-term nutritional trends
  - Potentials for growth dilution **and** starvation concentration.

Measured Variability with Fish Body Condition

- Fish Hg negatively correlates with condition factor
  - Striped bass (r^2 = 0.79) (Hinners, 2004; Cizdziel et al., 2003)
  - Yellow perch yearlings (r^2 = 0.66) (Suns and Hitchin, 1990)
    - *whole fish composites*
  - Yellow perch (r^2 = .35) (Greenfield et al., 2001)
    - *whole fish*

Body Condition: Cause or Effect?

- ***Body Condition Affects Hg Levels***
  - Condition varies by factor 1.4 – 1.7 (Lizama et al., 2002)
- ***Hg Levels Affect Body Condition***
  - Less protein synthesis enzymes at higher Hg levels (Nicholls et al., 1987; Suns and Hitchin, 1990)

Variability of Mercury Concentrations in Fish with Season, Year, and Body Condition

Paul Cocca, U.S. Environmental Protection Agency

Summary of the Literature

- Seasonal and interannual variability is significant
  - High concentration : Low concentration = 1.5 to 2.0
  - Higher concentrations in colder months
  - Higher concentrations in skinnier fish
- Mercury depuration is too slow to explain all variability
- Variable body condition affects fish mercury
  - *Growth dilution*
  - *Starvation concentration*

Considerations for Advisory Programs

Monitoring Design and Data Analysis

- Measure weight as well as length => condition factor
- Measure age as well as length => growth rate
- Correlations: length, weight, age, growth rate, condition
- Regressions on a sampling event basis
- Always sample the same season
- Conversely, sample all seasons and
  - Normalize concentrations to a standard season
  - Develop seasonality safety factors.
- Sample enough to estimate long-term means and variances

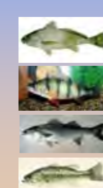
Considerations for Advisory Programs

Advisory messages, etc.

- Include seasons in advisories (e.g., “special note to ice fishers”)
- Include condition in advisories (e.g., “skinny bad, fat good”)
- Use condition factor as an inexpensive Hg index
- Promote fisheries health to reduce human exposure

Acknowledgments

- Tom Hinners, U.S. EPA, Las Vegas
- Ben Greenfield and Larry Curtis for permission to use figures from cited works
- Fish pictures from http://www.fishbase.org



References

- Barnham, C., and A. Baxter, 1998. Condition Factor, K, for Salmonid Fish. Fisheries Notes, State of Victoria, Department of Primary Industries. ISSN 1440-2254.
- Burrows, W.D., and P.A. Krenkel, 1973. Studies on uptake and loss of methylmercury-203 by bluegills (*Lepomis marcochirus* Raf.). *ES&T* 7(13):1127-1130.
- Cizdziel, J.V., T.A. Hinners, J.E. Pollard, E.M. Heithmar, and C.L. Cross, 2002. Mercury concentrations in fish from Lake Mead, USA, related to fish size, condition, trophic level, location, and consumption risk. *Arch. Environ. Contam. Toxicol*. 43: 309-317.
- Cizdziel, J.V., T.A. Hinners, C.L. Cross, and J.E. Pollard, 2003. Distribution of mercury in the tissues of five species of freshwater fish from Lake Mead, USA. *J. Environ. Monit.* 5:802-807.
- Doyon, J.F., R. Schentagne, and R. Verdon, 1998. Different mercury bioaccumulation rates between sympatric populations of dwarf and normal lake whitefish (*Coregonus clupeaformis*) in the La Grande complex watershed, James Bay, Quebec. *Biogeochemistry* 40:203-216.
- Foster E.P., D.L. Drake, and G. DiDomenico, 2000. Seasonal changes and tissue distribution of mercury in largemouth bass (*Micropterus salmoides*) from Dorena Reservoir, Oregon. *Contamination and Toxicology* 38(1):78-82.

References

- Fulton, T., 1902. Rate of growth of seas fishes. *Sci. Invest. Fish, Div. Scot. Reprt*, 20.
- Giblin and Massaro, 1973. Pharmacodynamics of methylmercury in the rainbow trout (Salmo gairdneri): Tissue uptake, distribution and excretion. *Toxicology and Applied Pharmacology* 24(1):81-91.
- Greenfield, B.K., T.R. Hrabik, C.J. Harvey, and S.R. Carpenter, 2001. Predicting mercury levels in yellow perch: use of water chemistry, trophic ecology, and spatial traits. *Can. J. Fish. Aquat. Sci*. 58:1419-1429.
- Greenfield, B.K., J.A. Davis, R.Fairey, C. Roberts, D. Crane, and G. Ichikawa, 2005. Seasonal, interannual, and long-term variation in sport fish contamination, San Francisco Bay. *Science of the Total Environment* 336:25-43.
- Hinners, T.A., 2004. Possible ramifications of higher mercury concentrations in fillet tissue of skinnier fish. National Forum on Contaminants in Fish, San Diego, California, January 25-28.
- Huckabee, J.W., J.W. Elwood, and S.G. Hildebrand, 1979. Accumulation of mercury in freshwater biota. The biogeochemistry of mercury in the environment. Edited by Nriagu. Elsevier/North-Holland Biomedical Press.

References

- Kehrig, H.A., O. Malm, and I. Moreira Kehrig, 1998. Mercury in a widely consumed fish Micropogonias furnieri (Demarest, 1823) from four main Brazilian estuaries. *Science of the Total Environment* 213(1-3):263-71.
- Lizama, M., A.P. Delos, and A.M. Ambrosio, 2002. Condition factor in nine species of fish of the Characidae family in the upper Paraná River floodplain, Brazil. *Braz. J. Biol.* 62(1):113-124.
- McKim, J.M., G.F. Olson, G.W. Holcombe, and E.P. Hunt, 1976. Long-tem effects of methylmercuric chloride on three generations of brook trout (*Salvelinus fontinalis*): toxicity, accumulation, distribution, and elimination. *J. Fish. Res. Board Can.* 33: 2726-2739.
- Nicholls, A., and Teichert-Kuliszewski, 1987. Effects on the Tissue of Young Fish and Rats of Exposure to Lead, Cadmium and Mercury, Report to the Ontario Ministry of the Environment.
- Park, J.-G., and L. R. Curis, 1997. Mercury distribution in sediments and bioaccumulation by fish in two Oregon reservoirs: point-source and nonpoint-source impacted systems. *Arch. Environ. Contam. Toxicol*. 33:423-429.
- Rodgers, D.W., and F.W.H. Beamish, 1982. Dynamics of dietary methylmercury in rainbow trout, *Salmo gairdneri*. *Aquatic toxicology* 2:271-290.

References

- Simoneau, M., M. Lucotte, S. Garceau, and D. Laliberte, 2004. Fish growth rates modulate mercury concentrations in walleye (Sander vitreus) from eastern Canadian lakes. *Environmental Research* 98:73-82.
- Suns, K., and G. Hitchin, 1990. Interrelationships between mercury levels in yearling yellow perch, fish condition and water quality. *Water Air Soil Pollut*. 650:255-265.
- Szefer, P., M. Domaga-a-Wieloszewska, J. Warzocha, A. Garbacik-Weso-owska, and T. Ciesielski, 2003. Distribution and relationships of mercury, lead, cadmium, copper and zinc in perch (*Perca fluviatilis*) from the Pomeranian Bay and Szczecin Lagoon, southern Baltic. *Food Chemistry* 81(1):73-83.
- Williams, J.E., 2000. The coefficient of condition of fish. In *Manual of Fisheries Survey Methods II*. Edited by James C. Schneider. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor. Available at http://www.michigandnr.com/PUBLICATIONS/PDFS/ifr/manual/SMII%20Chapter13.pdf.

Establishing Baseline Mercury Fish Tissue Concentrations for Regulatory Analysis

Janet F. Cakir, Office of Air and Radiation, U.S. Environmental Protection Agency

Establishing Baseline Mercury Fish Tissue Concentrations for Regulatory Analysis

Application and Evaluation of the National Descriptive Model of Mercury and Fish (NDMMF) for the Clean Air Mercury Rule

Overview of the Benefit Methodology

- Step 1: Establish baseline fish tissue concentrations in freshwater fish.
- Step 2: Model reductions in methylmercury fish tissue concentrations resulting from decreased Hg deposition.
- Step 3: Conduct population-level exposure modeling.
- Step 4: Link reductions in population-level exposure to health impacts and valuation.

Step 1: Estimate Typical MeHg Concentrations in Fish

- Goal:

  Reliable estimates of Hg concentrations to establish a "baseline" from which to predict concentration changes after proposed new regulation implementations.

Available Data – National Listing of Fish Advisories (NLFA)

- NLFA database contains several key pieces of information:
  - Hg sampled from aquatic life
  - Species
  - Location (extensive additional geocoding in 2002)
  - Date
  - Size of fish (length and weight).

Locations of NLFA Samples

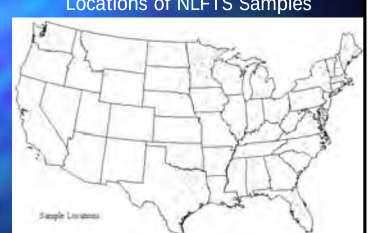
Advantages/Disadvantages of National Listing of Fish and Wildlife Advisories (NLFWA) Database

- Advantages:
  - Larger number of samples than any other single source.
- Disadvantages:
  - Waterbody to waterbody variability is confounded by a variety of factors:
    - More than 400 different species sampled, ranging in size from 1 inch to 1,700 inches (~141 ft.).
    - Several different sample methods employed by surveyors (fillet, whole, fillet skin on, etc.).
    - Samples range in date from 1967 to 2002.
    - Many samples are from fish that are not typically consumed (~12,000 samples from trophic level 1 or 2 species).

Available Data – National Lake Fish Tissue Study (NLFTS)

- NLFTS database contains several key pieces of information:
  - Hg sampled from aquatic life
  - Species
  - Location (extensive additional geocoding in 2002)
  - Date
  - Size of fish (length and weight).

Locations of NLFTS Samples



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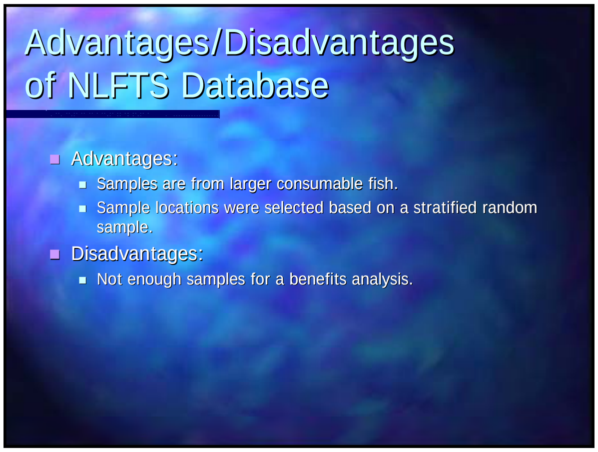

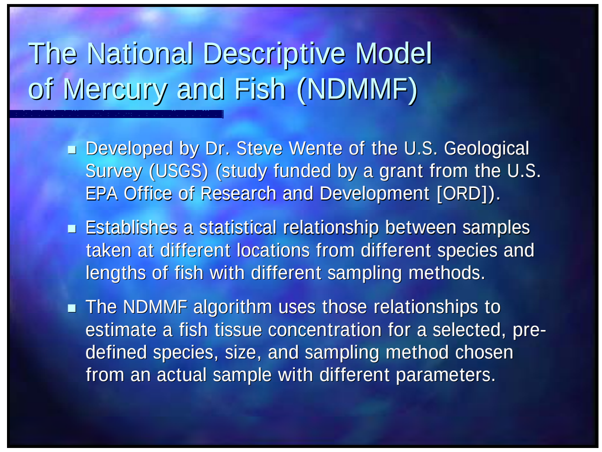

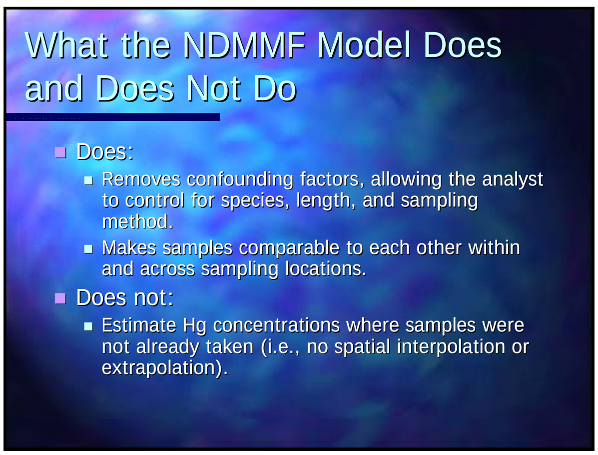

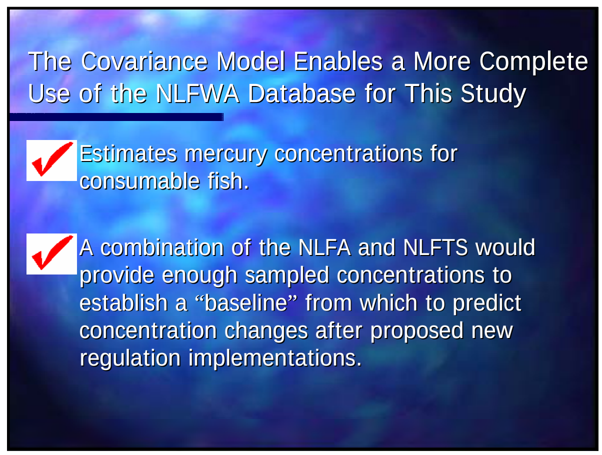

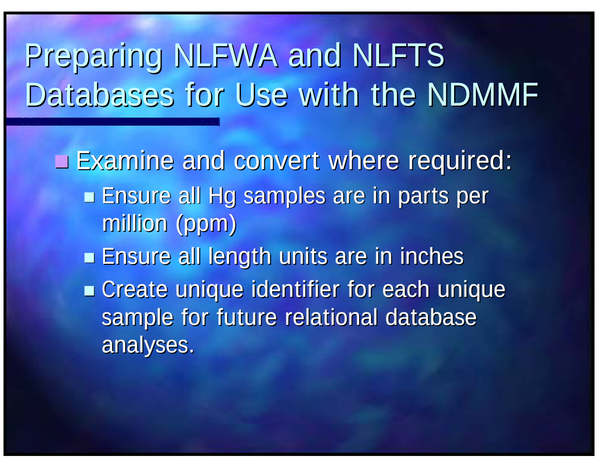

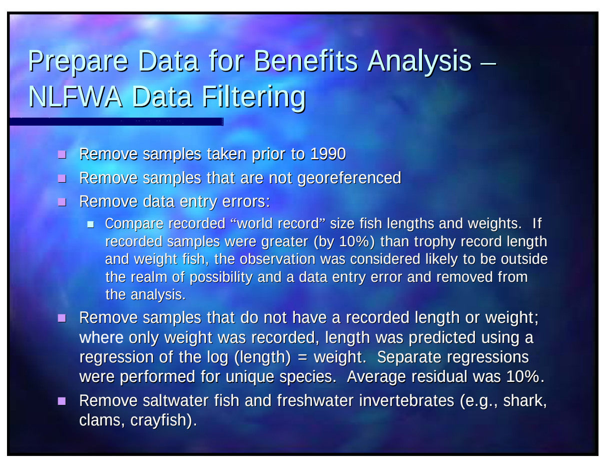

Establishing Baseline Mercury Fish Tissue Concentrations for Regulatory Analysis

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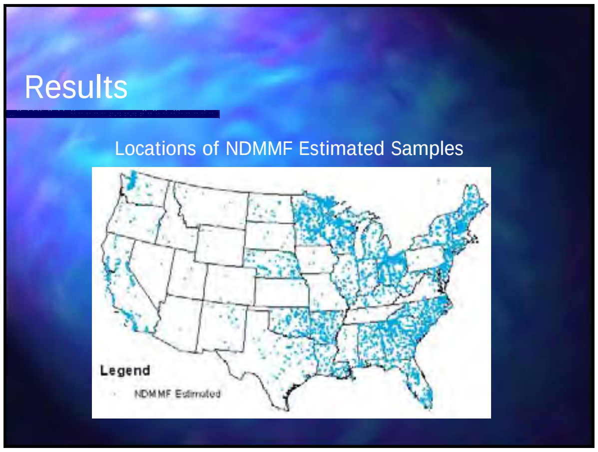
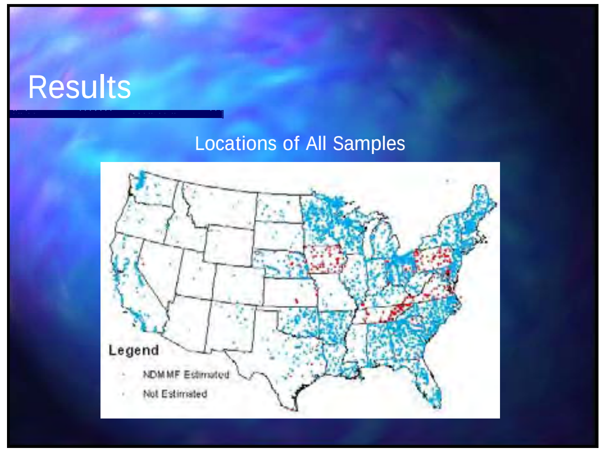
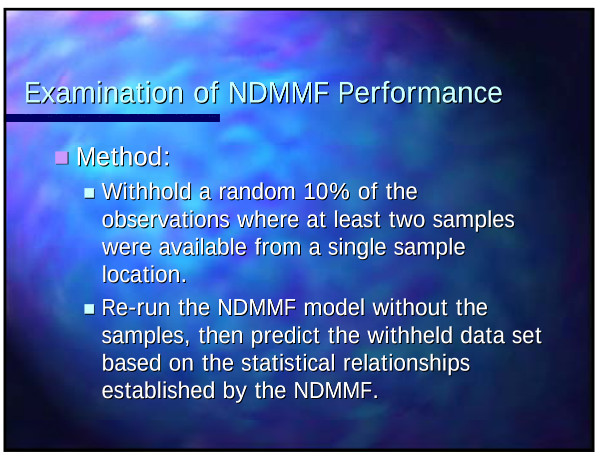
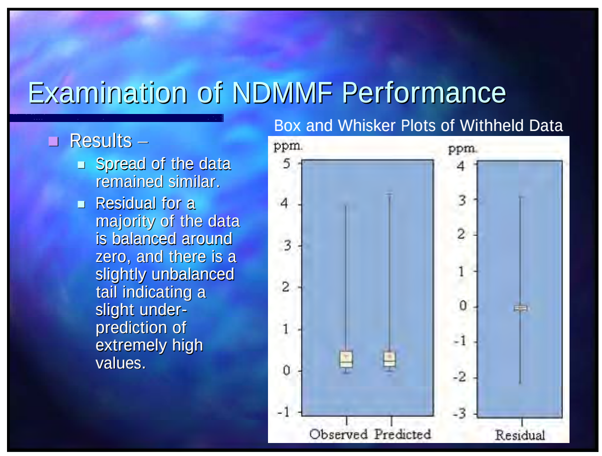
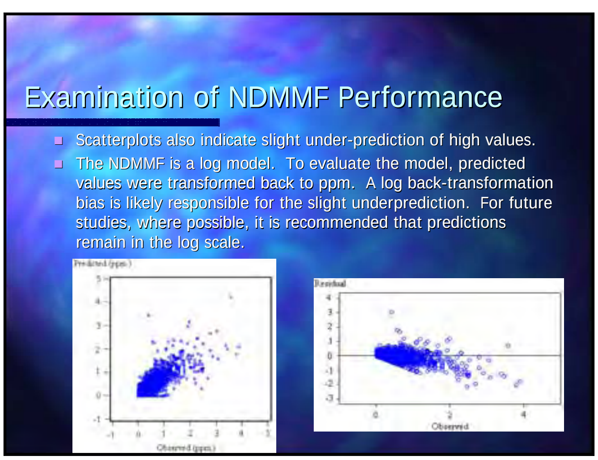
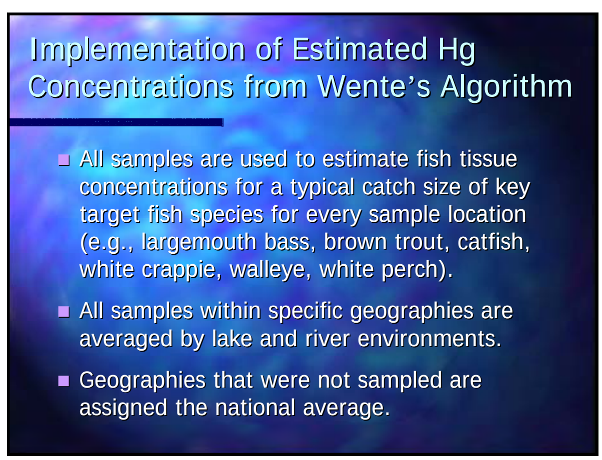


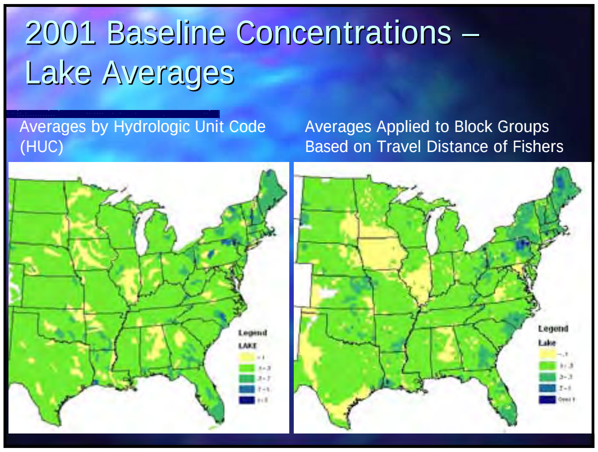






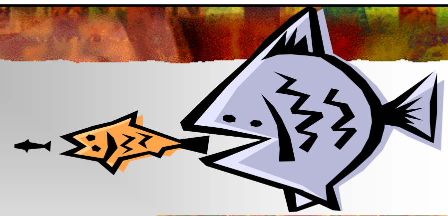





2001 Baseline Concentrations –
Lake Averages
Averages by Hydrologic Unit Code (HUC)
Averages Applied to Block Groups Based on Travel Distance of Fishers
Legend
LAKE
Legend
Lake

Projected Mercury Concentrations in Freshwater Fish and Changes in Exposure Resulting from the Clean Air Mercury Rule

Lisa Conner, U.S. Environmental Protection Agency



Projected Mercury Concentrations in Freshwater Fish and Changes in Exposure Resulting from the Clean Air Mercury Rule

2005 National Forum on Contaminants in Fish
Presented by: Lisa Conner, OAR/OAQPS
August 19, 2005

Overview

- Present methodologies used to estimate reductions in fish tissue concentrations resulting from the Clean Air Mercury Rule (CAMR)
  - Overview of CAMR rule
  - Scope of U.S. EPA's Benefit Analysis
  - Data on mercury concentrations in fish
  - Modeling changes in fish tissue and human exposure to mercury
  - Results
    - Fish tissue concentrations before CAMR
    - Fish tissue concentrations after implementation of the Clean Air Interstate Rule (CAIR) and CAMR
    - Maximum potential reduction due to utility emissions

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The Clean Air Mercury Rule

- Controls mercury emissions from utility sources (primarily coal-fired power plants) and other U.S. sources
- Two-stage emissions trading program evaluated in 2020
- Modeling impacts requires the integration of several models:
  - Integrated Planning Model (IPM) model provides estimates of change in emissions from utilities for alternative regulatory scenarios
  - Community Multi-Scale Air Quality (CMAQ) model estimates changes in air quality and mercury deposition from the air

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The Clean Air Mercury Rule

- Modeling impacts requires the integration of several models:
  - Mercury maps approach assumes that for a unit change in mercury deposition (e.g. 1% decrease), freshwater fish tissue will change proportionally (e.g. 1% decrease) when the ecosystem is in equilibrium
  - Benefits modeling assesses changes in fish tissue and improvements in human health
    - Focus of analysis is on freshwater fish due to data availability for a quantitative analysis; air quality changes occur primarily over freshwater sources, and mercury maps approach only applies to freshwater fish.

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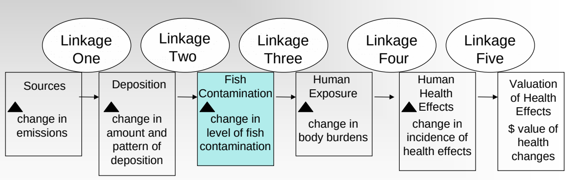
Framework for Assessing Benefits of Reduced Mercury Emissions



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Scope of Analysis

- Several factors were considered to determine the best approach to evaluate the impacts of CAMR on fish tissue:
  - Data on fish tissue concentrations
    - The NLFWA and NLFTS provide the most expansive set of fish tissue samples
    - Samples are primarily taken from freshwater sources in the eastern half of the United States (Texas to East Coast)

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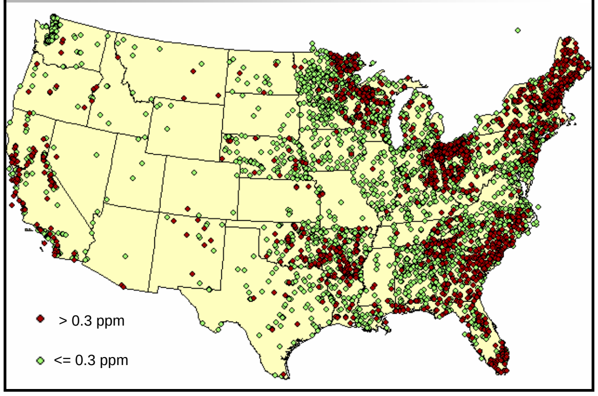
Raw Data of Fish Tissue Samples from the NLFWA and NLFTS



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  - Mercury deposition from utility sources occurs primarily in the eastern half of the United States (Texas to East Coast)

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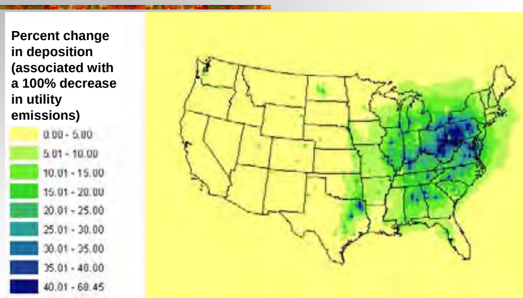
Mercury Deposition Attributable to Utility Emissions



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Scope of Analysis

- Several factors were considered to determine the best approach to evaluate the impacts of CAMR on fish tissue:
  - Data on fish tissue concentrations
    - The NLFWA and NLFTS provide the most expansive set of fish tissue samples
    - Samples are primarily taken from freshwater sources in the eastern half of the United States (Texas to East Coast)
  - Mercury deposition from utility sources occurs primarily in the eastern half of the United States (Texas to East Coast)
  - Most of the change in mercury deposition will occur over freshwater sources in the eastern half of the United States
    - Impacts on saltwater fish were considered by U.S. EPA in a qualitative manner

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Modeling Exposure to Mercury

- Assessing the amount of fish consumed and populations exposed to Hg for
  - Women of childbearing age (WCBA)
  - Native Americans
  - Southeast Asian Americans
  - Subsistence fishers
- Two approaches considered:
  - Population centroid approach
  - Angler destination approach

The selected method influences the aggregation approach of fish tissue concentrations used in our analysis

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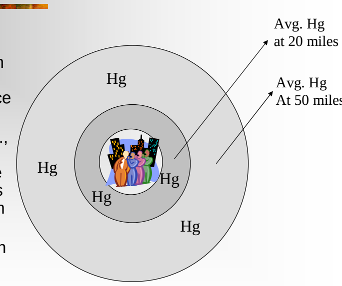
Population Centroid Approach

- Basis: Distance traveled for recreational fishing
- National Survey of Recreation and the Environment (NSRE, 1994) provide data on distance traveled
- For each ring of distance (e.g., 10, 20, 50, 100) around a population (census block), we estimate exposed populations and the concentration of Hg in fish
  - Average of normalized fish tissue across six species estimated for each travel distance ring



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Projected Mercury Concentrations in Freshwater Fish and Changes in Exposure Resulting from the Clean Air Mercury Rule

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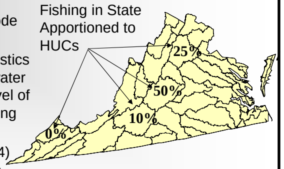
Angler Destination Approach

- Basis: Defines where people are most likely to fish
- The amount of fishing at a specific location is based on watershed characteristics
  - Geographic unit is Hydrological Unit Code (HUC)
  - A regression correlates HUC characteristics (e.g., size of HUC, miles of stream or water perimeter, population density) to the level of use (how often it is selected as the fishing destination)
  - Data obtained from NSRE (NSRE, 1994)
- Avg. Hg concentration of fish in each HUC is used to determine exposure
  - Average of normalized fish tissue concentrations across 6 species for each HUC



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Mercury Concentrations in Freshwater Fish Applied to Exposure Models

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Mercury Concentrations in Freshwater Fish

- Analyses conducted using a simple average of the NLFWA and NLFTS data were not able to identify whether differences in mercury concentrations among the samples were due to location (and possibly air deposition), fish species, size, or sampling method (e.g., filet, whole, filet skin on, composite)
- Normalization of data using USGS model – National Descriptive Model of Mercury in Fish Tissue (NDMMFT) – allows for direct comparison by location
  - Controls for differences in species, size, and sampling method
  - Allows for evaluation of difference in fish concentration due to location
  - Example: All NLFA samples can be scaled to a standardized 14-in bass for a specific location
- Dr. Steve Wente, USGS, presented the NDMMFT methodology at last year's Fish Forum
- Dr. Janet Cakir presented U.S. EPA's use of their model in the prior session today

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Predicted Freshwater Fish Tissue Concentrations

- NDMMFT model runs are conducted for six key consumable fish species (most often fished)
  - Bass, trout, perch, crappie, catfish, walleye
  - Model uses all NLFA and NFTS samples for each run
- Estimates are combined into one average "fish" by location
  - Population-centroid approach
  - Angler-destination approach
  - Table shows average for eastern half of the United States
- Simple average of the raw data is used in states for which the NLFWA does not contain a record of the size of the sample fish (TN, IA, OH, KS, VA, WV,MO, PA)

	Average Hg for Study Area* (ppm)
Bass	0.32
Walleye	0.41
Trout	0.11
Catfish	0.22
Crappie	0.14
Perch	0.26
Overall Average	0.24

* Average value represents the overall average concentration for the eastern half of the United States (Texas to East Coast).

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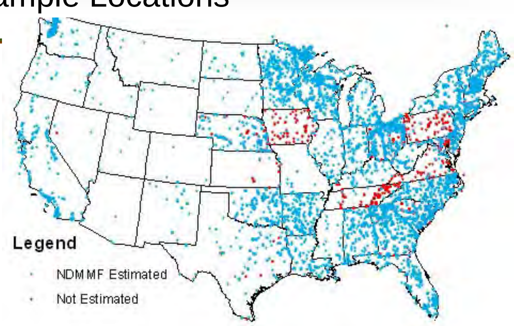
NDMMF Estimated and Raw Data Sample Locations



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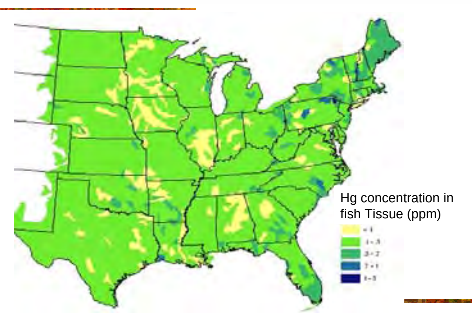
Baseline Scenario: Average Estimated Fish Tissue Concentration by HUC Prior to CAMR in 2001



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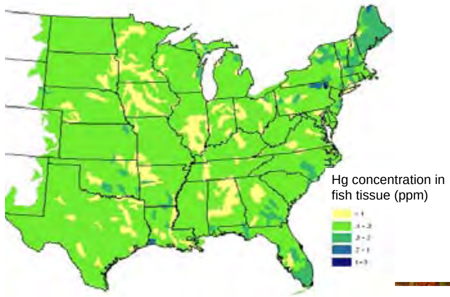
Post-Reg Scenario: Average Estimated Fish Tissue Concentration by HUC after CAMR in 2020



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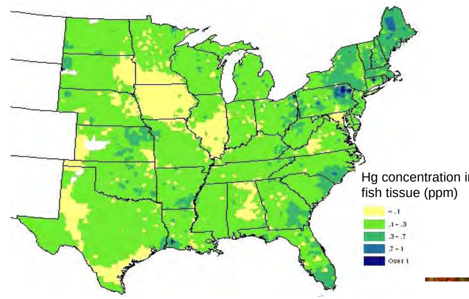
Baseline Scenario: Average Estimated Fish Tissue Concentration by Population Centroid Prior to CAMR in 2001



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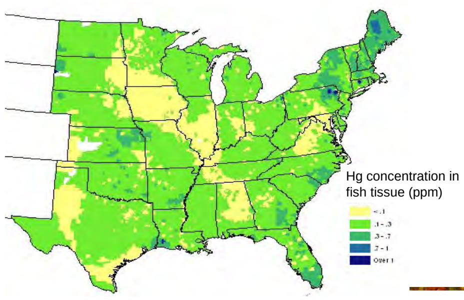
Post-Reg Scenario: Average Estimated Fish Tissue Concentration by Population Centroid after CAMR in 2020



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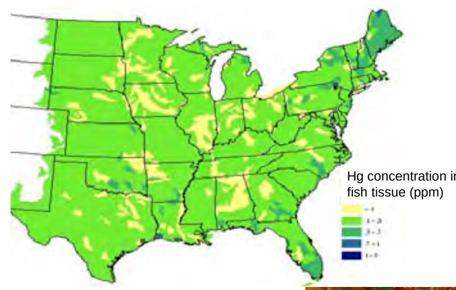
Maximum Potential Reduction from Utilities: Average Estimated Fish Tissue Concentration by HUC in 2020



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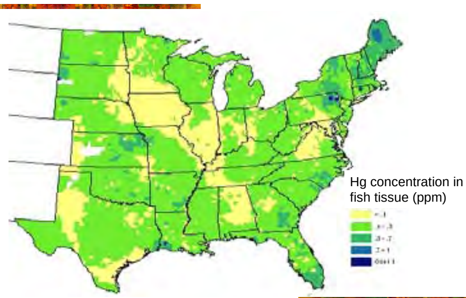
Maximum Potential Reduction from Utilities: Average Estimated Fish Tissue Concentration by Population Centroid in 2020



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Changes in Exposure Resulting from CAMR

Change in exposure resulting from CAMR in 2020 (relative to a 2001 baseline, including CAIR benefits)

	Total avoided IQ decrements*	Total monetized benefits**
Angler-destination approach	124,020 – 143,960	$38.4 – $46.8 million
Population-centroid approach	76,470 – 91,770	$22.2 – $27.4 million

* Estimates of total avoided IQ decrements are rounded to the nearest 10.
** Monetized benefits are rounded to the nearest thousands and do not reflect the potential for a threshold in IQ effects at the RfD.
Source: Regulatory Impact Analysis of the Final CAMR; Tables 10-19,21, 27, 29. (U.S. EPA 452/R-05-003), March 2005.

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More Information

- Regulatory Impact Analysis of the Final CAMR
  - Available at: http://www.epa.gov/ttn/ecas/regdata/RIAs/ mercury_ria_final.pdf
- Acknowledgments:
  - OAQPS Team: Janet Cakir, Zach Pekar, Bryan Hubbell
  - Contractor Support: Research Triangle Institute

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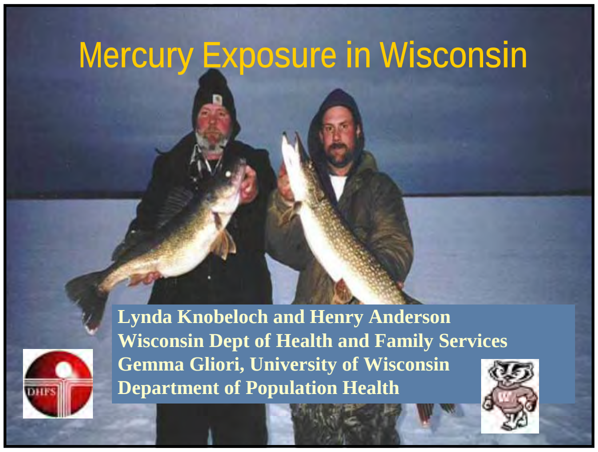
Mercury Exposure in Wisconsin

Lynda M. Knobeloch, Wisconsin Department of Health and Family Services



Study Methods & Funding

- 4,206 BRFSS participants were asked about fish consumption and advisory awareness
- 2,000 adult hair donors completed fish consumption/advisory awareness questionnaires
- Funding
  - $160,000 from the WI Dept of Administration's Focus on Energy Program
  - $38,000 from a CDC Environmental Public Health Tracking Grant

Research Questions

- How much fish are people eating?
- What types of fish are they eating?
- How much mercury are Wisconsin residents being exposed to?
- How much mercury are men being exposed to?

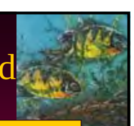
Demographics of Study Populations

Characteristic	BRFSS N = 4,206	Hair Donors N = 2,028	Different?
Income above $50,000/yr	35%	53%	✓
Male gender	49%	48%	NO
Average age in years	49.2	49.4	NO
White race	90%	95%	✓
College graduates	30%	59%	✓
Fishing license in home	37%	50%	✓
% who eat fish	83%	95%	✓
Had heard about Hg in fish	78%	94%	✓

Fish Intake & Mercury Hair Levels

	N	Ave # meals/month	Mean Hg ppm	% > 1 ppm
Men	978	7.7	0.93	29%
Women	1,050	7.7	0.52	13%
Fish consumers	1,928	8.1	0.75	21%
Non-consumers	100	0.0	0.09	0%
Fishing license holders	1,043	8.2	0.87	27%
Non-license holders	983	7.1	0.57	14%
White (1,936)	1,933	7.6	0.73	20%
Other races (95)	95	9.2	0.65	21%
All participants	2,028	7.7	0.73	20%

Types of Fish Consumed

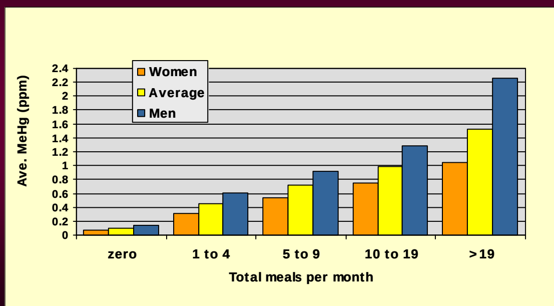


Types of fish reported eaten	
Light tuna	11%
Albacore tuna	12%
Restaurant servings	25%
Commercial fish cooked at home	28%
Sport-caught fish	17%
Total number of meals reported	15,635

Mercury Exposure in Wisconsin

Lynda M. Knobeloch, Wisconsin Department of Health and Family Services

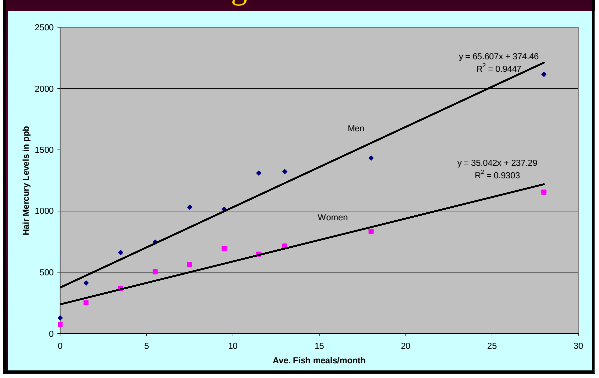
Mercury Levels vs. Fish Consumption by Gender



Correlation of Fish Intake and Hair Hg Level

# Meals/month	Ave Hg Level in ppm	No (%) > 1 ppm
0	0.09	0/97 = 0%
1-4	0.46	63/570 = 11%
5-8	0.71	140/717 = 18%
>8	1.00	222/703 = 32%

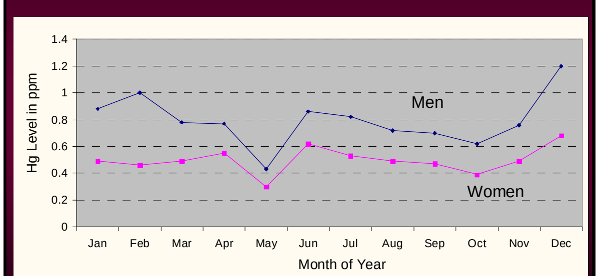
Average Hair Mercury Levels vs. Average Meals/Month



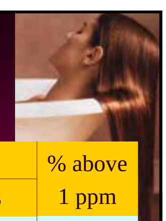
Hair Mercury by Gender and Age

		Hg Level in ppm		
Age group	**N**	**Mean**	**Median, Max**	**> 1 ppm**
Women				
<46 yrs.	**413**	**0.465**	**0.284, 3.8**	**11.8%**
>45 yrs.	**637**	**0.568**	**0.382, 5.3**	**13.3%**
Men				
<46 yrs.	**310**	**0.674**	**0.398, 5.4**	**18.7%**
>45 yrs.	**670**	**1.030**	**0.637, 15.2**	**32.9%**

Hair Mercury Levels vs. Month of Collection



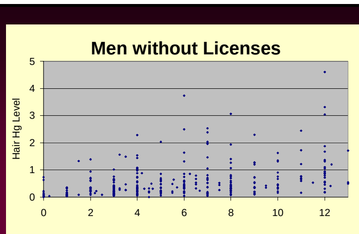
Median Hair Hg Level among Women of Childbearing Age NHANES, 12-State, WI 2004

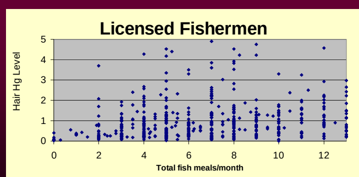


	# Meals/month			% above 1 ppm
	0	1 to 2	≥ 3	
NHANES N = 1,726	0.11 ppm	0.20 ppm	0.38 ppm	~12%
12-state N = 414	0.08 ppm	0.22 ppm	0.54 ppm	12%
WI 2004 N = 413	0.04 ppm	0.14 ppm	0.34 ppm	12%

Mercury Exposure in Wisconsin

Lynda M. Knobeloch, Wisconsin Department of Health and Family Services



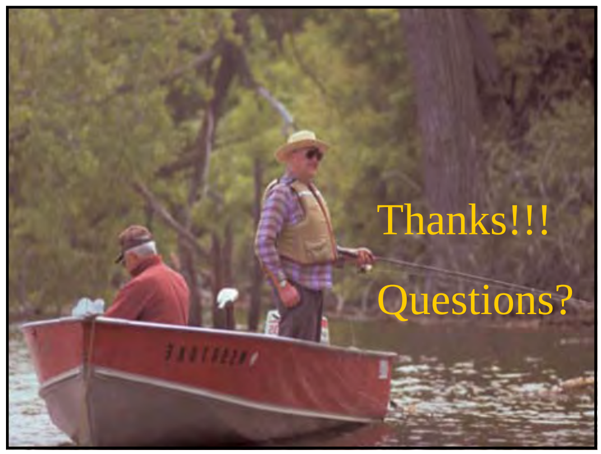


Low vs. High Exposure Groups

	Hair mercury level	
	< 0.1 ppm N = 188	>2.0 ppm N = 131
Gender	66% women	78% men
Race	94% white	>98% white
Average age	43 yrs	54 yrs
% over 50 yrs. of age	33%	63%
Fishing license holders	30%	70%
Advisory awareness	62%	87%
Income > $50,000/yr	49%	48%
Ave. fish intake rate	3 meals/mo.	12 meals/mo.
Ave. sportfish intake rate	0.3 meals/mo.	4 meals/mo.

Summary

- Approx 12% of Wisconsin adults are likely to exceed the exposure guideline for methylmercury
- Exposure risk factors:
  - Male gender, age over 50, sportfish consumption, ingestion of > 8 fish meals/month
- Future research questions
  - Why are hair mercury levels higher in men?
  - How are people who don't eat fish being exposed?
  - What are the levels in children?



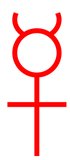
PHYSIOLOGICAL AND ENVIRONMENTAL IMPORTANCE OF MERCURY–SELENIUM INTERACTIONS

Nicholas V.C. Ralston
Energy & Environmental Research Center
Fish Forum 2005
September 19, 2005

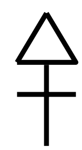
Chemical Context

1b	2b	3a	4a	5a	6a	7a	0
							He
		B	C	N	O	F	Ne
		Al	Si	P	S	Cl	Ar
Cu	Zn	Ga	Ge	As	Se	Br	Kr
Ag	Cd	In	Sn	Sb	Te	I	Xe
Au	Hg	Ti	Pb	Bi	Po	At	Rn

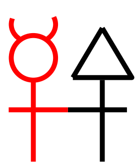
Mercury



Sulfur

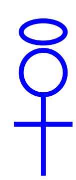


Mercuric Sulfide

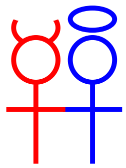


Also known as Cinnabar, stability coefficient 10^{39}

Selenium



Mercury Selenide

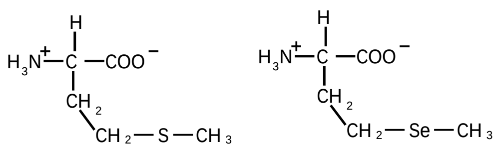


Also known as Tiemannite, stability coefficient 10^{45}

Se-Physiology Background

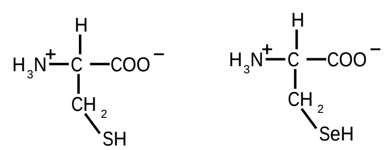
- Selenium is essential for normal selenoenzyme functions.
- Selenoenzymes are normally present in all animal cells.
- Selenium is the functional component of the 21st amino acid, selenocysteine, present at the active sites of selenoenzymes.
- Selenocysteine synthesis involves formation of selenide.
- Mercury binds to selenide better than any other partner.
- Brain selenoenzyme activities are normally unstoppable.
- Mercury toxicity impairs selenoenzyme activities in brain.

Sulfur and Selenium Amino Acids



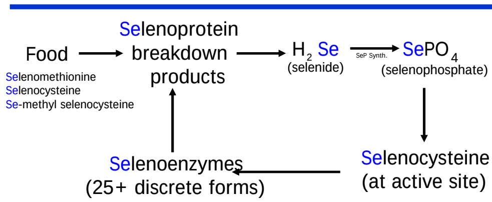
Methionine   Selenomethionine

Sulfur and Selenium Amino Acids



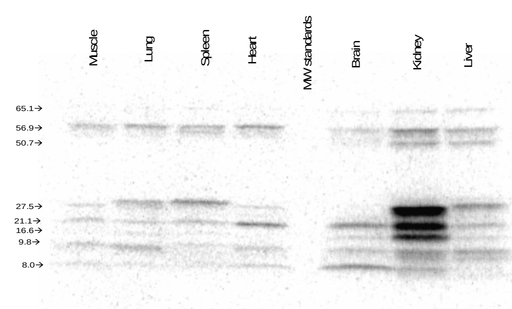
Cysteine   Selenocysteine

Selenoprotein Synthesis

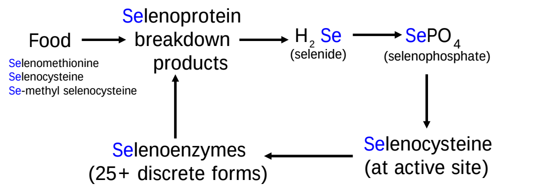


Selenocysteine is the <u>only</u> amino acid that must be recreated for each cycle of protein synthesis

Selenoproteins in Various Tissues



Selenoprotein Physiology Is Important, But Vulnerable.



Selenium enables enzymes to detoxify free radicals, convert thyroid hormones into their active forms, and support normal brain functions.

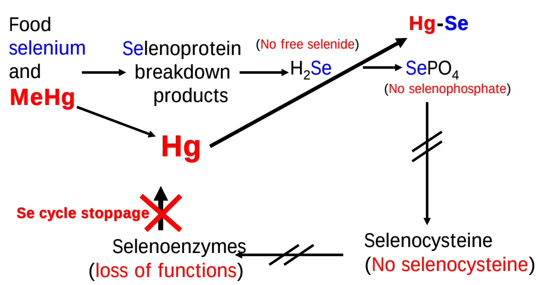
EERC

Methylmercury Toxicity

- Neurotoxic effects of high MeHg exposures well established in humans and animals.
- Silent latency characteristic of adult toxicity.
- Developing nervous system particularly sensitive to maternal MeHg exposure.
- MeHg impacts phospholipid glutathione peroxidase and selenoprotein W in brain.
- Implications of low level MeHg exposure remain controversial because contrasting results have been observed in the Faroes and the Seychelles.

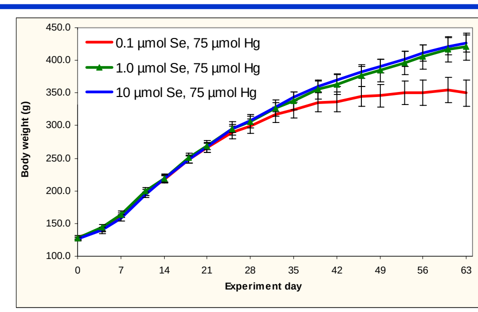
EERC

Mercury stops selenium from doing its work.



EERC

Effects of MeHg in Rats Fed Low, Normal, and Selenium-Rich Diets



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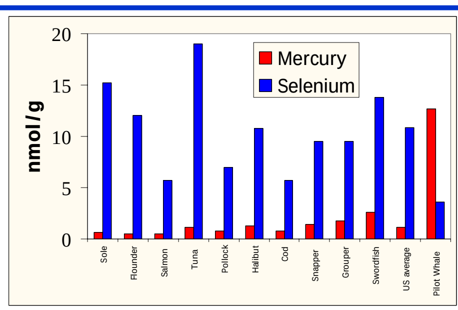
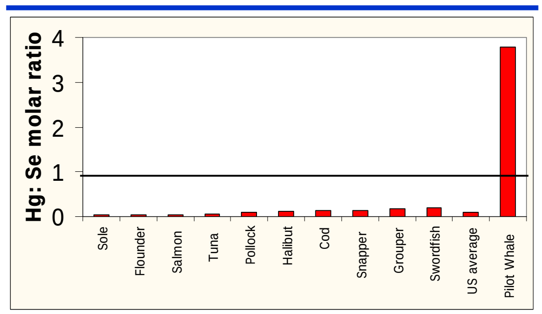
Molar Concentrations of Mercury and Selenium in Seafood



Aside from pilot whale (Julshamn et al., 1987) and swordfish (Friedman et al. 1978), data depicted originate from Hall et al. (1978).

EERC

Mercury: Selenium Molar Ratios

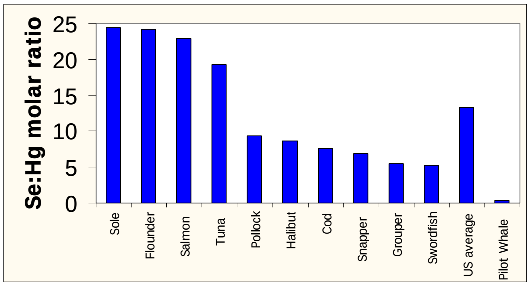


EERC

Physiological and Environmental Importance of Mercury Selenium Interactions

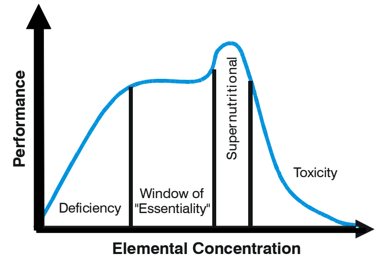
Nicholas V.C. Ralston, University of North Dakota

Selenium: Mercury Molar Ratios



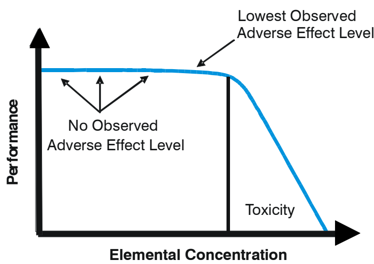
EERC

Generalized Dose-Effect Curve for Selenium



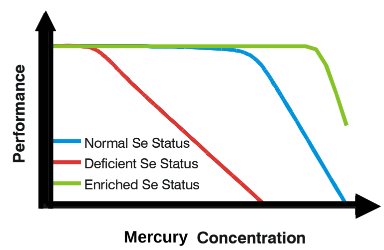
EERC

Generalized Toxic Element Dose-Effect Curve



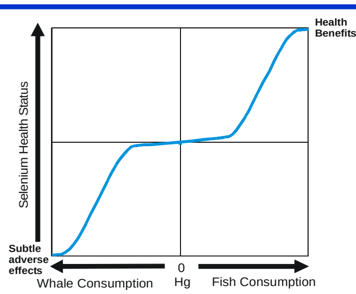
EERC

Effect of Dietary Se on Hg Dose-Toxicity Curve



EERC

Effects of Eating Whale vs. Fish

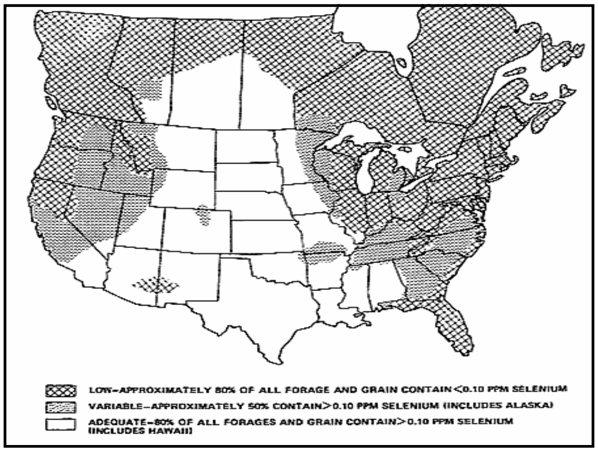


EERC

Se-Dependent Hg-Retirement

- Geographic regions with low soil Se have observed higher Hg-bioaccumulation; e.g., Florida, Northern Canada, Finland, Sweden, Northern Europe.
- Moderate additions of Se to lakes in Sweden reduced Hg-concentrations in fish by 75%.
- Mechanisms responsible for Se-dependent lowering Hg in fish have not been determined, but appear likely to involve formation of insoluble HgSe that exits the biologically available pool of cycling Hg.

EERC



Summary

- The molecular mechanism of mercury toxicity and the molecular mechanism of selenium's protective effects are related, possibly identical.
- Mercury toxicity occurs in populations exposed to foods containing disproportionate quantities of mercury relative to selenium.
- Although ocean fish are rich in selenium, availability of environmental selenium will vary the amount of mercury accumulated in freshwater fish and simultaneously influence the Hg:Se ratio in ways that may result in enhanced risk.

NHANES 1999–2002 Update on Mercury

Kathryn R. Mahaffey, U.S. Environmental Protection Agency

NHANES 1999-2002 Update on Mercury & *Fish Forum – 2005*

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Washington, DC
September 2005

The findings and conclusions in this presentation have not been formally disseminated by U.S. EPA and should not be construed to represent any agency determination or policy.

Overview

- Update on all four years of NHANES blood mercury data for adult women.
- Look at subgroups and absence of trend data.
- Comparison with exposures associated with U.S. EPA's reference dose for methylmercury.

Updated Analysis of NHANES Data on Adult Women's Blood Mercury Concentrations Since January 2004

- Includes two additional years of NHANES data: 2001 and 2002.
- Data from > 30 additional "stands" or communities.
- Separate analysis of blood mercury data for women residing in "coastal" areas compared with those living in "noncoastal" geographic residences.
- Comparison of 1999/2000 and 2001/2002 data for blood organic [Hg].
- Assessment of subpopulations' mercury exposures.

Distribution of Blood Organic Mercury (µg/L) Adult Women – NHANES 1999–2002

Group	Sample Persons	Arithmetic Mean	95% CI	75th	90th	95th
Total	3,613	1.43	(1.19-1.67)	1.52	**3.52**	**5.8**
Mexican/ American	1,099	0.89	(0.77-1.02)	1.02	**2.10**	**3.32**
Other Hispanic	218	1.54	(0.84-2.24)	1.72	**3.30**	**4.50**
Non-Hispanic Whites	1,368	1.38	(1.07-1.68)	1.42	**3.42**	**6.00**
Non-Hispanic Blacks	789	1.61	(1.28-1.94)	1.82	**3.62**	**5.22**
Other race	139	2.46	(1.72-3.19)	3.70	**6.70**	**9.02**

Comparison of Blood Organic [Hg] µg/L for Adult Women NHANES 1999 – 2002 by Income

Annual Income	Sample Persons	Arithmetic Mean	(95% CI)	75th%	90th%	95th%
Total (all incomes)	3,613	1.43	(1.35-1.50)	1.52	**3.52**	**5.8**
Less than $20,000	1,164	1.19	(0.88-1.49)	1.30	**2.80**	**4.22**
$20,000 or more	2,432	1.52	(1.26-1.79)	1.60	**3.92**	**6.20**

Women Statistically More Likely to Have Higher Blood Mercury Concentrations

- "Other" category, which includes Asians, Native Americans, persons of "Island" ethnicity. [Also see Hightower et al., 2005. Environmental health perspectives on line, in press.]
- Women with incomes higher than the "poverty" level.
- Trends in the NHANES data for adult women are supported by a number of additional studies.

Geographic Differences in Blood Mercury Concentrations of Adult Women – NHANES 1999 – 2002

- Utilizing NCHS Data Center, divided NHANES data into those stands located in Coastal counties – any stand in a county bordering the Atlantic Ocean, the Pacific Ocean, or the Gulf of Mexico – and stands located in non-coastal counties, which were all other areas.

Distribution of Adult Female Subjects with Organic Hg Data – NHANES 1999 – 2002 by Coastal and Non-Coastal Categories

Total = 3,613
Coastal = 1,431
(Atlantic Ocean = 598)
(Gulf of Mexico = 184)
(Pacific Ocean = 649)
Non-Coastal = 2,182
(Midwest = 524)
(North East = 219)
(South = 969)
(West = 470)

Comparison of Blood Organic [Hg] by Coastal and Non-Coastal Residence and by Region for Adult Women Aged 16–49 Years, NHANES 1999–2002: µg/L

Group	N	Arithmetic Mean	(95th % C.I.)	90th
Total	3,613	1.43	1.2 - 1.7	3.5
Non-Coastal	2,182	1.03	0.8 - 1.2	2.4
Coastal	1,431	2.21	1.8 - 2.6	5.9
Atlantic	598	2.72	2.4 - 3.1	7.7
Pacific	649	1.73	1.5 - 1.9	4.7
Gulf of Mexico	184	1.31	0.6 - 2.0	3.2

Findings for Fish Intake by Coastal Subpopulations Consistent with Higher Blood Mercury Concentrations

- In France, fish consumption by coastal residents reported to be three times higher than fish intake by non-coastal residents (Crepet et al., 2005. *Regul. Toxicol. Pharmacol.* 42:179-189).
- Observed for fish intake in Florida in the 1990s. 50th percentile intake comparable to 90th percentile intake of NHANES survey (Denger et al., 1994).

Comparison of Numbers of Women Ages 16 – 49 Years

- 1,707 women in the 1999 and 2000 report had blood organic [Hg] analyses (Mahaffey et al., 2004).
- 1,906 women in the 2001 and 2002 period had blood organic mercury analyses.
- 3,613 women in the 1999 through 2002 report had blood organic [Hg] analyses reported.
- More subjects in the latter 2 years.

Number of Years of NHANES Data Needed for Comparisons

- Generally recommended that at least 3 years of data be utilized for national estimates.
- Estimates based today utilize 4 years of NHANES data: 1999, 2000, 2001, and 2002.

Comparison of Coastal and Non-Coastal Residence of Women Participating in NHANES by Release Year Counts Based on 24-Hour Dietary Recall Data

1999 and 2000 Release

- Coastal
  n = 744 or 42.9%
  % fish consumers: 18.3
  Mean g eaten (consumers only): 58.0
- Non-Coastal
  n = 991 or 57.1%
  % fish consumers: 10.6
  Mean g eaten (consumers only): 48.1

2001 and 2002 Release

- Coastal
  n = 676 or 35.0%
  % fish consumers: 16.7
  Mean g eaten (consumers only): 59.9
- Non-Coastal
  n = 1,257 or 65.0%
  % fish consumers: 13.0
  Mean g eaten (consumers only): 69.3

Question

- Does the decline reported in blood mercury between the 1999/2000 release and the 2001/2002 release reflect the ratio of coastal to non-coastal residences or other study design considerations?

Question

- How should we interpret exposure data based on women's blood mercury levels compared with U.S. EPA's reference dose for methylmercury?

What Is U.S. EPA's RfD for Methylmercury Based On?

- It's not a LOAEL.
- It's not a NOAEL.
- It's a Benchmark Dose (BMD). A dose that produces a predetermined change in response rate of an adverse effect compared to background. Specifically a BMD Lower Confidence Limit (BMDL) in which the point of departure is set at a level in which there is a 5% increase in the prevalence of the endpoint against a population prevalence of 5% for the adverse effect, i.e., *the prevalence of the adverse effect doubles*.

BMDL for Methylmercury: Adverse Neurological Effects

- Methylmercury exposure associated with *doubling* the prevalence of children scoring in the lowest 5th percentiles on tests of neurodevelopment.
- Using IRIS language: "BMDs are calculated under the assumption that 5% of the responses will be abnormal in unexposed subjects (P0 = 0.05), assuming a doubling of the excess risk (BMR = 0.05).
- Means that at the BMDL the prevalence of neurological deficits increases from 5% to 10%.
- Dose calculated in µg/kg-bw/day for the mother that will produce a cord blood concentration measured in µg/L.

Are There Estimated BMDLs Lower than the 58 μg/L Recommended by the NAS?

- BMDL for Methylmercury (IRIS, U.S. EPA, 2001) utilized a number of endpoints from three major cohort studies: Faroes, Seychelles, and New Zealand
  - Median values, calculated as µg Hg/L cord blood
- Faroes
  - $BMDL_{05}$ ppb mercury = 48 μg/L cord blood
- Integrative
  - $BMDL_{05}$ ppb mercury = 32 μg/L cord blood
- New Zealand
  - $BMDL_{05}$ ppb mercury = 24 μg/L cord blood

Distribution of Blood Mercury Concentrations for Adult Women and Comparison with NAS's and U.S. EPA's Benchmark Dose

- Based on cord blood mercury concentration.
- BMDL: 58 μg Hg /L cord blood.
- To calculate a reference dose, the NAS's Committee on Toxicology of Methylmercury recommended use of an uncertainty factor (UF) of not less than 10.
- 5 years ago, there was minimal recognition of extent to which methylmercury is concentrated across the placenta.

Comparison of UF for Methylmercury Risk Assessment between 2000/2001 and 2005

- The UF is for variability and uncertainty. The UF was 10 in 2000/2001 as recommended by NAS and used by U.S. EPA. No change in the past 5 years.
- However, there are additional data regarding maternal-fetal methylmercury kinetics between 2001 and 2005.
- What do these advances in understanding physiology mean for the exposure assessment part of risk assessment?

Exposure Analysis

- Stern and Smith (2003) compared cord blood with maternal blood [Hg] concluding that the mean cord blood was 70% higher than maternal blood [Hg]. Based on a meta-analysis of 10 separate data sets for cord : maternal [Hg] analyses.
- Subsequent to this publication, there have been at least three additional studies published describing geographically diverse populations yielding very similar results.

Studies Published on Cord : Maternal Blood [Hg] Subsequent to Stern & Smith, 2003

- Sakamoto et al., 2004. Range 1.1 to 2.2; r = 0.92. **x = 1.6** for ratio of cord to maternal RBC-Hg. Japanese 63 maternal-fetal pairs.
- Morrisette et al., 2004. Average cord blood OHg was **1.7 times** O Hg in maternal blood. 92 Canadian maternal-fetal pairs.
- Butler et al., 2005. Arithmetic mean ratio (cord : maternal) for methylmercury (**1.86**; n = 294 pairs; r = 0.90) and for total mercury (1.49; n = 320 pairs; r = 0.95). Range 1.2 to 1.7 for THg, from 1.3 to 2.0 for MeHg. Canadian: Caucasian, Dene/Métis, Inuit, and others.

Understanding the BMDL in Biomonitoring Values

- BMDL of 58 μg/L in cord blood is equivalent to 35 μg/L in maternal blood because of bioconcentration of methylmercury across the placenta.
- When conducting an exposure assessment based on organic blood mercury concentrations for adult women 35 μg/L is associated with fetal methylmercury exposures in the range of the BMDL.
- Blood mercury concentrations in this range likely reflect exposure from fish or marine mammal consumption, unless there is an indication of some other highly unusual source of exposure.

Based on the Combined NHANES 1999 – 2002 Data for Adult Women and National Center for Health Statistics Data in the United States

- During the combined years 1999-2002, among women ages 16 through 49 years who participated in the NHANES, 10.2% had blood mercury concentrations >/= 3.5 µg/L.
- The number of women delivering babies during these years* were
  - 1999: 3,959,417
  - 2000: 4,058,814
  - 2001: 4,025,933
  - 2002: 4,021,726
  - Average: 4,016,427

  Estimate number of infants born to mothers with blood organic mercury concentrations >/= 3.5 µg/L:

  10.2% x 4,016,427 = 409,676 or ~ 410,000

Martin, J.A., et al., *Births: Final Data for 2002.* National Vital Statistic Reports, Vol. 52, Number 10. Available at http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_10pdf. (accessed August 26, 2005).

Reasons and Revised Estimates for the Number of Women Estimated to Have Exposures Greater than U.S. EPA's Reference Dose for Methylmercury

- Number of years of NHANES data.
- Previous estimates (based on NHANES data for 1999 and 2000) of the number of births to women having blood organic mercury concentrations indicative of methylmercury exposures > U.S. EPA's RfD, ranged between 300,000 (no bioconcentration) and 600,000 (with bioconcentration) depending on whether placental bioconcentration of CH_3Hg was considered.
- Current estimates (based on NHANES data for 1999 through 2002) of the number of births to women having blood organic mercury concentrations indicative of methylmercury exposures > U.S. EPA's RfD, are ~ 220,000 using blood [Hg] of 5.8 µg/L (no bioconcentration) and ~ 410,000 using 3.5 µg/L (with bioconcentration) with no adjustment for placental concentration of methylmercury.
- There is bio-concentration of methylmercury across the placenta based on approximate 30 separate studies of mother-child pairs reported in the peer-reviewed literature.

NHANES Is and Is Not

- Is: Nationally representative data
- Is not: Representative of the highest exposures.
- Published reports of higher exposures to methylmercury within the United States and territories include the following:

Mercury Exposure among Groups with Much Higher Fish Consumption than the General Population: United States and Territories

- Health-aware urbanites

  San Francisco private practice – blood Hg: 89% of 116 patients had blood [Hg] > 5 µg/L. 16% > 20 µg/L. 4 patients > 50 µg/L.

  New York City rehabilitation clinic – neuropathies – blood Hg: 27-96 µg/L.
- Island population

  Vieques (Puerto Rican women) – hair Hg: 90th percentile, 9 ppm; 3 women had values of 15, 25, and 101 ppm.
- Commercial fishermen and families

  Louisiana – blood [Hg] ranging from < 0.3 to 35 µg/L. 2% > 20 µg/L.
- Coastal populations

  New Jersey – pregnant women 1% to 2% had hair [Hg] > 4 ppm.

These Data Indicate

- Should use larger sample size for 1999 through 2002 NHANES, which is more geographically representative than was 1999 through 2000 NHANES.
- Coastal populations, "Other" subpopulations, and women with incomes higher than poverty level have higher blood mercury concentrations.
- Substantial number of women have blood mercury concentrations (3.5 µg/L) greater than those associated with U.S. EPA's 2000/2001 RfD based on cord blood mercury (i.e., 5.8 µg/L).

A Fresh Look at the Uncertainty Factor Adjustment in the Methylmercury RfD

Alan H. Stern, New Jersey Department of Environmental Protection

A Fresh Look at the Uncertainty Factor Adjustment in the Methylmercury RfD

Alan H. Stern, Dr.PH, DABT

New Jersey Department of Environmental Protection

RfD Derivation 101 – UFs

- RfD = NOAEL (or LOAEL, or BMDL) / (UF_1 x UF_2 ....UF_i)
- UF = **Uncertainty** Factor
  - This is **NOT a "safety" factor**
    - Not designed to add an extra margin of safety
  - Intended to account for uncertainties in the NOAEL/BMDL derivation that, if known, could results in a smaller NOAEL/BMDL

RfD Derivation 101 – UFs (cont.)

- Uncertainty Factor categories
  - UF_A - animal → human
  - UF_L - LOAEL → NOAEL
  - UF_{SC} - subchronic → chronic
  - **UF_H - average humans → sensitive humans**
  - **UF_D - database insufficiency**
  - (UF_M - modifying factor)

RfD Derivation 101 – UFs (cont.)

- UFs generally applied as factor of 3 or 10
  - 1 or ½ log unit
- However, there is no formal requirement restricting the UF to these values

The Current RfD

- UF = 10
- There are at least 2 new developments that could affect the appropriate value of the UF
  - Cord blood:maternal blood Hg ratio
    - 1.7 (Stern and Smith, 2003)
  - Re-analysis of the maternal dose corresponding to the cord blood BMDL ("the dose conversion")
    - (Stern, 2005)
    - Incorporates cord:maternal ratio

The Current RfD (cont.)

- Ideally, we would insert the new information into the existing UF structure
- Unfortunately, the structure of the current UF derivation is unclear and ambiguous

The Current RfD (cont.)

- Three sources of information about the structure of the current UF adjustment
  - IRIS entry
  - Rice et al. (2003)
    - Methods and rationale for derivation of a reference dose for methylmercury by the U.S. EPA.
  - Rice (2004)
    - The U.S. EPA reference dose for methylmercury: sources of uncertainty

The Current RfD UF Issues (cont.)

- These sources do not agree as to how and whether the cord blood:maternal blood Hg ratio was addressed in the UF for toxicokinetics
- If the dose conversion is now adjusted from a 1.0 cord:maternal ratio to a 1.7 ratio, would the UF of 3 for toxicokinetics need to be reduced to avoid double counting?
  - If so, by how much?
- There is now clarity as to the cord:maternal ratio
  - It is no longer necessary to treat it as an uncertainty

The Current RfD Issues (cont.)

- **UF_H (sensitive humans)**
  - IRIS
    - "A quantitative uncertainty analysis of toxicodynamics was not possible. However, the population of the Faroe Islands is ... extremely homogeneous. The average toxicodynamic response of this population compared with that of the United States ... is unknown…. A threefold UF for toxicodynamic variability and uncertainty was applied."

The Current RfD Issues (cont.)

- UF_D (database uncertainty)
  - EPA allocated the entire UF of 10 to toxicokinetics (i.e., variability in the dose conversion, with or without cord:maternal ratio) and toxicodynamics (i.e., sensitive humans)
  - It is clear that uncertainty about whether **other endpoints** might be more sensitive than neurodevelopment is **not addressed in the UF**
    - **cardiovascular**
    - **sequalae with aging**
    - **immunotoxicity**

A Modest Proposal

- It would be informative to examine what the UF might look like if we apply the new information and new perspectives in a new UF derivation
  - Dose conversion with updated cord:maternal ratio
  - Cardiovascular effect data
  - Fresh look at sensitive populations

The Dose Conversion

- The dose conversion is derived probabilistically (Monte Carlo)
  - **Captures the population variability in the maternal dose corresponding to the cord blood BMDL**
- In the NAS/NRC assessment and in EPA's RfD derivation, there was uncertainty about appropriate central tendency estimates in the analysis
  - **Central tendency and variability were separated**
  - **Mean maternal dose was estimated**
  - **Variability was incorporated as a UF**
    - **the variability is the UF of 3 for "toxicokinetic variability"**

The Dose Conversion (cont.)

- Recent re-analysis (Stern, 2005) of the dose conversion is a more careful analysis
  - Largely uses maternal physiological parameters specific to pregnancy
  - Issues of central tendency largely eliminated
- No longer useful to separate central tendency and variability estimates
  - Can select the appropriate percentile of the distribution of maternal dose corresponding to the BMDL
    - e.g., 58 ug/L

The Dose Conversion (cont.)

- Updated cord:maternal ratio (1.7) and its variability (Stern and Smith 2003) are incorporated directly
- Estimated maternal dose for a cord blood BMDL of 58 ug/L
  - 5^{th} percentile (lower 95^{th}) = 0.3 ug/kg/day
  - 1^{st} percentile (lower 99^{th}) = 0.2 ug/kg/day
- Using these doses as the starting point eliminates the need for a toxicokinetic UF factor (i.e., 3)

Database Insufficiency – UF_D

- Of the three major studies, two are positive for heart disease (MI, etc.)
  - Finnish group (Salonen et al., 1995)
  - Multicenter study (Guallar et al., 2002)
- One is (arguably) equivocal
  - U.S. Health Professionals (Yoshizawa et al., 2002)
- Should cardiovascular effects be addressed by a UF_D ?

Database Insufficiency – UF_D (cont.)

- To include UF for database uncertainty, it is only necessary that there be a reasonable basis for assuming that another endpoint could be more sensitive than the modeled endpoint.
  - **EPA generally accounts for lack of developmental and/or reproductive studies in RfD derivation <u>without supporting data</u>**
- In the Finnish studies, the mean hair Hg conc. is approx. 2.0 ppm
  - **This is equivalent to approx 90^{th} percentile of U.S. adult men**
  - **Hair Hg >2.0 corresponded to a 1.96 relative risk for AMI**

Database Insufficiency – UF_D (cont.)

- Yoshizawa et al. (U.S. Health Professionals) used toenail Hg as biomarker
  - Cannot yet relate to hair or blood Hg
  - Non-dentists presumably reflect general U.S. male population
    - Mean = 0.45 +/- 0.4 ug/g
- Guallar et al. also used toenail Hg
  - Elevated O.R. for MI clearly seen in range of 0.4-0.7 ug/g
  - Corresponds to ~ mean Hg exposure in U.S. non-dentists
    - Presumably corresponds to mean exposure in U.S. males

Database Insufficiency – UF_D (cont.)

- Therefore, it appears that for the two clearly positive studies, significantly elevated risk of MI occurred within the range of current dietary exposures of the U.S. adult male population
- This appears to justify application of a UF_D based on cardiovascular effects alone
  - A value of 2-3 appears to be appropriate
    - My judgment

Sensitive Humans – UF_H

- To include UF-sensitive humans, it is only necessary that there be a reasonable basis for assuming that the U.S. population could have a greater range of sensitivity than the population from which the RfD was derived
- EPA (IRIS) used data from Faroes and NZ studies
  - Faroese are a homogeneous population
  - Could result in more or less sensitivity than U.S. population
    - **e.g., founder effect**

Sensitive Humans – UF_H (cont.)

- NZ population is ethnically varied
  - 8% Europeans
  - 26% Maori
  - 66% Pacific Islanders
- Comparing Faroes and New Zealand studies
  - Standardized regression coefficients in NZ are about 41% larger
  - BMD values for NZ are about half those for Faroes
  - Consistent with greater sensitivity due to ethnic diversity
    - But other explanations are also plausible

Sensitive Humans – UF_H (cont.)

- Homogeneity of Faroese, and possible greater sensitivity in the varied NZ population argues that U.S. population may have a greater range of sensitivity
- However, to some extent, the RfD is based on the NZ data
  - Partly incorporates the greater sensitivity in that population
- At most, NZ population shows potential for about a two-fold greater sensitivity
- This argues for a UF_H of only 1.5-2
  - My judgment

Some Possible Calculations (Based on My Own Conclusions)

- Point of departure – maternal dose
  - Corresponding to 58 ug/L
  - 1st (lower 99th) percentile incorporating cord:maternal and toxicokinetic variability
    - This is percentile used in current RfD
  - 0.2 ug/kg/day
- UF toxicodynamics (current EPA factor – default)
  - 3
- UF_H (sensitive populations - alternate toxicodynamic)
  - 1.5-2
- UF_D (cardiovascular)
  - 2-3

Some Possible Calculations (Based on My Own Conclusions)

- Current EPA calculation

  (old dose conversion)
  - UF toxicokinetics = 3
  - UF toxicodynamics = 3

$$\frac{1.1 \text{ ug/kg/day}}{10} = 0.1 \text{ ug/kg/day}$$

Some Possible Calculations (Based on My Own Conclusions)

- Using new dose conversion and U.S. EPA's current UF for toxicodynamics
  - i.e., UF_H = 3

$$\frac{0.2 \text{ ug/kg/day}}{3} = 0.07 \text{ ug/kg/day}$$

Some Possible Calculations (Based on My Own Conclusions)

- Using new dose conversion
  - Maximum UF_D and
  - Current U.S. EPA UF for toxiocdynamics
  - UF_{total} (= 9)

$\frac{0.2 \text{ ug/kg/day}}{3 \times 3} = 0.02 \text{ ug/kg/day}$

Some Possible Calculations (Based on My Own Conclusions)

- Using new dose conversion and
  - Minimum UF_D and UF_H
  - UF_{total} (= 3)

$\frac{0.2 \text{ ug/kg/day}}{2 \times 1.5} = 0.07 \text{ ug/kg/day}$

- Other possible combinations fall in between

Conclusions – Finally

- A fresh look at the UF for methylmercury incorporating new data and analyses presents a range of possible appropriate values for the resulting RfD
- These values extend from 70% of the current RfD to 20% of the current value
- There is no uniquely correct value, but this analysis presents a basis for a rational and transparent decision

Review of Cardiovascular Health Effects of Mercury – A U.S. Perspective

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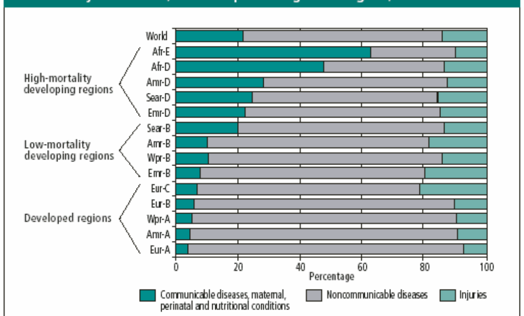
The Top 10 Causes of Death in 2001

1. Heart Disease: 700,142
2. Cancer: 553,768
3. Stroke: 163,538
4. COPD: 123,013
5. Accidents: 101,537
6. Diabetes: 71,372
7. Pneumonia: 62,034
8. Alzheimer's: 53,852
9. Kidney disease: 39,480
10. Septicemia: 32,328

Source: Monthly Vital Statistics Report, 2004

Figure 1.8 Disease burden (DALYs) among adults (aged 15 years and over) by broad cause, selected epidemiological subregions, 2002



See List of Member States for an explanation of subregions.

World Health Report, 2003

Mercury Toxicity

- Brain
- Kidney
- Fetus

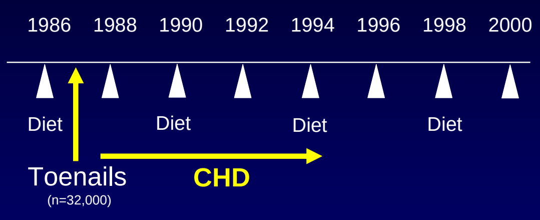
Mercury Toxicity in the Heart

- Systemic Effects
  - ↑ Free radicals and reactive O_2 species
  - ↓ Antioxidant system function (e.g., glut. peroxidase)
  - ↑ Lipid peroxidation
  - ↑ Coagulation
- Direct Cardiovascular Effects
  - ↓ Myocardial contractile force
  - ↑ Ca^{++} release from myocardial sarcoplasmic reticulum
  - ↓ Left ventricular myosin ATP-ase activity
  - ↓ HR variability and ↑ blood pressure

Health Professionals' Follow-up Study

- Prospective cohort of 51,529 U.S. male health professionals aged 40-75 years in 1986
  - Dentists
  - Veterinarians
  - Pharmacists
  - Osteopaths
  - Podiatrists
  - Optometrists

Health Professionals' Follow-up Study (n = 51,529)



Health Professionals' Follow-up Study (n = 51,529)

- Repeated assessments of diet, lifestyle behaviors, and medical history.
- During 5 years of follow-up, 409 cases:
  - nonfatal MI
  - fatal CHD
  - CABG/PTCA.

Toenail Assessment: Neutron – Activation

Dr. Steve Morris – Research Reactor Center, Univ. of Columbia-Missouri, Research Park

- Long-term feeding studies suggest that toenails and hair are good markers of intake and exposure.

Mean Characteristics Between Prospectively Identified CHD Cases and Matched Controls

Characteristics	Cases	Controls
Age (years) *	60.6	60.6
Mercury (μg/g)	0.72	0.74
BMI (kg/m^2)	26.0	25.3
Current smokers (%)*	10.1	10.8
Diabetes	7.4	3.8
Hypertension	33.9	24.1
Hypercholesterolemia	15.2	10.5
Alcohol (g/day)	10.4	12.9

Baseline Characteristics by Quintile of Toenail Mercury (Controls Only)

	Median Mercury Levels in Toenails					P,value
	0.15 (0.03-0.21)	0.28 (0.22-0.35)	0.45 (0.36-0.54)	0.67 (0.55-0.86)	1.34 (0.87-14.56)	
N	85	94	97	97	91	
Age	61	64	62	60	62	0.22
BMI (kg/m^2)	26.2	24.9	25.8	25.0	24.7	0.02
Dentist (%)	40	61	62	70	84	<0.001
Hypertension	22 (26%)	28 (30%)	21 (22%)	23 (24%)	20 (22%)	0.37
Diabetes	3 (4%)	2 (2%)	2 (2%)	4 (4%)	7 (8%)	0.12

Yoshizawa et al., 2002. *NEJM*.

Baseline Characteristics by Quintile of Toenail Mercury (Controls Only)

	Median Mercury Levels in Toenails					P,value
	0.15 (0.03-0.21)	0.28 (0.22-0.35)	0.45 (0.36-0.54)	0.67 (0.55-0.86)	1.34 (0.87-14.56)	
N	85	94	97	97	91	
Fish (g)	20.7	26.1	30.4	37.2	51	<0.001
Red meat (servings)	1.1	0.9	0.9	0.9	0.5	<0.001
Poultry (servings)	0.2	0.3	0.3	0.3	0.4	0.02
Fruits/veg (servings)	4.7	4.8	4.6	5.1	6.0	0.01
Alcohol (g)	4.7	6.5	7.5	9.2	10.9	0.006

Yoshizawa et al., 2002. *NEJM*.

Multivariate Adjusted Relative Risks of CHD among Men Selected for a Nested Case-Control Study (1987–1992) and Enrolled in the Health Professionals Follow-up Study

	Quintiles of Toenail Mercury 1	2	3	4	5	p, trend
Toenail Mercury (ug/g)	0.15	0.28	0.45	0.67	1.34	
All CHD Cases (n)	101	93	90	90	96	
Relative risk adjusted for matching factors* (95% CI)	**1.0** (ref)	**0.83** (0.55, 1.25)	**0.77** (0.51, 1.16)	**0.77** (0.51, 1.16)	**0.87** (0.57, 1.31)	0.83
Multivariate (95% CI)	**1.0** (ref)	**0.93** (0.60, 1.43)	**0.83** (0.53, 1.30)	**0.96** (0.62, 1.51)	**1.03** (0.65, 1.65)	0.55

- Age, smoking, and month of toenail return.
- Multivariate model includes BMI, age, smoking, alcohol, diabetes, hypertension, hypercholesterolemia, family history of MI, and folate intake, n-3 intake.

Predictors of Toenail Mercury

- Dentist vs. non-dentist
- General practice vs. specialist
- Amalgam preparation methods

Dietary Predictors	%
– Tuna fish	49
– Other fish	19
– Dark Fish	9
– Rice	2
– Coffee	2
– Skim Milk	1

GISSI Trial of n-3 Supplements and Secondary Prevention Of CVD

	n-3 PUFA (n=2836)	Control (n=2828)	Relative risk (95% CI)
Main endpoints			
Death, non-fatal MI, and non-fatal stroke	356 (12·3%)	414 (14·6%)	0·85 (0·74–0·98)
Cardiovascular death, non-fatal MI, and non-fatal stroke	262 (9·2%)	322 (11·4%)	0·80 (0·68–0·95)
Secondary analyses			
All fatal events	236 (8·3%)	293 (10·4%)	0·80 (0·67–0·94)
Cardiovascular deaths	136 (4·8%)	193 (6·8%)	0·70 (0·56–0·87)
Cardiac death	108 (3·8%)	165 (5·8%)	0·65 (0·51–0·82)
Coronary death	100 (3·5%)	151 (5·3%)	0·65 (0·51–0·84)
Sudden death	55 (1·9%)	99 (3·5%)	0·55 (0·40–0·76)
Other deaths	100 (3·5%)	100 (3·5%)	0·99 (0·75–1·30)
Non-fatal cardiovascular events	140 (4·9%)	144 (5·1%)	0·96 (0·76–1·21)
Other analyses			
CHD death and non-fatal MI	196 (6·9%)	259 (9·2%)	0·75 (0·62–0·90)
Fatal and non-fatal stroke	54 (1·9%)	41 (1·5%)	1·30 (0·87–1·96)

Table 3: **Overall efficacy profile of n-3 PUFA treatment** Lancet, 1999

Multivariate Adjusted Relative Risks of CHD among Men Selected for a Nested Case-Control Study (1987–1992) and Enrolled in the Health Professionals Follow-up Study

	1	2	3	4	5	p, trend
Toenail Mercury (ug/g)	0.15	0.28	0.45	0.67	1.34	
All CHD cases (n)	101	93	90	90	96	
Relative risk adjusted for matching factors* (95% CI)	**1.0** (ref)	**0.83** (0.55, 1.25)	**0.77** (0.51, 1.16)	**0.77** (0.51, 1.16)	**0.87** (0.57, 1.31)	0.83
Multivariate (95% CI)	**1.0** (ref)	**0.93** (0.60, 1.43)	**0.83** (0.53, 1.30)	**0.96** (0.62, 1.51)	**1.03** (0.65, 1.65)	0.55

- Age, smoking, and month of toenail return
- Multivariate model includes BMI, age, smoking, alcohol, diabetes, hypertension, hypercholesterolemia, family history of MI, and folate intake, n-3 intake.

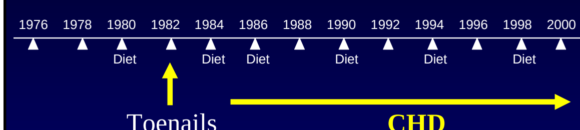
Multivariate Adjusted Relative Risks of CHD: Quintile 5 vs. Quintile 1 after Exclusion of Dentists

	Q5 Vs Q1
• Total Cohort	0.87 (0.57, 1.31)
• Exclude Dentists	1.27 (0.62, 2.59)
• Control for n-3	1.70 (0.78, 3.73)

No interaction with selenium

Future Directions

Nurses' Health Study (n=121,700)



Health Professionals Follow-up Study (n=52,000)

Strengths

- Large sample size with wide variability
- Neutron activation analysis
- Nested prospective data

Limitations

- Relative short follow-up with only a single measure of exposure
- Measurement error
- Unmeasured confounding

Conclusions

- Toenail mercury reflects intake
- The CVD benefit of n-3 fatty acids in fish is strongly supported by a wide range of scientific evidence
- Whether the mercury content of fish leads to elevated CVD has support from some European studies, less so from U.S. studies
- Further prospective studies are needed to help clarify the association, if any, between mercury and CHD

Cardiovascular Health Effects of Mercury—European Data
Eliseo Guallar, Johns Hopkins Bloomberg School of Public Health

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Cardiovascular Health Effects of Mercury – European Data

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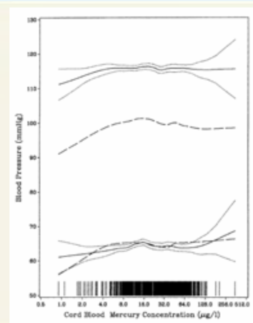
Etiology of Atherosclerotic CVD

- **Some key pathogenic processes**
  - Oxidative stress
  - Endothelial dysfunction
  - Inflammation
  - Thrombosis
- **Some key risk factors**
  - High blood pressure
  - High LDL cholesterol
  - Low HDL cholesterol
  - Diabetes, insulin resistance

Possible Mechanisms of Action of Mercury on CVD

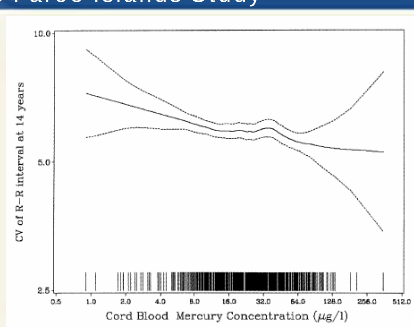
- **Increase oxidative stress**
  - Production of free radicals, hydrogen, and lipid peroxides
  - Binds to and inactivates selenium
  - High affinity for thiol groups, and may inactivate glutathion, catalase, and SOD
  - Correlated with oxidized-LDL levels
- **Effects on blood pressure and heart rate variability**
- **Effects on endothelial cells and inflammatory response**
- **Effect on intima-media thickness**

Blood Cord MeHg Levels and Blood Pressure at Ages 7 and 14 — The Faroe Islands Study



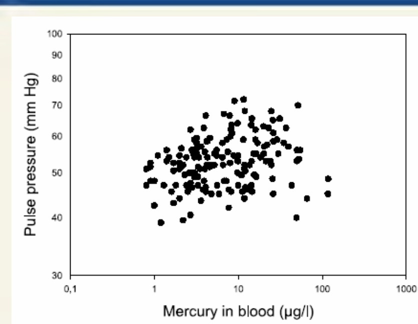
Grandjean, P., et al., 2004. *J Pediatr* 144:169–76.

Blood Cord MeHg Levels and R-R Interval Variation at Age 14 — The Faroe Islands Study



Grandjean, P., et al., 2004. *J Pediatr* 144:169–76.

Blood Hg Levels and 24-h ABPM Pulse Pressure among Danes and Greenlanders

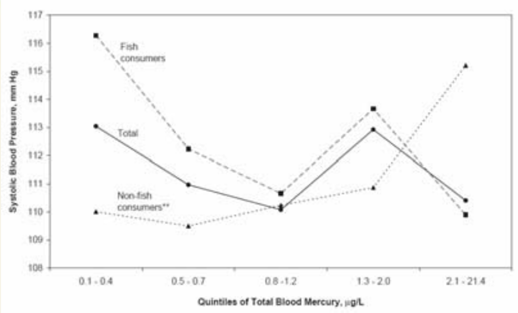


Pedersen, E.B., et al., 2005. *AJH* 18:612–618.

Cardiovascular Health Effects of Mercury—European Data

Eliseo Guallar, Johns Hopkins Bloomberg School of Public Health

Blood Hg Levels and SBP among Women 16 – 49 Years Old in NHANES, 1999 – 2000



Vupputuri, S., et al., 2005. *Env Res* 97:195–200.

Kuopio Ischemic Heart Disease Study

- Cohort study of 1,833 men in Eastern Finland
- 42 to 60 years of age
- High intake of freshwater fish from locally contaminated Hg lakes
- Hair Hg content measured by flow injection analysis – cold vapor AAS and amalgamation
- CV for duplicate measurements ~ 8%
- Mean hair Hg 1.98 µg/g
- Mean follow-up ~ 5 years

Salonen, J.T., et al., 1995. *Circulation* 91:645–655.

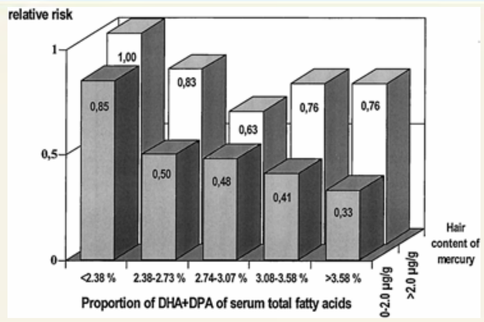
Kuopio Ischemic Heart Disease Study – RR of Fatal or Nonfatal MI

	RR		95% CI
Hair mercury, µg/g	1.094	*P*=.037	1.01 to 1.19
Hair mercury, ≥ 2.0 µg/g	1.96	*P*=.005	1.23 to 3.13
Fish intake, g/d	1.005	*P*=.002	1.002 to 1.008
Fish, ≥ 30 g/d	2.08	*P*=.004	1.26 to 3.40
Mercury intake, g/d	1.028	*P*=.006	1.008 to 1.048
No. of men with event	73		

Adjusted for age, examination year, ischemic exercise ECG, and maximal 0_2 uptake.

Salonen, J.T., et al., 1995. *Circulation* 91:645–655.

Kuopio Ischemic Heart Disease Study – Association of Hg and n–3 Fatty Acids with Acute Coronary Events



Rissanen, T.R., et al., 2000. *Circulation* 102:2677–2679.

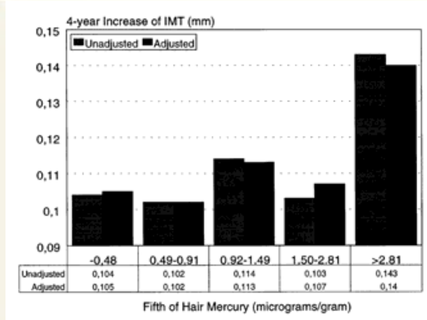
Kuopio Ischemic Heart Disease Study – Association of Hair Hg and Acute Coronary Events

	Lowest Third RR	Middle Third RR (95% CI)	Highest Third RR (95% CI)	*P* for Trend	Highest vs lower Two Thirds Combined RR (95% CI)
Incidence of acute coronary event					
Model 1*	1	1.02 (0.74–1.41)	1.61 (1.20–2.17)	0.001	1.59 (1.25–2.03)
Model 2†	1	1.04 (0.75–1.44)	1.55 (1.14–2.11)	0.003	1.52 (1.19–1.94)
Model 3‡	1	1.08 (0.77–1.50)	1.67 (1.22–2.30)	0.001	1.60 (1.24–2.06)
Model 4§	1	1.07 (0.77–1.49)	1.66 (1.20–2.29)	0.001	1.60 (1.24–2.06)

*Adjusted for age and examination years; †adjusted for model 1 and HDL and LDL cholesterol, BMI, family history of ischemic heart disease, systolic blood pressure, maximal oxygen uptake, urinary excretion of nicotine metabolites, serum selenium, and alcohol intake; ‡adjusted for model 2 and serum DHA+DPA as proportion of all fatty acids in serum; §adjusted for model 3 and intake of saturated fatty acids, fiber, and vitamins C and E.

Virtanen, J.K., et al., 2005. *Arterioscler Thromb Vasc Biol* 25:228–233.

Kuopio Ischemic Heart Disease Study – 4-year Change in IMT by Quintile of Hg



Salonen, J.T., et al., 2000. *Atherosclerosis* 148:265–273

British Journal of Nutrition (2001), **86**, 397–404
DOI: 10.1079/BJN2001415
© The Authors 2001

Markers of high fish intake are associated with decreased risk of a first myocardial infarction

C. G. Hallgren[1,4], G. Hallmans[5], J.-H. Jansson[7]*, S. L. Marklund[6], F. Huhtasaari[8], A. Schütz[2], U. Strömberg[2], B. Vessby[3] and S. Skerfving[2]

High intake of fish has been associated with reduced risk of CHD. The high content of *n*-3 polyunsaturated fatty acids (PUFA) in fish has been suggested to be a protective factor. In addition, fish is the entirely dominating source of methylmercury for the general population, and the concentration of Hg in erythrocytes (Ery-Hg) is often used as an index of fish consumption. Our aim was to study the relationships between a first-ever myocardial infarction, Ery-Hg, activity of gluthathione peroxidase in erythrocytes (Ery-GSH-Px) and plasma concentration of the *n*-3 PUFA eicosapentaenoic and docosahexaenoic acids (P-PUFA). In a population-based prospective nested case–control study within Northern Sweden seventy-eight cases of a first-ever myocardial infarction were compared with 156 controls with respect to Ery-Hg, P-PUFA and Ery-GSH-Px. Both Ery-Hg and P-PUFA, but not Ery-GSH-Px, were significantly ($P < 0·0001$) higher in subjects reporting high fish intake (at least one meal per week) than in those with lower intake. This finding suggests that Ery-Hg and P-PUFA reflect previous long-term fish intake. Low risk of myocardial infarction was associated with high Ery-Hg or high P-PUFA. In a multivariate model the risk of myocardial infarction was further reduced in subjects with both high Ery-Hg and high P-PUFA (odds ratio 0·16, 95 % CI 0·04, 0·65). In conclusion, there is a strong inverse association between the risk of a first myocardial infarction and the biomarkers of fish intake, Ery-Hg and P-PUFA, and this association is independent of traditional risk factors.

Västerbotten Intervention Programme – ORs of MI

		Model 1*		Model 2†		Model 3‡	
Factor	Category	OR	95 % CI	OR	95 % CI	OR	95 % CI
Ery-Hg (ng Hg/g erythrocyte)	≤6	1·0	–				
	>6	0·51	0·21, 1·24				
P-PUFA (%)	≤5·5	1·0	–				
	>5·5	0·49	0·26, 0·91				
Ery–Hg × P–PUFA	≤6 and ≤5·5			1·0	–	1·0	–
	≤6 and >5·5			0·58	0·30, 1·11	0·87	0·37, 2·02
	>6 and ≤5·5			1·46	0·31, 6·94	1·09	0·19, 6·23
	>6 and >5·5			0·18	0·06, 0·56	0·16	0·04, 0·65
Smoking status	Non-smoker					1·0	–
	Smoker					2·20	0·95, 5·10
BMI (kg/m²)	≤25					1·0	–
	>25					3·62	1·44, 9·15

OR, odds ratio; Ery-Hg, Hg level in erythrocytes; P-PUFA, sum concentration of *n*-3 polyunsaturated fatty acids 20:5 and 22:6 in blood plasma phospholipids.

* Ery-Hg and P-PUFA considered as two independent factors in the same model. The interaction between these two factors was tested by the likelihood ratio test ($P = 0·10$). Thus, there was a tendency for a multiplicative interaction effect between these two factors (in contrast to model 2).

† Ery–Hg × P–PUFA considered as one factor (each individual was classified according to his or her Ery-Hg and P-PUFA). The numbers of individuals (cases:control subjects) in each category were: ≤6 and ≤5·5,: 34:42; ≤6 and >5·5, 26:60; >6 and ≤5·5, 4:6; >6 and >5·5, 6:32.

‡ Ery–Hg × P–PUFA, smoking status and BMI considered as three independent factors in the same model. The factors serum cholesterol, diastolic blood pressure and education did not contribute significantly to the model (test for linear trend; $P = 0·5$, $P = 0·16$ and $P = 0·9$ respectively).

Hallgren, C.G., et al., 2001. *Br J Nutr* 86:397–404.

Omega-3 Fatty Acids in Adipose Tissue and Risk of Myocardial Infarction
The EURAMIC Study

Eliseo Guallar, Antti Aro, F. Javier Jiménez, José M. Martin-Moreno, Irma Salminen, Pieter van't Veer, Alwine F.M. Kardinaal, Jorge Gómez-Aracena, Blaise C. Martin, Lenore Kohlmeier, Jeremy D. Kark, Vladimir P. Mazaev, Jetmund Ringstad, José Guillén, Rudolph A. Riemersma, Jussi K. Huttunen, Michael Thamm, Frans J. Kok

Abstract—Omega-3 fatty acids have potential antiatherogenic, antithrombotic, and antiarrhythmic properties, but their role in coronary heart disease remains controversial. To evaluate the association of omega-3 fatty acids in adipose tissue with the risk of myocardial infarction in men, a case-control study was conducted in eight European countries and Israel. Cases (n=639) included patients with a first myocardial infarction admitted to coronary care units within 24 hours from the onset of symptoms. Controls (n=700) were selected to represent the populations originating the cases. Adipose tissue levels of fatty acids were determined by capillary gas chromatography. The mean (±SD) proportion of α-linolenic acid was 0.77% (±0.19) of fatty acids in cases and 0.80% (±0.19) of fatty acids in controls ($P=0.01$). The relative risk for the highest quintile of α-linolenic acid compared with the lowest was 0.42 (95% confidence interval [CI] 0.22 to 0.81, *P*-trend=0.02). After adjusting for classical risk factors, the relative risk for the highest quintile was 0.68 (95% CI 0.31 to 1.49, *P*-trend=0.38). The mean proportion of docosahexaenoic acid was 0.24% (±0.13) of fatty acids in cases and 0.25% (±0.13) of fatty acids in controls ($P=0.14$), with no evidence of association with risk of myocardial infarction. In this large case-control study we could not detect a protective effect of docosahexaenoic acid on the risk of myocardial infarction. The protective effect of α-linolenic acid was attenuated after adjusting for classical risk factors (mainly smoking), but it deserves further research. **(*Arterioscler Thromb Vasc Biol.* 1999;19:1111-1118.)**

EURAMIC Study – Study Population

- **Men aged 70 years or younger; native residents of 8 European countries or residents of Israel**
- **Subjects excluded if they had a previous diagnosis of myocardial infarction (MI), drug or alcohol abuse, major psychiatric disorders, if they were institutionalized, or if they had modified their dietary pattern in the past year**

Guallar, E., et al., 2002. *N Engl J Med* 347:1747–1754.

EURAMIC Study – Case Selection

- **Cases were men with a first acute MI, confirmed by ECG and enzyme changes, and hospitalized within 24 hours from the onset of symptoms**
- **Cases were recruited from the coronary care units of participating hospitals**

Guallar, E., et al., 2002. *N Engl J Med* 347:1747–1754.

EURAMIC Study – Control Selection

- **Controls: Men without history of MI, frequency matched to cases in 5-year intervals**
- **In Finland, Israel, Germany, Scotland, and Switzerland, selected by random sampling from local population registers**
- **In Russia and Spain, from patients admitted to hospital for disorders not known to be associated with dietary factors**
- **In the Netherlands, from the catchment area of the patient's general practitioners**
- **In Norway, by inviting friends and relatives of the cases**

Guallar, E., et al., 2002. *N Engl J Med* 347:1747–1754.

Cardiovascular Health Effects of Mercury—European Data

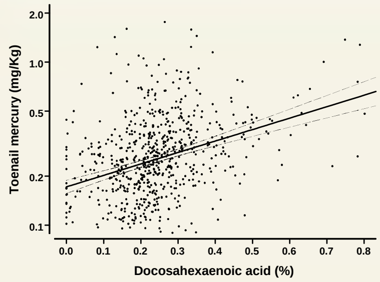
Eliseo Guallar, Johns Hopkins Bloomberg School of Public Health

EURAMIC Study – Description of Cases and Controls

Risk Factor	Patients (N=684)	Controls (N=724)	P Value
Age (yr)	54.7±8.9	53.2±9.3	0.002
Body-mass index†	26.5±3.9	25.9±3.4	0.004
Total cholesterol (mmol/liter)‡	5.46±1.11	5.56±1.10	0.11
HDL cholesterol (mmol/liter)‡	0.98±0.25	1.09±0.29	<0.001
Hypertension (%)§	26.0	17.4	<0.001
Current smoker (%)	61.3	37.5	<0.001
Diabetes mellitus (%)§	8.4	3.9	<0.001
Alcohol intake (g/day)	18.2±27.2	17.8±24.0	0.75¶
Parental history of myocardial infarction (%)	57.6	45.3	<0.001

Guallar, E., et al., 2002. *N Engl J Med* 347:1747–1754.

EURAMIC Study – Association between Hg and DHA among Controls



EURAMIC Study – Case/Control Ratios of Toenail Hg

Center	No. of Patients/ No. of Controls	Patient Participation Rate/ Control Participation Rate	Mean Toenail Mercury Level in Patients/ Mean Toenail Mercury Level in Controls (95% CI)†
		%	
Helsinki, Finland	56/62	97/51	1.16 (0.93–1.44)
Berlin, Germany	75/97	82/73	1.08 (0.90–1.30)
Jerusalem, Israel	57/59	60/53	1.20 (0.99–1.46)
Zeist, the Netherlands	64/57	75/50	0.98 (0.75–1.28)
Sarpsborg, Norway	96/101	96/98	1.03 (0.89–1.19)
Moscow, Russia	92/97	97/79	1.02 (0.85–1.24)
Edinburgh, United Kingdom	39/25	98/61	0.85 (0.65–1.10)
Granada, Spain	55/52	45/67	0.92 (0.70–1.21)
Málaga, Spain	94/100	89/77	1.33 (1.08–1.63)
Zurich, Switzerland	56/74	93/26	0.97 (0.76–1.23)
Overall	684/724	81/64	1.07 (1.00–1.14)
Overall‡			1.10 (1.03–1.18)
Overall§			1.15 (1.05–1.25)

†The ratios have been adjusted for age (continuous variable) and center (indicator variable). The P value for heterogeneity by center was 0.22. CI denotes confidence interval.

‡The ratios have been adjusted for age, center, and docosahexaenoic acid level (continuous).

§The ratios have been adjusted for age, center, docosahexaenoic acid level, body-mass index (continuous), smoking (indicator variables for current smokers and former smokers), high-density lipoprotein cholesterol (continuous), history of hypertension (indicator variable), diabetes (indicator variable), alcohol intake (indicator variables for current and former drinkers), adipose-tissue α-tocopherol level (continuous), adipose-tissue β-carotene level (continuous), toenail selenium (continuous), and toenail weight (continuous).

Guallar, E., et al., 2002. *N Engl J Med* 347:1747–1754.

EURAMIC Study – Odds Ratios of MI by Quintile of Toenail Hg

Measure	Quintile 1	2	3	4	5	P for Trend
Mercury Median (µg/g)	0.11	0.17	0.24	0.36	0.66	
	odds ratio (95% CI)					
Model 1†	1.00	0.86 (0.61–1.22)	1.01 (0.71–1.44)	1.08 (0.76–1.55)	1.47 (0.99–2.14)	0.01
Model 2‡	1.00	0.93 (0.64–1.36)	1.11 (0.76–1.63)	1.24 (0.83–1.84)	1.86 (1.20–2.91)	0.001
Model 3§	1.00	0.86 (0.49–1.50)	1.18 (0.67–2.07)	2.08 (1.12–3.84)	2.16 (1.09–4.29)	0.006

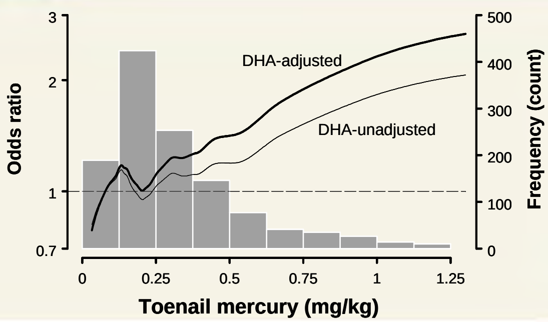
†Model 1 is adjusted for age (continuous variable) and center (indicator variable).

‡Model 2 is further adjusted for DHA (docosahexaenoic acid) (continuous variable) when the relative risk in mercury quintiles is modeled and is adjusted for mercury (continuous variable) when the relative risk in DHA quintiles is modeled.

§Model 3 is further adjusted for body-mass index (continuous), waist:hip ratio (continuous), smoking status (indicator variables for current smokers and former smokers), alcohol intake (indicator variables for current and former drinkers), high-density lipoprotein cholesterol (continuous), diabetes (indicator variable), history of hypertension (indicator variable), parental myocardial infarction (indicator variable), α-tocopherol level (continuous), β-carotene level (continuous), toenail selenium level (continuous), and toenail weight (continuous).

Guallar, E., et al., 2002. *N Engl J Med* 347:1747–1754.

EURAMIC Study – Non-parametric Odds Ratios of MI by Level of Toenail Hg



Guallar, E., et al., 2002. *N Engl J Med* 347:1747–1754.

EURAMIC Study – Odds Ratios of MI by Quintile of Adipose Tissue DHA

Measure	Quintile 1	2	3	4	5	P for Trend
DHA Median (%FA)	0.10	0.16	0.22	0.28	0.44	
	odds ratio (95% CI)					
Model 1†	1.00	1.13 (0.80–1.61)	1.26 (0.87–1.83)	1.27 (0.87–1.88)	0.80 (0.53–1.23)	0.23
Model 2‡	1.00	1.07 (0.75–1.54)	1.15 (0.79–1.66)	1.07 (0.72–1.58)	0.66 (0.42–1.03)	0.01
Model 3§	1.00	1.07 (0.63–1.84)	1.12 (0.64–1.94)	0.83 (0.47–1.49)	0.59 (0.30–1.19)	0.02

†Model 1 is adjusted for age (continuous variable) and center (indicator variable).

‡Model 2 is further adjusted for DHA (docosahexaenoic acid) (continuous variable) when the relative risk in mercury quintiles is modeled and is adjusted for mercury (continuous variable) when the relative risk in DHA quintiles is modeled.

§Model 3 is further adjusted for body-mass index (continuous), waist:hip ratio (continuous), smoking status (indicator variables for current smokers and former smokers), alcohol intake (indicator variables for current and former drinkers), high-density lipoprotein cholesterol (continuous), diabetes (indicator variable), history of hypertension (indicator variable), parental myocardial infarction (indicator variable), α-tocopherol level (continuous), β-carotene level (continuous), toenail selenium level (continuous), and toenail weight (continuous).

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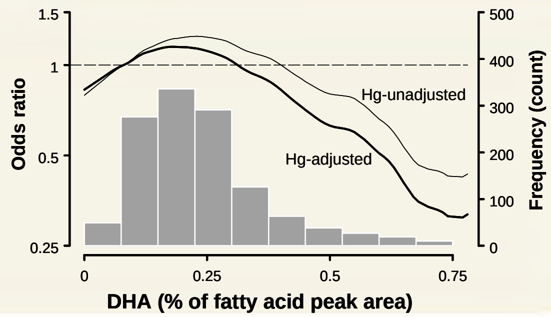
EURAMIC Study – Non-parametric Odds Radios of MI by Level of Adipose Tissue DHA



Guallar, E., et al., 2002. *N Engl J Med* 347:1747–1754.

EURAMIC Study – Strengths and Limitations

- **Strengths**
  - Large sample size
  - Use of toenail Hg / neutron activation analysis
  - Use of adipose tissue DHA
  - Multicenter design
- **Limitations**
  - Case-control design
  - Lack of data on dietary intake
  - Measurement error
  - Non-fatal cases of MI

Conclusions

- More data is needed to assess the effect of Hg on CVD
- Hg seems to oppose the effect of n-3 fatty acids in fish
- Effect of Hg needs to be analyzed in combination with effect of n–3 fatty acids
- Other contaminants / micronutrients in fish may also need to be considered

Developmental Toxicity of PFOS and PFOA

Christopher Lau, U.S. Environmental Protection Agency

Developmental Toxicity of PFOS and PFOA

Christopher Lau

Reproductive Toxicology Division
National Health and Environmental Effects Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency

In Recent Press

Safety of nonstick cookware unresolved (Charlotte Observer, Aug 17, 2005)

Consumers should be aware of controversy before using products

After more than two years of study by the federal government, questions concerning the safety of nonstick cookware remain unresolved…. The questions center around a man-made chemical called perfluoroctanoic acid – PFOA for short. PFOA is used in the production of Teflon and other nonstick-coated cookware and water-, grease- and stain-repellent products used in carpet, fabric, paper, leather and other goods.

EPA charges DuPont hid Teflon's risks (Chicago Tribune, Jan 18, 2005)

U.S. orders study on health perils of key chemical

More than 50 years after DuPont started producing Teflon near this Ohio River town, federal officials are accusing the company of hiding information suggesting that a chemical used to make the popular stick- and stain-resistant coating might cause cancer, birth defects and other ailments. Environmental regulators are particularly alarmed because scientists are finding perfluorooctanoic acid, or PFOA, in the blood of people worldwide, and it takes years for the chemical to leave the body. The U.S. Environmental Protection Agency reported last week that exposure even to low levels of PFOA could be harmful.

What Are PFOS and PFOA?

- Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA) belong to a family of perfluoroalkyl acids (PFAA) that have a carbon backbone (4-15) fully substituted by fluorine and a functional group of sulfonic or carboxylic acid.
- These chemicals are man-made (in existence in the last 50 years); very stable, hydrophobic, and oleophobic; and are terminal metabolites of their derivative products.
- Their surfactant properties lend themselves to wide (> 200) industrial and consumer applications. In 2000, global production of PFOS was estimated at 3,500 metric tons/year and PFOA at 500 metric tons/year.
- Because of environmental concerns, 3M phased out production of PFOS by the end of 2002, but replacement PFAA are poised to take up the market void left by PFOS.

Environmental Exposure – Humans

Sources	Serum Levels (ppb)
Production workers	300-8,000 (2,500)
Non-production employees	28-96 (47)
Human serum samples	7-82 (28)
Blood bank pools	9-56 (30)
Children	7-515 (44)

G. Olsen

Environmental Exposure – Wildlife

Sources	Liver (ppb)	Plasma (ppb)
Marine mammals	400-500	10-100
Fresh water mammals	300-2600	–
Birds	400-600	400-500
Fish	50-100	–
Turtles and Frogs	200-300	100
Polar bears	180-680	–

J. Geisy and K. Kannan

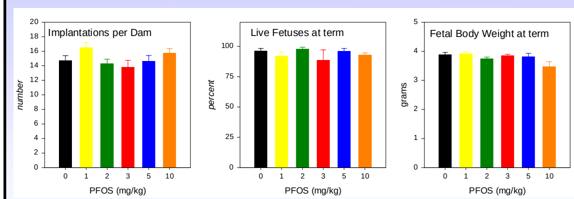
Agency Concerns

- PFAA are stable, persistent, and bio-accumulated in the environment.
- PFOS (C8), PFOA (C8), and PFHS (C6) have been detected in humans, while PFOS, PFOA, and PFNA (C9) are found in the wildlife.
- These chemicals are distributed globally, but their fate, transport, and exposure routes are not well characterized.
- Most of these chemicals are readily absorbed, but poorly eliminated. Estimated half-life in humans for PFOS is 5.4 yr; PFOA, 3.8 yr; PFHS (C6), 8.7 yr; and PFBS (C4), 2-3 wk.
- Results from laboratory animal studies indicated developmental toxicity, hepatotoxicity, immunotoxicity, carcinogenicity, metabolic, and endocrine-disrupting potentials of these chemicals, but modes of their action are ill-defined.
- Replacement products of PFOS are in the market or being developed, yet little is known about their health-risk potentials.

Developmental Study of PFOS

- **PFOS**
  - Potassium salt, Fluka/3M
  - Prepared in 0.5% Tween-20 Vehicle
- **Animal Models**
  - Sprague-Dawley rat:
    GD 2-21, 1, 2, 3, 5, 10 mg/kg
  - CD-1 mouse:
    GD 1-18, 1, 5, 10, 15, 20 mg/kg

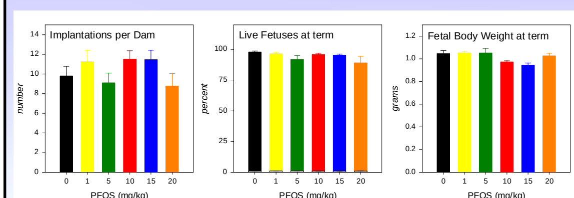
Prenatal Findings: Rat



Notable Malformations in Rat Fetuses at Term

	Control	1 mg/kg	2 mg/kg	3 mg/kg	5 mg/kg	10 mg/kg
Cleft palate %	0	9 ± 9	14 ± 14	10 ± 10	0	60 ± 13
# Sternal defects/f	1.2 ± 0.3	1.7 ± 0.3	2.1 ± 0.3	2.6 ± 0.2	2.1 ± 0.2	3.4 ± 0.4
Anasarca %	0	0	0	18 ± 9	17 ± 8	44 ± 12
Large rt. atrium %	0	2 ± 2	8 ± 8	0	23 ± 7	9 ± 4
Vent. sep. defect %	0	0	0	0	13 ± 6	15 ± 5

Prenatal Findings: Mouse



Notable Malformations in Mouse Fetuses at Term

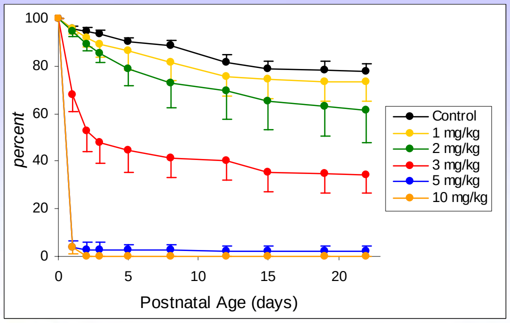
	Control	1 mg/kg	5 mg/kg	10 mg/kg	15 mg/kg	20 mg/kg
Cleft palate %	0	0	0	2 ± 2	21 ± 8	73 ± 12
# Sternal defects/f	0.5 ± 0.1	–	–	2.1 ± 0.2	2.6 ± 0.2	3.3 ± 0.7
Large rt atrium %	0	–	–	26 ± 8	23 ± 7	35 ± 9
Vent. sep. defect %	2 ± 2	–	–	5 ± 3	5 ± 3	30 ± 16

Influences of PFOS on prenatal development of rat and mouse are unremarkable …

Developmental Toxicity of PFOS and PFOA

Christopher Lau, U.S. Environmental Protection Agency

Postnatal Survival: Rat

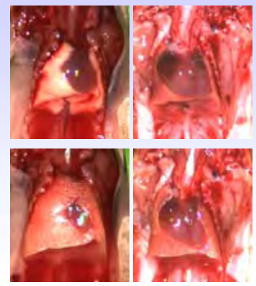


Newborn Rat Lung

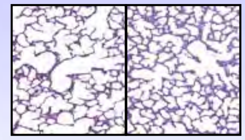
Control PFOS

Pre

Post

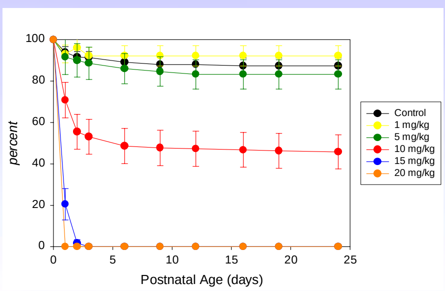


Control PFOS



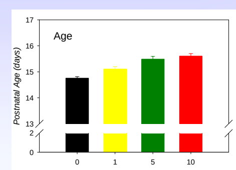
PFOS (mg/kg)	Air Space (%)	Septal Space (%)
0	63.9 ± 1.5	31.6 ± 1.3
5	56.7 ± 2.1	41.2 ± 2.0
10	55.2 ± 2.2*	43.6 ± 1.9

Postnatal Survival: Mouse

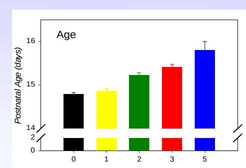


Eye Opening

Rat



Mouse



… on the other hand, *in utero* exposure to PFOS profoundly compromised the survival of the newborn rodents, most likely due to pulmonary insufficiency. Postnatal growth and development are also adversely impacted by PFOS.

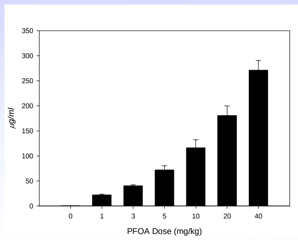
Developmental Study of PFOA

- Major sex difference in PFOA elimination in rat: serum $t_{½}$ in males = 7.4 days, in females = 3.7 h after oral exposure; PFOA was undetectable 24 h after treatment in pregnant rat.
- Unremarkable developmental toxicity findings with rat: delayed sex maturation in high dose group (30 mg/kg).
- No significant gender differences found in humans and primates.
- Mouse as alternative animal model: serum $t_{½}$ in males = 19.1days and in females = 16.6 days after oral exposure.

Study Design

- CD-1 mouse
- PFOA-NH_4^+
- GD 2-18

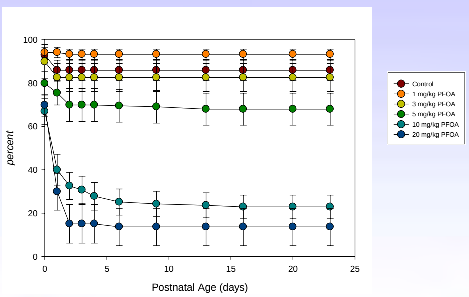
Maternal serum PFOA at term



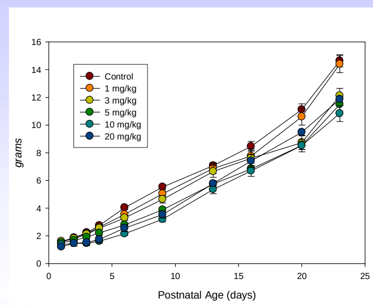
Prenatal Findings of PFOA – Mouse

	Control	1 mg/kg	3 mg/kg	5mg/kg	10 mg/kg	20 mg/kg
Prenatal loss (%)	4.1 ± 1.4	1.0 ± 0.7	7.4 ± 2.5	2.4 ± 0.8	7.7 ± 3.3	25.9 ± 11.7
Fetus weight (g)	1.05 ± 0.02	0.98 ± 0.03	1.03 ± 0.04	1.03 ± 0.04	0.98 ± 0.05	0.86 ± 0.11
Ossified sternabrae (#)	5.9 ± 0.1	6.0 ± 0.1	6.0 ± 0.1	5.5 ± 0.3	5.7 ± 0.2	4.0 ± 1.1
Ossified caudal vertebrate (#)	4.3 ± 0.3	4.1 ± 0.1	4.0 ± 0.2	4.3 ± 0.3	3.7 ± 0.2	2.1 ± 0.7
Ossified proximal forelimb (#)	4.8 ± 0.8	1.8 ± 1.0	2.2 ± 0.9	2.9 ± 0.9	1.0 ± 0.6	0
Ossified proximal hindlimb (#)	3.9 ± 0.9	0.4 ± 0.3	1.5 ± 1.0	2.8 ± 0.9	1.0 ± 0.6	0
Calvaria (%)	13.5 ± 9.2	62.5 ± 15.5	66.7 ± 13.0	22.7 ± 10.4	35.0 ± 12.7	55.0 ± 20.0
Enlarged fontanel (%)	17.3 ± 9.1	66.7 ± 21.1	53.6 ± 15.8	18.29.6	45.0 ± 20.0	95.0 ± 5.0
Microcardia (%)	0	0	0	0	5.0 ± 5.0	30.0 ± 18.3

Postnatal Survival



Postnatal Growth



Developmental Landmarks

	Eye opening		Vaginal opening		First estrus		Preputial separation	
PFOA Dose (mg/kg)	N	Age (days)	N	Age (days)	N	Age (days)	N	Age (days)
0	22	14.8 ± 0.1	54	28.9 ± 0.4	47	29.9 ± 0.4	56	30.5 ± 0.2
1	8	15.2 ± 0.2	21	27.9 ± 0.6	21	28.2 ± 0.6	22	26.7 ± 0.2
3	8	15.5 ± 0.1	21	28.8 ± 0.4	21	30.2 ± 0.4	20	27.1 ± 0.2
5	17	16.0 ± 0.2	43	29.9 ± 0.4	43	31.8 ± 0.5	46	28.2 ± 0.2
10	13	17.2 ± 0.3	28	29.3 ± 0.3	27	30.2 ± 0.3	28	28.5 ± 0.3
20	3	17.9 ± 0.8	11	31.3 ± 0.5	8	30.9 ± 0.4	4	31.7 ± 1.1

Summary

- Developmental toxicity of PFOS and PFOA are indicated in laboratory rodent models.
- Survival at birth, postnatal growth, and development are compromised by chemical exposure during pregnancy and lactation.
- Effects of these chemical exposures on maturation of physiological functions should be investigated.
- Body burdens of PFOS and PFOA in the animal models should reflect the exposure levels and can be correlated with human levels (CDC/NHANES) for MOE estimation.
- Routes of human exposure to these chemicals must be investigated.

PFAA Contaminants in Lake Trout from the Great Lakes

in ppb	PFOS (C8)	PFDS (C10)	PFOA (C8)	PFNA (C9)	PFDA (C10)	PFUnA (C11)	PFDoA (C12)
Lake Erie	410	11.7	0.7	4.9	3.9	3.1	1.1
Lake Ontario	137	4.7	0.9	3.0	1.6	1.9	0.9
Lake Huron	113	0.4	0.8	5.8	1.6	2.3	0.9
Lake Michigan	48	1.4	2.4	1.3	0.4	0.7	0.5
Lake Superior	15	0.9	0.9	2.2	0.5	0.9	0.4

V. Furdui and S. Mabury

ORD NHEERL

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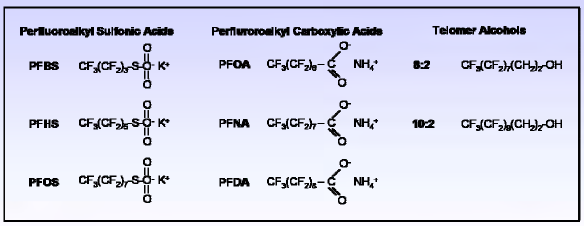
PFAA Commonly Found in the Environment



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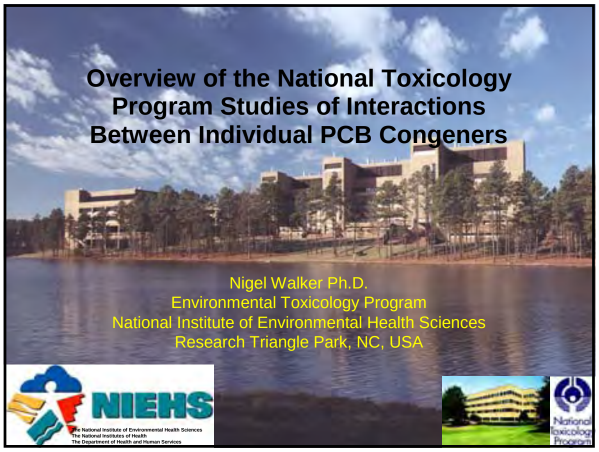
Overview of the National Toxicology Program Studies of Interactions between Individual PCB Congeners

Nigel Walker, National Institute of Environmental Health Sciences, National Institutes of Health



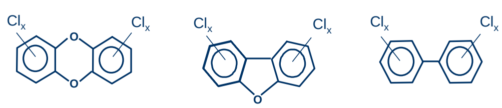
Effects of PCBs

- Extensive body of literature on PCB mixtures and individual PCBs
- Health effects
  - Reproductive
  - Endocrine
  - Neurological
  - Immunological
- Carcinogenicity
  - Demonstrated carcinogenicity of PCB mixtures (e.g., aroclors) in laboratory animals
    - Probable human carcinogens
  - Liver (hepatocellular) neoplasms as primary response
- Quantitative cancer risk assessment approaches
  - PCB effects of a mixture
  - Dioxin-like effects of mixture.

Toxic Equivalency Factors (TEFs)

- A risk-assessment tool
- Used for estimating exposure to mixtures of "dioxins"
- Single potency factor relative to 2,3,7,8-TCDD
- Calculate index chemical equivalent dose (ICED)
- Total equivalents (TEQ) =

  ∑([individual "dioxin"] x respective TEF)

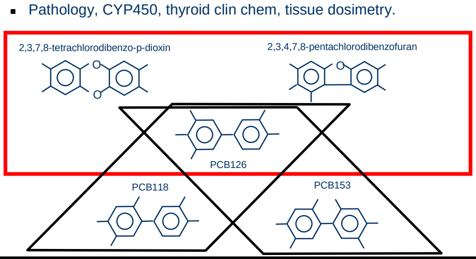


Evaluating the TEF concept

- TEF methodology nominated for evaluation by the NTP
- Dose additivity for carcinogenicity of mixture vs. individual
  - Are the shapes of individual dose-response curves the same?
  - Are the effects seen for a mixture dose additive?
  - Is the effect for a TEQ mixture same as TCDD alone?
- Testing interactions between different classes of PCBs
  - Evaluate carcinogenic potency of specific PCBs
    - No chronic carcinogenicity studies of individual congeners
  - Is the potency of a dioxin-like PCB affected by co-exposure to other PCBs?

The NTP Dioxin TEF Evaluation

- Chronic 2-year rat cancer studies
  - Female Harlan Sprague-Dawley rats; 5 days/week for 2 years
  - Multiple doses, interim studies at 14, 31, 53 weeks
  - Pathology, CYP450, thyroid clin chem, tissue dosimetry.



Phase I – Summary Results

- TCDD, PCB 126, PeCDF, and TEF mixture
- Expected increases in dioxin responses
  - Increases in CYP1 expression
  - Lower T4 and increased T3 for all studies
  - Increased TSH at early time points
- Hepatotoxicity
  - Increase in incidence and severity
- Non-neoplastic effects in multiple organs
- Increased incidence of neoplasms
  - Liver
    - Cholangiocarcinoma
    - Hepatocellular adenoma
  - Lung-cystic keratinizing epithelioma
  - Oral Mucosa-squamous cell carcinoma.

Overview of the National Toxicology Program Studies of Interactions between Individual PCB Congeners

Nigel Walker, National Institute of Environmental Health Sciences, National Institutes of Health

General Findings – Cancer Data

- Dose-response models of four core studies
  - TCDD, PeCDF, PCB126, and TEF mixture
  - Administered dose for all tests
- Evaluating same shape dose-response curves
  - Non-linear behavior
  - Cannot reject they have same shape
- Dose additive model for the mixture
  - Cannot reject at p<0.01.

Walker, N.J., P. Crockett, et al., 2004. Dose-additive carcinogenicity of a defined mixture of "dioxin-like compounds." *Environ Health Perspect* doi:10.1289/ehp.7351.

Potency Factors Close to TEF Values

	PCB126	PeCDF	TEF Mixture
WHO TEF	0.1	0.5	(1.0)
Cholangiocarcinoma	0.11	0.16	0.98
Hc adenoma	0.10	0.35	1.02
Lung CKE	0.19	0.34	1.21
Gingival SCC	0.09	0.24	0.467
CYP1A1	0.02 - 0.19	0.1 - 0.44	0.63 - 2.27
CYP1A2	0.17 - 0.51	0.17 - 0.47	0.51 - 0.80

Phase 2 – PCB Interaction Studies

- PCB153
  - Highest abundance PCB in human tissues on a mass basis
  - Not in TEF scheme
- PCB126: PCB153 mixture
  - Interaction between non-ortho and di-ortho PCBs
- PCB126: PCB118 mixture
  - Additivity of non-ortho and mono-ortho PCBs
  - Initially planned as a study of PCB118 alone
    - PCB126 "contamination" of 0.6% prompted reclassification as mixture
- PCB118 (study still in life phase)
  - Restarted study (99% predicted TEQ attributed to PCB118)
  - Highest abundance mono-ortho PCB in human tissue
  - Highest TEQ contributor of mono-ortho class in TEF scheme.

Summary of Effects of PCB153

- Equivocal evidence of carcinogenicity
  - Occurrences of rare cholangiomas
- Liver
  - Increased cytochromes P450 activity
    - Liver PROD increased at all doses 100 μg/kg and higher at all times
    - Weak increase on liver EROD and ACOH
  - Hepatoctye hypertrophy, fatty change, bile duct hyperplasia, oval cell hyperplasia
- Thyroid
  - Decreases in T3 and T4; no effect on TSH
  - Increase in incidence of follicular cell hypertrophy
- Other tissues
  - Inflammatory responses in ovary, oviduct, and uterus.

PCB Mixtures Summary

- PCB 126/PCB153 and PCB126/118
- Increased incidence of neoplasms in multiple organs
  - Liver – Cholangiocarcinoma and hepatocellular adenoma
  - Lung – Cystic keratinizing epithelioma
  - Oral Mucosa – Squamous cell carcinoma
- Expected increases in dioxin-like responses
  - Increases in CYP1 expression at all doses, all times, in both studies
  - Lower T4 and increased T3 for both studies, inconsistent effect on TSH
- Hepatotoxicity
  - Dose- and duration-dependent increase in incidence and severity
- Non-neoplastic effects in multiple organs
  - Notably lung, oral mucosa, pancreas, adrenal cortex, thyroid, thymus, and kidney.

Neoplasm	TCDD	126	PeCDF	Mix	126/153	126/118	153
Cholangiocarcinoma	+++	+++	++	+++	+++	+++	
Hepatocellular adenoma	+++	++	++	+++	+++	+++	
Hepatocellular carcinoma					+	+	
Cholangioma	+	+				+	+
Hepatocholangioma	+	++			+++	+	
Lung – cystic keratinizing epithelioma	+++	+++	+	+++	+++	+++	
Lung – SCC		+			+		
Gingival – SCC	+++	+++	++		+++	++	
Pancreas – adenoma/ carcinoma	+		+	+	++		
Uterus – SCC	++				+		
Uterus – adenoma/ carcinoma			+				
Adrenal cortex – adenoma/ carcinoma		+					

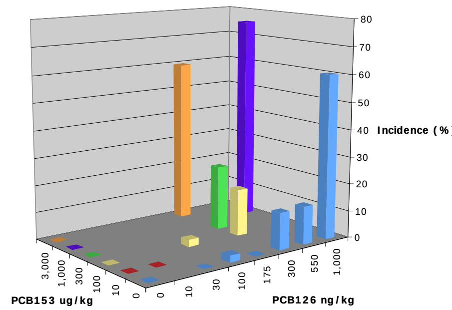
Overview of the National Toxicology Program Studies of Interactions between Individual PCB Congeners

Nigel Walker, National Institute of Environmental Health Sciences, National Institutes of Health

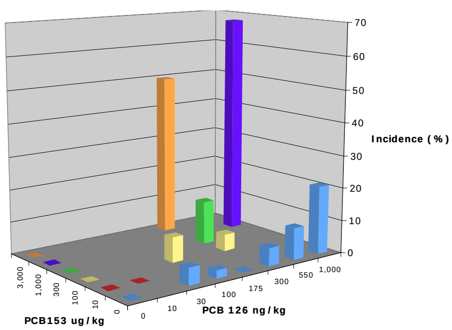
PCB126/153 Mixture Design

PCB153 (μg/kg)	PCB 126 (ng/kg)				
	0	10	100	300	1000
0	Group 1		TR520	TR520	TR520
10	TR529	Group 2			
100	TR529		Group 3	Group 4	
300	TR529			Group 5	
1,000	TR529				Group 7
3,000	TR529			Group 6	

Cholangiocarcinoma



Hepatocellular Adenoma



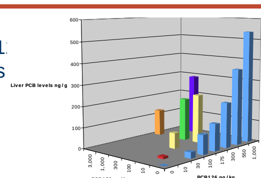
Liver Non-neoplastic Interactions

- Effect of PCB153 on incidence induced by PCB126 at 300 ng/kg
- Decreased with increasing PCB153
  - Liver – EROD – 53 weeks
  - Liver – PCB126 ng/g concentration
- Increased with increasing PCB153
  - Hepatocyte hypertrophy
  - Fatty change, diffuse
  - Fatty change focal
  - Basophilic focus
  - Eosinophilic focus
  - Clear cell focus
  - Cholangiofibrosis
  - Bile duct hyperplasia
  - Liver EROD – 14 weeks

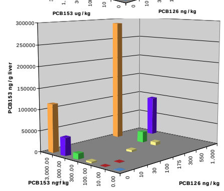
Pharmacokinetic Interactions – Liver

- Lower levels of PCB1: in co-exposed groups

PCB126

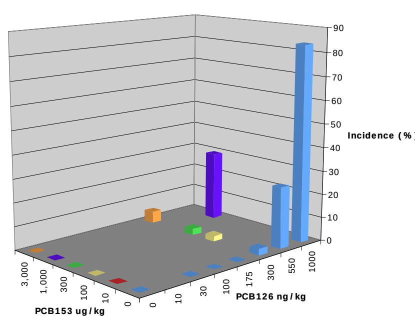


- Increase in PCB153 in the liver in co-exposed group



PCB153

Cystic Keratinizing Epithelioma



Overview of the National Toxicology Program Studies of Interactions between Individual PCB Congeners

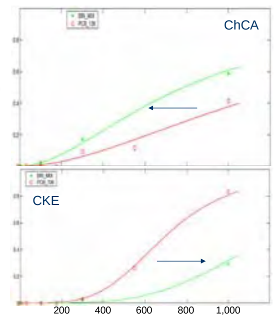
Nigel Walker, National Institute of Environmental Health Sciences, National Institutes of Health

Lung – Interactions

	300 ng126/kg + μg153/kg				126:153	126 alone
	0	100	300	3000	1000:1000	1000
Animals examined	53	50	53	50	52	51
AE, metaplasia, bronchiolar	39*	39	34	30*	32*	40*
Cystic keratinizing epithelioma	1	1	1	1	11*	35*
PCB126 ng/g – 2 years	553	902	459	478	479	1842

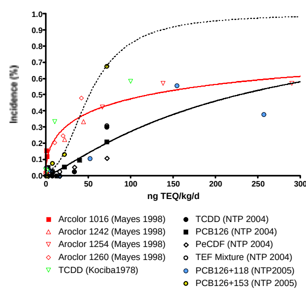
Altered Potency of PCB126 by PCB153

- Modeled assuming same shape of dose-response curve
- Cholangiocarcinoma (ChCA)
  - PCB126 alone
    - ED_{50}=952 ng/kg
  - In presence of PCB153
    - ED_{50}=556 ng/kg
    - 1.7x increase in potency
- Cystic keratinizing epithelioma (CKE)
  - PCB126 alone
    - ED_{50}=698 ng/kg
  - In presence of PCB153
    - ED_{50}=1213 ng/kg
    - 1.7x decrease in potency.



NTP Bioassays in Perspective

- Lower potency vs. aroclor studies
- Lower potency vs. TCDD dosed feed study (Dow)
- Why?
  - Rat stock differences
  - Pharmacokinetics
    - Dietary vs. gavage
- PCB interactions?
  - Higher potency in PCB126/153 study.



Implications

- Support for the concept of TEFs and dose additivity for mixtures
- Interactions can impact interpretation of TEQ in mixtures of PCBs with multiple modes of action.

Thanks

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J. Cullen
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L. Birnbaum
M. DeVito

National Toxicology Program

- Multi-agency program headquartered at NIEHS
  - NIEHS/NIH, NIOSH/CDC, NCI, NCTR/FDA
  - Sponsored by the U.S. taxpayers
- Not a “regulatory” agency – does not set policies
- Coordinates toxicological research/testing in DHHS
  - Strengthen the science base in toxicology
  - GLP-compliant studies
  - Provide information to health regulatory agencies and the public
- Data are publicly available
  - ntp-server.niehs.nih.gov
  - liaison@starbase.niehs.nih.gov
  - (919) 541-0530

National Toxicology Program

Establishing PCB Fish Advisories: Consideration of the Evolving Science

John D. Schell, Ph.D.
BBL Sciences
Houston, TX

Types of PCB Fish Advisories

1. Risk/consumption-based: Great Lakes Sport Fish Advisory Task Force (1993)
2. FDA-based: Based on established tolerance level (2 ppm)

Risk/Consumption Based

- Fish consumption goes up ⇒ Allowable fish tissue level goes down
- Example from GLSFATF:
  - 0.2 ppm – 1 meal per week
  - 1.9 ppm – 6 meals per year.

How Are the Risk-Based Advisories Established?

- Consumption results in a dose
- Risk associated with that dose determined using state or federally promulgated toxicity factors.

PCB Risk-Based Advisories

Establish trigger level:

1. Using toxicity factors (e.g., CSF) derived from aroclor mixtures (U.S. EPA, 1996); PCBs in fish tissue reported in aroclor equivalents.
2. Using toxicity factors from aroclor mixtures (U.S. EPA, 1996); PCBs in fish tissue reported as “total PCBs.”
3. Using toxicity factors derived from PCB congeners using TEF approach (U.S. EPA, 2003); PCBs in fish tissue reported as individual congeners.

Procedure 1: Aroclor Based

- Establish trigger level using toxicity factors (e.g., CSF) derived from aroclor mixtures.
- For exposure via fish consumption, use the upper bound CSF from aroclor 1254 – 2.0 per mg/kg/day (U.S. EPA, 1996).
- Trigger level is concentration plus consumption rate corresponding to an “acceptable risk.”
- Survey data reported as aroclor equivalents and individual aroclor concentrations summed for total PCBs.

Procedure 1: Advisory Level and Compliance Are Aroclor Based

Advantages:

1. Aroclor-based toxicity factors consider response to multiple PCB congeners.
2. Current CSF based on well-performed studies.
3. Allows consistency with historical approaches.
4. Laboratory costs significantly lower than alternatives.

Procedure 1: Advisory and Compliance Are Aroclor Based

Disadvantages:

1. Mixture in fish not represented by aroclor mixtures.
2. Because of "weathering" may underestimate PCB concentration.
3. Some "dioxin-like" PCBs may be proportionally higher, potential for underestimating risk from these congeners.

Procedure 2: Advisory Aroclor-Based Toxicity; Compliance Total PCBs in Tissue

- Establish advisory level using toxicity factors (e.g., CSF) derived from aroclor mixtures.
- Survey data reported as individual congeners or homologues, summed and expressed as "total PCBs."

Procedure 2: Advisory Aroclor-Based Toxicity; Compliance Total PCBs in Tissue

Advantages:

1. Aroclor-based toxicity factors consider response to multiple PCB congeners.
2. Current CSF based on well-performed studies.
3. Analysis accounts for ***all*** congeners present in tissue, total PCBs not underestimated.

Procedure 2: Advisory Aroclor-Based Toxicity; Compliance Total PCBs in Tissue

Disadvantages:

1. Congener or homologue pattern may differ among reaches, but assume all equivalent.
2. Applying aroclor-based advisory level to variable patterns may under- or over-estimate risk.
3. Analytical costs, especially for congener-specific data, very high.

Procedure 3: Advisory Is Congener (TEF) Based; Compliance Is Congener Based

Develop fish advisory level:

- Advisory level actually based on 2,3,7,8-TCDD cancer potency.
- Establish acceptable dioxin concentration based on TCDD CSF.
- Apply TEFs for PCBs to determine compliance.

Issue an Advisory?

- Assign dioxin-like PCB congener a dioxin toxic equivalency factor (TEF) (WHO, 1998)
  - [NTP recently completed cancer bioassay to confirm TEF of 0.1 for PCB-126 (3,3',4,4',5-Pentachlorobiphenyl)]
- Multiply tissue congener concentration by specific TEF – dioxin equivalent concentration
- Add dioxin equivalent concentration – total dioxin toxic equivalency (TEQ).

What Approach Should Be Used?

Selection criteria:

1. Protect public health
2. Ability to implement the program
   - Analytical cost
   - Interpret results.

Are Procedures Equally Protective?

- Example: Housatonic River Data – but **NOT** the actual risk assessment!
  - "Total PCB" in Fish Tissue: 1.3 mg/kg
  - PCB-TEQ in Fish Tissue: 9.4 ng/kg*
  - Assume 32 grams/day; 70 kg body weight

* TEQ dependent on accumulation of PCB-126 (TEF – 0.1)

Are Procedures Equally Protective?

Source of CSF	Cancer risk
Aroclor CSF	1.2×10^{-3}
Current U.S. EPA dioxin CSF	6×10^{-4}
Proposed U.S. EPA dioxin CSF	4.3×10^{-3}
Cal/EPA dioxin CSF	1×10^{-4}

- Same [tPCB] different TEQ

Cost – Benefit Considerations

- Cost of approach a consideration – need to be able to adequately monitor waters of the state
- Aroclor analysis: $100
- PCB homologues: $245
- PCB congeners: $495 to $950.

Need to Adopt an Alternative Approach?

If the TEQ cancer potency of "dioxin-like PCBs" in fish is *greater* than the aroclor cancer potency of total PCBs.

Summary

- Aroclor-based toxicity factors adequately protective of public health.
- Use of homologues to estimate total PCBs in fish tissue addresses concerns that environmental mixture different from commercial mixture.
- Given uncertainties associated with TEQ approach, hypothetical "protectiveness" not commensurate with additional cost.

History of Mercury Action Level and PCB Tolerance

P. Michael Bolger, Ph.D., DABT
Center for Food Safety and Applied Nutrition
U.S. Food and Drug Administration
College Park, MD

Overview

- Statutory safety/risk thresholds and/or standards for contaminants
- Methylmercury – establishment of fish and shellfish action level
- Polychlorinated biphenyls (PCBs) – establishment of fish and shellfish tolerance

Food Adulteration Standards Federal Food, Drug, and Cosmetic Act

Contaminants – 402(a)(1) "If it bears or contains any poisonous or deleterious substance which may render it injurious to health: but in case the substance is not an added substance such food shall not be considered adulterated under this clause if the quantity of such substance in such food does not ordinarily render it injurious to health."

Methylmercury (MeHg) in Fish

- Mass poisoning episodes in Japan in the 1950s and 60s resulted from environmental contamination and accumulation of methylmercury (MeHg) in fish.
- Health effects included significant and gross developmental abnormalities and death.
- Poisoning outbreaks in Iraq resulted from grain treated with MeHg used to make bake goods, which also resulted in significant morbidity and mortality.

Mercury Action Level

- Action level of 0.5 ppm established in 1969.
- Action level reviewed in 1970 by expert study group (FDA and non-FDA scientists) and reaffirmed.
- Action level reviewed in 1971 by *ad hoc* U.S. and Canadian committee and reaffirmed.
- In 1974, proposal published to establish action level of 0.5 ppm by formal rulemaking.
- In 1979, proposal is withdrawn and an action level of 1 ppm is established.

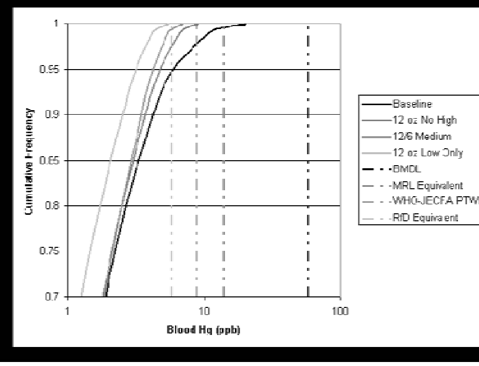
Mercury Action Level

- Proposed action level of 0.5 ppm was withdrawn in 1979 and set at 1 ppm because of 2 issues raised in the *Anderson Seafoods* case involving swordfish.
  - Newer analysis indicated MeHg exposure via fish was less than originally estimated.
  - Analysis of dose-response data of newer data (e.g., Swedish fisherman) indicated the practical threshold for adult effect (parathesia) was greater than 50 ppm (hair).
- In 1984, action level was changed from total mercury to methylmercury.

FDA – 1994 MeHg Advisory

- *FDA Consumer* magazine (September 1994)
  - Importance of fish as source of protein
  - Consumption of a variety of fish
  - Pregnant women and women of child-bearing age limit consumption of swordfish and shark to no more than once a month
  - For the remainder of the population limit consumption of these species to no more than once a week.

Estimated Mercury Hair Levels in Women of Child-Bearing Age (ages 16 – 49)



FDA – Current MeHg Advisory

(http://www.cfsan.fda.gov/~dms/admehg.html)

1. Do not eat shark, swordfish, king mackerel, or tilefish because they contain high levels of mercury.
2. Eat up to 12 oz (2 average meals) a week of a variety of fish and shellfish that are lower in mercury.
   - 5 of the most commonly eaten fish that are low in mercury are shrimp, canned light tuna, salmon, pollock, and catfish.
   - Another commonly eaten fish, albacore ("white") tuna has more mercury than canned light tuna. So, when choosing your 2 meals of fish and shellfish, you may eat up to 6 oz (1 average meal) of albacore tuna per week.
3. Check local advisories about the safety of fish caught by family and friends in your local lakes, rivers, and coastal areas. If no advice is available, eat up to 6 oz (1 average meal) per week of fish you catch from local waters, but don't consume any other fish during that week.

Statutory Food Adulteration Standards – Federal Food, Drug, and Cosmetic Act

- Sec. 406. TOLERANCE FOR POISONOUS INGREDIENTS IN FOOD (Contaminants), Sec. 402(a)(1) applies and depending on substance being "added," "may or ordinarily render it injurious to health" applies, but also consider detectability, avoidability, multi-source exposure, competing dietary risks
- Sec. 409. FOOD ADDITIVES (Safe use), "reasonable certainty of no harm" – safety factors prescribed

PCB Food Tolerances

- In 1972, due to presence in diet and documented toxicity in laboratory animals and episodes of human intoxication, tolerances in several food groups were proposed, including 5 ppm in fish.
- In 1973, a temporary tolerance of 5 ppm was established.
- In 1977, a proposal was published to lower the temporary tolerances. The temporary tolerance for fish was lowered to 2 ppm.
- In 1979, 3 of the 4 tolerances were finalized. The proposed revision of the tolerance for fish and shellfish was stayed pending the outcome of an administrative hearing process.
- In 1984, the tolerance for fish and shellfish was formally established.

PCB Risk-Based Tolerance in Fish

	Lifetime risks/100,000 – 90th percentile consumers			
Bioassay	No tolerance	5 ppm	2 ppm	1 ppm
NCI - total cancers	10.6	9.8	7.2	4.4
NCI - liver cancer and adenoma	2.5	2.3	1.7	1.0
NCI - hematopoietic cancers	7.0	6.5	4.7	2.9
Kinbrough - liver cancer	3.4	3.1	2.3	1.4
Allen - primate reproduction	883	811	595	367

Cordle, F., 1983. *Regulatory Toxicology and Pharmacology* 3:252-274.

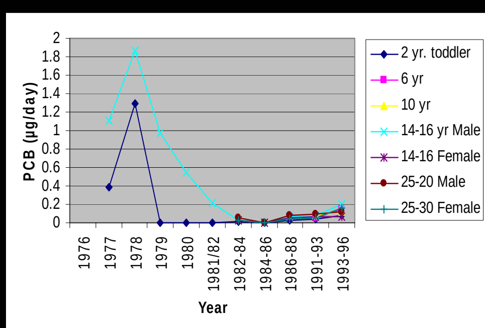
Dioxin-like Contaminants Program Goals

- Obtain profiles of background levels of dioxin-like compounds (DLCs), which include DLC-PCBs in a wide variety of food and feed suspected to contain these compounds.
- Identify opportunities for DLC reduction by identifying sources/pathways that can be mitigated.

Total Diet Study – TDS

- Annual market basket program initiated in 1961 involves purchase of selected foods across the country and analysis for essential minerals, toxic elements, radionuclides, industrial chemicals, and pesticides.
- Designed to monitor on a yearly basis nutrient and contaminant content of food supply and observe trends over time in more than 280 core foods.
- In 1999, FDA's dioxin monitoring program began analyzing TDS foods.
  - 7 PCDD/10 PCDF congeners
  - 3 dioxin-like PCB congeners (PCB-77, -126, -169) were added in 2004.

TDS – Polychlorinated Biphenyls (PCBs)



FDA DLC Targeted Sampling

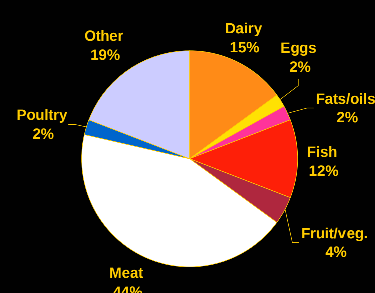
- Milk and dairy products
- Fish, wild/aquaculture (retail/grower)
- Eggs
- Grains/cereals
- Fats/oils
- Tree nuts
- Fat soluble vitamins (A, D, E, K)
- Fruits/vegetables
- Finished feed
- Feed components

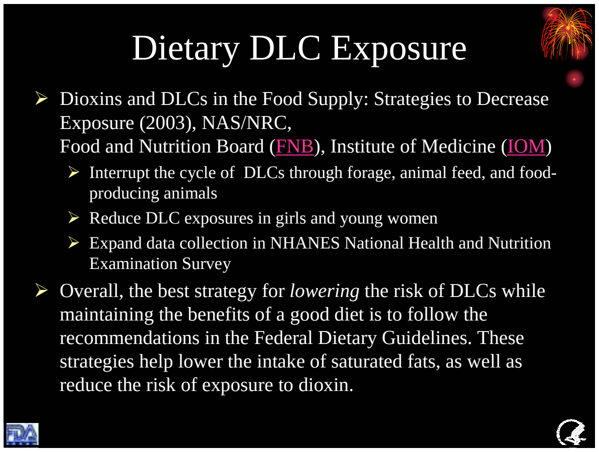
FDA DLC Targeted Fish and Shellfish Sampling

- Finfish
  - Bluefish, flounder, halibut, sole, striped bass (Rockfish), tuna (canned and fresh), salmon (wild and farmed), pollack, cod, sardine (canned), swordfish ocean perch, haddock, mackerel, croaker (Atlantic), sablefish, orange roughy, shark, weakfish (Sea Trout), porgy (Scup), catfish (farmed), tilapia, Basa (farmed)
- Shellfish
  - Scallop, shrimp, clam, oyster, crab, mussels, lobster, crayfish, or crawfish
- Fish and cod liver oil

PCDD/PCDF Exposure Estimates from 2001, 2002, and 2003 TDS Foods

Total U.S. population (ND=0)




Dietary DLC Exposure
Dioxins and DLCs in the Food Supply: Strategies to Decrease Exposure (2003), NAS/NRC, Food and Nutrition Board (FNB), Institute of Medicine (IOM)
Interrupt the cycle of DLCs through forage, animal feed, and food-producing animals
Reduce DLC exposures in girls and young women
Expand data collection in NHANES National Health and Nutrition Examination Survey
Overall, the best strategy for *lowering* the risk of DLCs while maintaining the benefits of a good diet is to follow the recommendations in the Federal Dietary Guidelines. These strategies help lower the intake of saturated fats, as well as reduce the risk of exposure to dioxin.

U.S. EPA's New Cancer Guidelines

2005 National Forum
on Contaminants in Fish
September 18-21, 2005

Rita Schoeny, Ph.D.
Senior Science Advisor
U.S. EPA Office of Water

They're Official!!

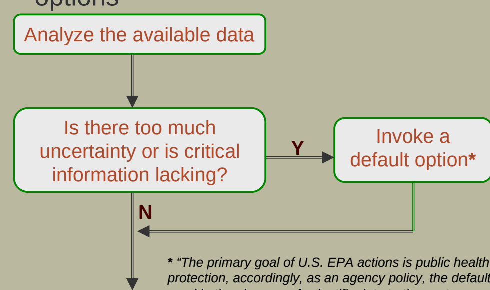
- Revision process has been underway since the early 1990s
- Many incarnations,reviewed extensively
- Published March 2005
- Concurrent release of *Supplemental Guidance for Assessing Cancer Risks from Early-Life Exposures*
  - Supplemental guidance will be revised periodically.

What's Different from 1986?

- Analyze data before invoking default options
- Mode of action is key in decisions
- Weight-of-evidence narrative replaces the previous "A-B-C-D-E" classification scheme
- Two-step dose response assessment
  - Model in observed range
  - Extrapolate from point of departure
- Consider linear and non-linear extrapolation
- Address differential risks to children.

Use of Default Options

- Analyze all data before use of default options



** "The primary goal of U.S. EPA actions is public health protection, accordingly, as an agency policy, the defaults used in the absence of scientific data to the contrary should be health protective (SAB, 1999)."*

What Is Mode of Action?

- . . . a sequence of key events and processes, starting with interaction of an agent with a cell, proceeding through operational and anatomical changes, and resulting in cancer formation. . . Mode of action is contrasted with "*mechanism of action*," which implies a more detailed understanding and description of events, often at the molecular level, than is meant by mode of action.

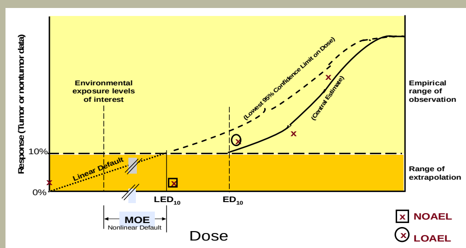
U.S. EPA Cancer Guidelines, 2005

Why Do You Care?

- MOA is key in hazard identification
  - Helps describe circumstances under which agent is carcinogenic (High dose? Route?)
  - Relevance of data for humans
    - Alpha-2-u-globulin and kidney cancer – male rats only
    - Atrazine effect on hypothalamic-pituitary-ovarian function – female Sprague Dawley rat mammary tumors (but likely reproductive toxicant).

Why Do You Care Quantitatively?

- Two-step dose response process



Caring Quantitatively (cont.)

- Choice of low-dose extrapolation depends on MOA
- Nonlinear extrapolation
  - When there is no evidence of linearity, *and*
  - Sufficient info to support MOA nonlinear at low doses
- Linear extrapolation
  - Mutagenic MOA or another MOA expected to be linear at low doses, *or*
  - Linear extrapolation is *default* when data do not establish the MOA.

And You Care About Kids?

- Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens
  - In risk characterization, **mutagenic MOA** risk is increased by age-dependent adjustment factor (used with exposure info for age group)*
    - <2 yrs. old, 10-fold
    - 2 to < 16 yrs., 3-fold.

* In absence of data supporting separate risk estimates for childhood exposure.

Mode of Action Framework

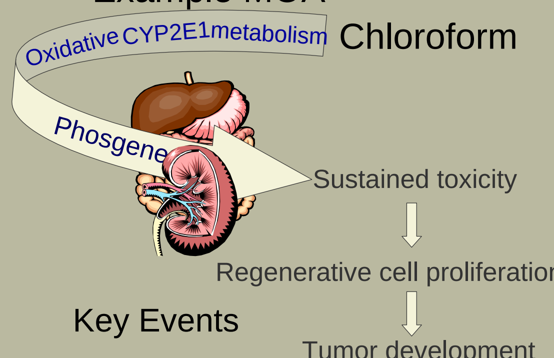
- Hypothesized MOA: summary description and identification of key events
- Experimental support:
  - Strength, consistency, specificity of association
  - Dose-response concordance
  - Temporal relationship
  - Biological plausibility and coherence
- Consideration of the possibility of other MOAs
- Relevance to humans.

Key Event

- A *"key event"* is an empirically observable precursor step that is itself a necessary element of the mode of action or is a biologically based marker for such an element.

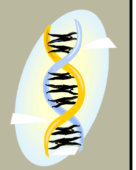
Example MOA

Chloroform



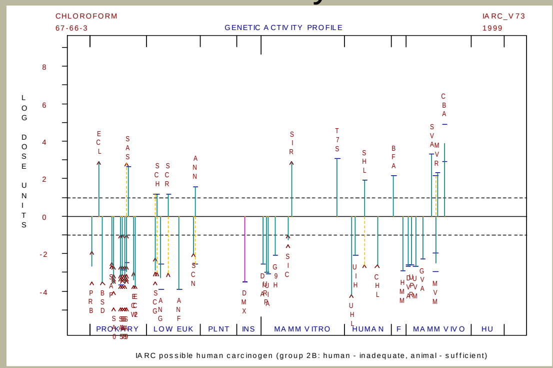
Key Events

Mutagenic MOA ?

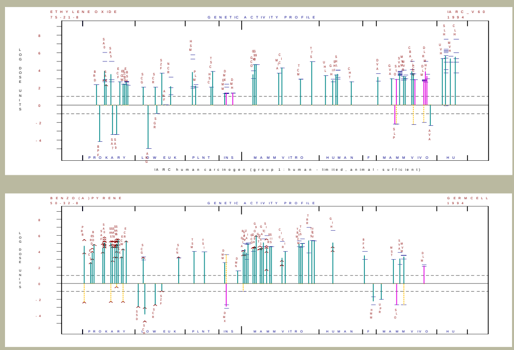


- Weight of evidence
  - Mutagenicity is not a component of chloroform-induced neoplasia.

Genetic Activity Profile



Genetic Activity Profile (cont.)



Bottom Line, Mutagenic MOA

- Mutagenic – however defined – is not equal to mutagenic Mode of Action for cancer or other health effects.

Mutagenic MOA Flowchart

Analyze mutagenicity data
- Obtain mutagenicity data
- Determine WOE for the data

↓

Is chemical mutagenic?

No → No/low concern. Consider non-mutagenic MOA if data are available.

Yes ↓

Flowchart 2

MOA framework applied
- Analyze all data for mutagenic MOA
- Determine support for mutagenic MOA in animals
- Determine support for mutagenic MOA in humans

↓

Is mutagenic MOA established?

No → Consider non-mutagenic MOA if data are available.

Yes ↓

Some Conclusions

- Genotoxic ≠ Mutagenic ≠ Mutagenic MOA
- U.S. EPA is working on guidance for establishing both mutagenicity and mutagenic MOA
  - Way to organize data, decision points
  - Look for some progress (but not the definitive word) soon
- Gene-tox data are best used in the context of the whole database for MOA.

PBDE Exposure and Accumulation in Fish: The Impact of Biotransformation

Heather M. Stapleton, Duke University

Duke UNIVERSITY

PBDE Exposure and Accumulation in Fish: The Impact of Biotransformation

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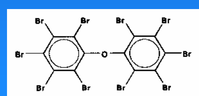
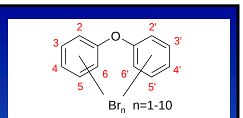


What Are PBDEs?

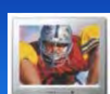
- Polybrominated diphenyl ethers (PBDEs) are brominated flame retardant chemicals applied to consumer products
  - TVs, carpet padding, furniture, circuit boards

Flame retardant:
- "A substance added or a treatment applied to a material in order to suppress, significantly reduce or delay the combustion of the material."
  EHC:192, WHO 1997

Congener (# Br)	Percent of total
Penta-BDE commercial mixture	
BDE-47 (4)	27
BDE-85 (5)	1.6
BDE-99 (5)	43
BDE-100 (5)	9.8
BDE-153 (6)	8.5
BDE-154 (6)	9.3
hexa-BDE	1.1
Octa-BDE commercial mixture	
BDE-153 (6)	6.7
BDE-154 (6)	1.7
BDE-183 (7)	44
2 hepta-BDEs	2.5
3 octa-BDEs	34
nona-BDE	12
Deca-BDE commercial mixture	
BDE-209 (10)	>98

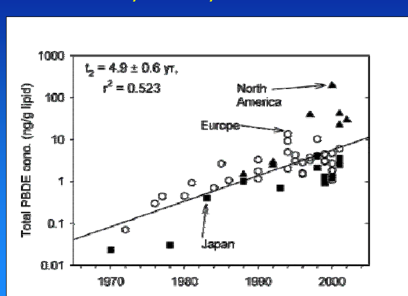


Polybrominated Diphenyl Ether (PBDE)



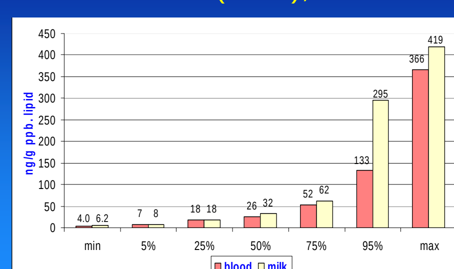
Congener (# Br)	Percent of total	Flame retardant	U.S. demand (MT)
Penta-BDE commercial mixture			(2001)
BDE-47 (4)	27		
BDE-85 (5)	1.6		
BDE-99 (5)	43		
BDE-100 (5)	9.8	Flexible polyurethane foam (furniture)	7,[illegible]0 X
BDE-153 (6)	8.5		
BDE-154 (6)	9.3		
hexa-BDE	1.1		
Octa-BDE commercial mixture			
BDE-153 (6)	6.7		
BDE-154 (6)	1.7		
BDE-183 (7)	44	Acrylonitrile-butadiene-styrene (business equipment)	1,[illegible]0 X
2 hepta-BDEs	2.5		
3 octa-BDEs	34		
nona-BDE	12		
Deca-BDE commercial mixture			
BDE-209 (10)	>98	High-impact poylstyrene (electronic enclosures)	24,500

PBDE Concentrations in Human Blood, Milk, and Tissue



Hites, 2004. *ES&T*

Population-Based PBDE Levels in U.S. Human Blood (n=50) and Milk (n=62), 2005



Data from Schecter et al., 2005

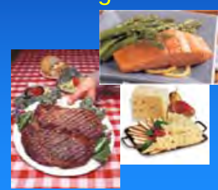
PBDE Exposure and Accumulation in Fish: The Impact of Biotransformation

Heather M. Stapleton, Duke University

Market Basket Survey of U.S. Food, 2003

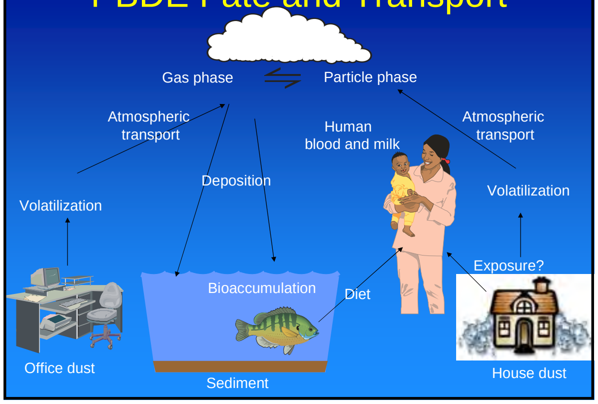
- 62 food samples purchased from 3 Dallas, TX, supermarket chains in 2003
- Measured 13 individual PBDE congeners.

	Sum PBDEs Median (ppt, ww)
Fish, n=24	616
Meat, n=18	190
Dairy, n=15	32.2
Miscellaneous, n=5	84-2835

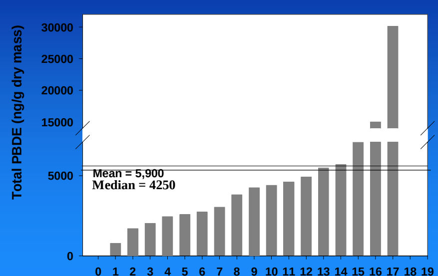


Data from Schecter et al., 2004, 2005

PBDE Fate and Transport



Total PBDE (22 Congeners) in House Dust Samples



Stapleton et al., 2005. *ES&T*

A Comparison of PBDE Intake Rates Among People

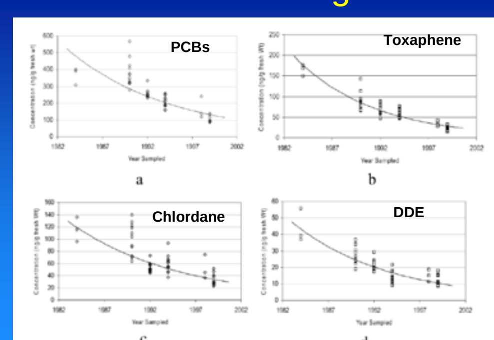
Exposure Route	Population	Country	Intake (ng/day)	Congeners Included	Reference
Diet	Adults	Sweden	**40-51**	47, 99, 100, 153, 154	*Darnerud et al., 2001*
Diet	Adults	Finland	**44**	47, 99, 100, 153, 154	*Kiviranta et al., 2004*
Diet	Adults	Spain	**80-97**	Tetra- through octaBDEs	*Bocio et al., 2003*
Diet	Adults	United Kingdom	**107**	47, 99, 100, 153, 154	*Harrad et al., 2004*
Nursing	Newborns	U.S.A.	**1770[a]**	17, 28, 47, 66, 77, 85, 99, 100, 138, 153, 154, 209	*Schecter et al., 2003*
Nursing	Newborns	United Kingdom	**210[a]**	47, 99, 100, 153, 154	*Kalantzi et al., 2004*
Nursing	Newborns	Sweden	**96[a]**	47, 99, 100, 153, 154	*Lind et al., 2003*
Inhalation	Adults	United Kingdom	**20**	47, 99, 100, 153, 154	*Harrad et al., 2004*
Dust ingestion	Children 1-4	U.S.A.	**120-1180[b]**	17, 28, 47, 66, 71, 85, 99, 100, 138, 153, 154, 156, 183, 184, 190, 191, 196, 197, 206, 207, 208, 209	*This Study*
Dust ingestion	Adults	U.S.A.	**3.3[c]**	17, 28, 47, 66, 71, 85, 99, 100, 138, 153, 154, 156, 183, 184, 190, 191, 196, 197, 206, 207, 208, 209	*This Study*

a-assuming milk sampled is 3% lipid and that a 5-kg infant ingests 800 mL milk/day.
b-assuming an average PBDE concentration of 5,900 ng/g dust and that children ingest between 0.02 g to 0.2 g of dust/day.
c- assuming an average PBDE concentration of 5,900 ng/g dust and that adults ingest 0.00056 g/day of dust.

PBDE Levels in Fish from the Great Lakes:

How Do PBDEs Compare to PCBs?

POPs in Lake Michigan Smelt

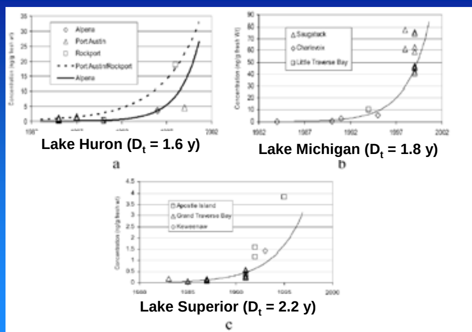


Cherynak et al., 2005. *ET&C*

PBDE Exposure and Accumulation in Fish: The Impact of Biotransformation

Heather M. Stapleton, Duke University

PBDEs in Great Lakes Smelt



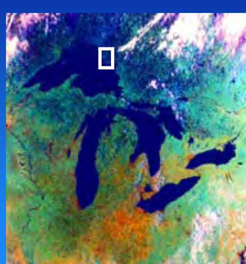
Cherynak et al., 2005. *ET&C*

PBDE Levels Reported in Fish (ng/g lipid)

Location	Fish	Year Sampled	Total PBDE
Columbia River	Whitefish	1992-2000	50 to 1,060
Eastern Virginia	Carp	1998-1999	100 to 47,900
Lake Michigan	Trout	1996	2,970
Great Lakes	Trout, walleye	2000	369 to 1,395
Indiana	Crappie, bluegill	1999	150 to 300
Detroit River	Large mouth bass	1999	86 to 251

From Review in Hites, 2004 (*ES&T* 38:945-956) and Rice et al., 2002 (*Chemosphere* 49:731-737)

Accumulation of Atmospheric and Sedimentary PCBs and Toxaphene in a Lake Michigan Food Web

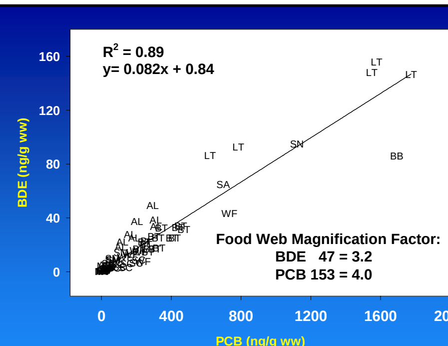


Grand Traverse Bay, Lake Michigan, 1997-1999

Sampled:

Trophic Level

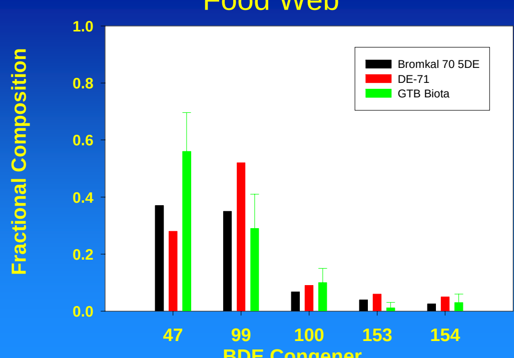
- **Phytoplankton**
- **Zooplankton**
- **Benthic amphipods**
- **Mysid shrimp**
- **Alewife**
- **Bloater chub**
- **Deepwater sculpin**
- **Whitefish**
- **Lake trout**



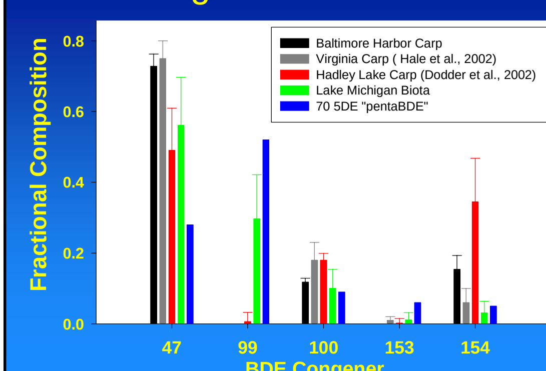
LT = lake trout; BB = burbot; SA = salmon; AL = alewife; BT = bloater chub; SC = sculpin; WF = whitefish; AP = amphipod

Stapleton et al., 2002. *Arch. Environ. Contam.* 45:227-234

Commercial PentaBDE Mixtures vs. Food Web

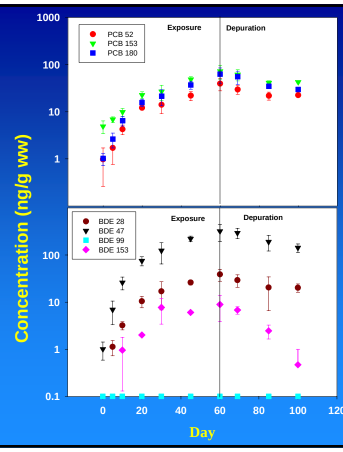


BDE Congener Patterns in Biota



PBDE Exposure and Accumulation in Fish: The Impact of Biotransformation

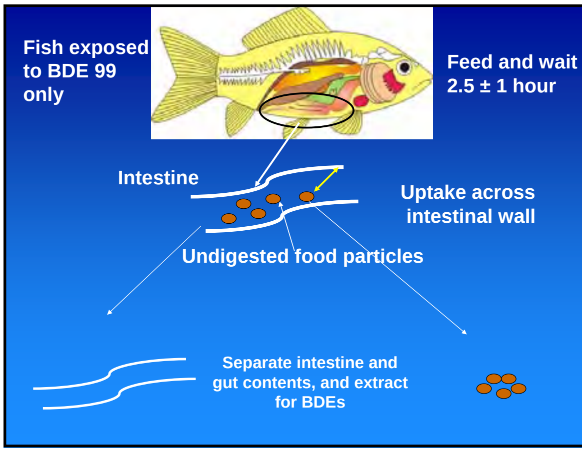
Heather M. Stapleton, Duke University



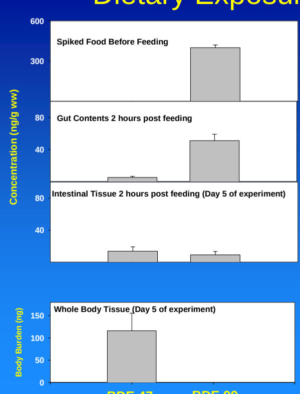
Assimilation Efficiency (%)

Congener	Carp	Pike[a]; rainbow trout[b]
PCB 52	38 ± 7	50 ± 20[a]; 38 ± 2[b]
PCB 153	43 ± 4	70 ± 20 [a]; 48 ± 3 [b]
PCB 180	40 ± 3	NA
BDE 28	20 ± 7	NA
BDE 47	93 ± 14	90 ± 20 [a]
BDE 153	4 ± 3	40 ± 10 [a]
BDE 99	0	60 ± 20 [a]

[a] Burreau et al., 1997
[b] Fisk et al., 1998



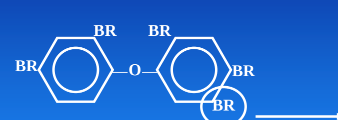
Dietary Exposure to BDE 99



- Food spiked with BDE 99
- BDE 47 appears in gut contents 2.5 hours later
- Only BDE 47 is observed in whole body tissues

Stapleton et al., *Environ. Sci. Technol.* 38:1054-1061.

BDE 99

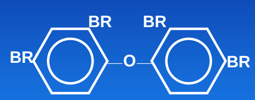


Biological Debromination?

PBDE Exposure and Accumulation in Fish: The Impact of Biotransformation

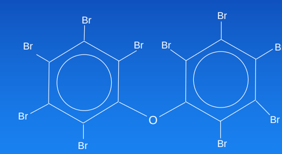
Heather M. Stapleton, Duke University

BDE 99 Becomes

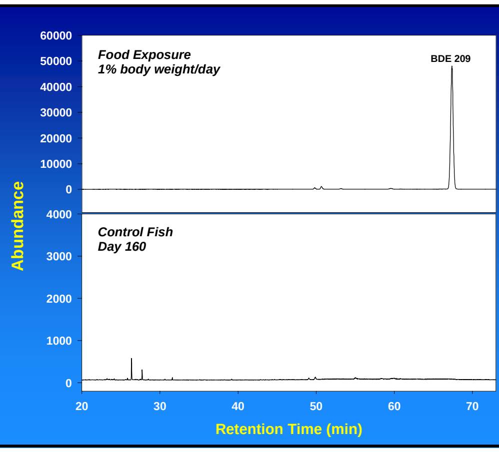


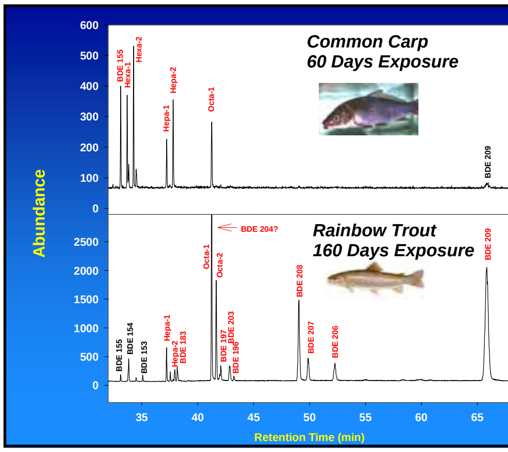
2,2',4,4'-tetrabromodiphenyl ether or BDE 47

BDE 209 Exposure Decabromodiphenyl Ether (DecaBDE)



Estimated log K_{ow} = 10





Assimilation of BDE 209

Common Carp:

- Minimal % accumulated
  - 60-day exposure = 0.4%

Rainbow Trout:

- Minimal % accumulated
  - 160-day exposure = ~ 3.5%

Assimilation of PentaBDEs

Common Carp

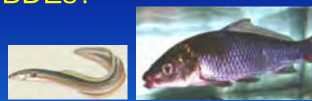
- BDE 28
  - 60-day exposure = 20%
- BDE 47
  - 60-day exposure = 68%*

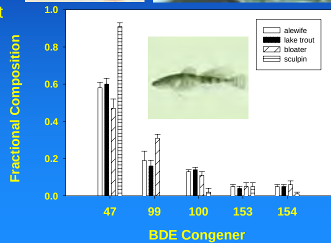
Northern Pike (Burreau et al., 1997):

- BDE 47 = 90%
- BDE 99 = 60%
- BDE 153 = 40%

What Other Fish Can Debrominate PBDEs?

- Common carp (*Cyprinus carpio*)
- Largescale suckers
- Deepwater sculpin (Great Lakes)
- American eel (*Anguilla anguilla*)
- Striped bass?
- Smallmouth bass?





Summary and Conclusions

- PBDEs are ubiquitous contaminants.
- PBDE levels in human serum and milk are ~ 20 times higher in U.S. population vs. Europe.
- Voluntary phase-outs of pentaBDE and octaBDE have occurred in the United States. However, products that contain PBDEs will be around for years.
- Tetra- and PentaBDE congeners have similar bioaccumulation potentials as PCBs.
- Significant biotransformation of PBDEs occurs enzymatically in fish via debromination pathways.
- Recommend using GC/ECNI-MS; measure nona- and octaBDEs.
- Yes, they help save lives … but are their better alternatives?

Acknowledgments

Advisor: Joel E. Baker, University of Maryland Center for Environmental Science, Solomons, MD

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Cambridge Isotope Laboratories

Hunting Creek Fisheries

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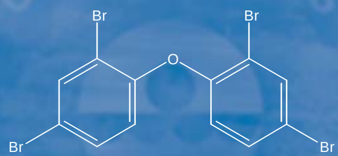
PBDEs: Toxicology Update

Linda S. Birnbaum, U.S. Environmental Protection Agency



PBDEs: Toxicology Update

Linda S. Birnbaum, Ph.D., DABT
Director, Experimental Toxicology
NHEERL/ORD/U.S. EPA
Fish Forum – Baltimore, September 20, 2005

Composition of Commercial PBDE Mixtures

- DBDE – 97% DBDE; 3% NBDE
- OBDE – 6% HxBDE; 42% HpBDE; 36% OBDE; 13% NBDE; 2% DBDE – multiple congeners (unclear if any PeBDE)
- PeBDE – Mainly PeBDE+TeBDE, some HxBDE

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Ecotoxicity

- PeBDE>>OBDE>DBDE
  - Highly toxic to invertebrates (e.g., larval development, LOECs in low µg/l range)
  - DE71 – developmentally toxic to fish at low concentrations (Duke paper)
- DBDE/OBDE
  - May be low risk to surface water organisms and top predators
  - Concern for wastewater, sediment, and soil organisms
  - Concern for lower brominated congeners in OBDE, potential for debromination, and generation of PBDDs/PBDFs
  - Association of porpoise die-off with elevated PBDEs in Baltic

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Mammalian Toxicity of PBDEs in Adult Rodents

- Hepatotoxic
- Enzyme Induction
  - UDP-glucuronyl transferase
  - Cytochrome P450
    - Induction of CYP2B1/2 via PXR/CAR
- DBDE – hepatocarcinogen (high dose)

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New Information

- Endocrine effects
- Developmental reproductive toxicity
- Developmental neurotoxicity

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Endocrine-Disrupting Effects

- AhR effects
  - Relevance for commercial BFRs?
  - Combustion can produce PBDDs/PBDFs
- Thyroid homeostasis
  - OH-PBDE metabolites bind to transthyretin
  - Parent PBDEs – Effects on T4 seen *in vivo*
    - Induction of UDP-glucuronyl transferase
      - Not a low-dose effect
- Estrogen Homeostasis (mostly *in vitro*)
  - OH-PBDEs may be anti-estrogenic
  - Sulfotransferase inhibition could be estrogenic
  - New work from FIRE – T. Hamer

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Developmental Reproductive Effects

- DE71 (NHEERL) – Pubertal exposures
  - Delay in puberty
  - Effects on male organs
  - Anti-androgenic *in vitro* – esp BDEs100, 47
- BDE-99 (Switzerland, Germany) – *in utero* exposures
  - Delay in puberty
  - Ovarian toxicity
  - Male organ effects and decreased sperm

Developmental Neurotoxicity

- DE-71 – Rats (NHEERL)
  - Perinatal exposure
  - Deficits in sensory and cognitive function
  - Just reviewed study – PNd 6-13
- BDE-99 – Mice (Sweden, Italy)
  - Infantile exposure ("Rapid Brain Growth") – Permanent effects on learning
    - Also observed in rats
    - Also seen with BDE-47, 153, and 209
  - Perinatal exposure – Delay in sensory motor development
  - BDE 47, 153, 206, 208, 209
- BDE-99+PCB-52 – Mice (Sweden)
  - Effects may be more than additive

Developmental Neurotoxicity of PBDEs

- Both mice and rats
  - Mice very sensitive (clear effects at 0.8 mg BDE-99/kg) in infantile period
  - F1 rats show effects following single dose of 60 ug/kg o GD6 to pregnant dam
- Sensory and cognitive effects
- Mechanism unknown
  - Depression in serum T4 as low as 0.8 mg/kg
- PBDEs alter cell signaling *in vitro*
  - Kodavanti and Derr-Yellin, 2002
    - Altered calcium-dependent release of arachidonic acid (associated with learning and memory)
    - New paper from Norway – changes in PKC

Pharmacokinetics of PBDEs

- Absorption – DBDE is poorly absorbed; lower brominated congeners are well absorbed
- Distribution – lipid binding is important
  - Fat: 47>99>>>209
  - Liver: covalent binding from 99,209
    - Implies metabolism
- Metabolism – hydroxylation, debromination, O-methylation
- Excretion – feces is major route

Other Ongoing PBDE Health Effects Research

- Dose/Response (NHEERL, NIEHS, USDA, Sweden)
  - Extrapolation issues
  - Half-life
  - Metabolism
- Cell signaling *in vitro* (NHEERL)
  - Altered calcium associated with changes in learning and memory

New Data on PBDE 47

- BDE 47, major BDE in most biota and human samples
- Well absorbed
- Behavior is dose-dependent
- Very persistent in rats
- Rapidly eliminated UNCHANGED in mice
- What does this mean for people???

PBDEs: Toxicology Update

Linda S. Birnbaum, U.S. Environmental Protection Agency

PK of BDE 99, 100, and 153

- Well absorbed
- Higher urinary elimination in mice than rats
- Urine elimination decreases as the number of bromine atoms increases
- BDE-99 is most metabolized

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PBDEs in Human Samples

- Pattern of congeners is different from commercial mixtures (and food)
  - 47>99 (others: 100,153,183, 209?)
- Large inter-individual differences
- Increasing time trends – levels doubling every 2–5 years
- PBDEs and PCBs levels are not correlated
  - Different sources and/or time sequence
- North American levels ~ 10X Europe/Japan

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PBDE Toxicity

- Adult Mammalian Toxicity
  - Hepatic enzyme induction and toxicity
    - DBDE – Hepatocarcinogen (high dose)
  - Endocrine Disruptor
    - Thyroid
    - Estrogen/anti-androgen
- Developmental Reproductive Toxicity
  - Penta/Octa, BDE99
    - Delayed puberty, sex organ wt. changes, ovarian toxicity, decreased sperm counts
- Developmental Neurotoxicity
  - Penta/BDE47, 99, 203, 206, 209
    - Deficits in sensory, motor, and cognitive function

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Potential Health Risk of PBDEs

- Top 5% of current human exposure in U.S. – >400 ng/g lipid
  - If humans are 25% lipid, then their “dose” is ~0.1 mg/kg body weight
- Significant dose causing DNT
  - Mice – $\leq$ 0.8 mg BDE99/kg
  - Rats – $\leq$0.7 mg BDE47/kg
- Mouse tissue concentrations associated with DNT are only ~10X higher that total PBDE concentrations in human tissues in North America
- Margin of exposure for PBDEs appears low
- Additional concern: Are PBDEs interacting with other PBTs?

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Big Questions

- Deca
  - Toxicity?
  - Breakdown products?
- Human variability
  - Biological or exposure?
- Interactions with other PBTs
  - PCBs? Hg?
- What next?
  - HBCD

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Special thanks to …

- Daniele Staskal, Janet Diliberto, Kevin Crofton, Mike Devito, Prasada Kodavanti, Tammy Stoker of NHEERL
- Dan Axelrad, Tala Henry of EPA HQ
- Tom Burka, Mike Sanders of NIEHS
- Tom McDonald, Tom Webster, Arnie Schecter

… and all of my colleagues worldwide.

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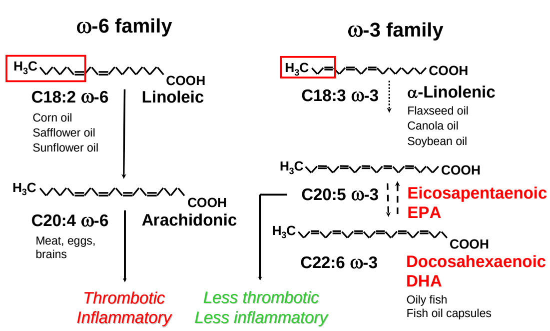
Omega-3 Fatty Acids: The Basics

William S. Harris, University of Missouri-Kansas City School of Medicine

Omega-3 Fatty Acids: The Basics

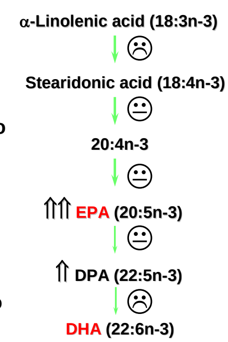
- What are omega-3 fatty acids?
- What are common dietary sources?
- Plant vs. fish omega-3 fatty acids
- Omega-6:omega-3 ratio
- Omega-3 fatty acid supplements
- The omega-3 index
- Blood omega-3 fatty acids and risk for heart attack

Essential Fatty Acid Families

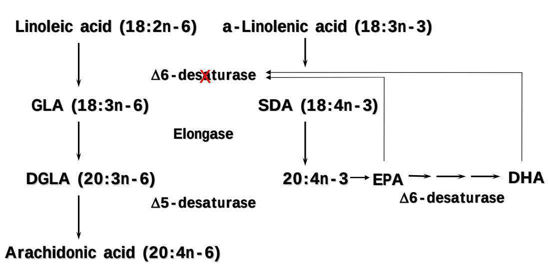


a-Linolenic Acid Conversion to EPA and DHA

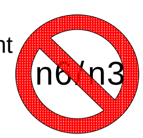
- In adults, the conversion rate is less than 1% for ALA to EPA, and <0.01% to DHA
- No known need for ALA independent of its conversion to EPA/DHA
- Adequate EPA/DHA may eliminate the need for dietary ALA
- With low consumption of EPA/DHA, higher n-6 FA intake will inhibit conversion of ALA to EPA/DHA



Metabolism of n-6 and n-3 PUFA

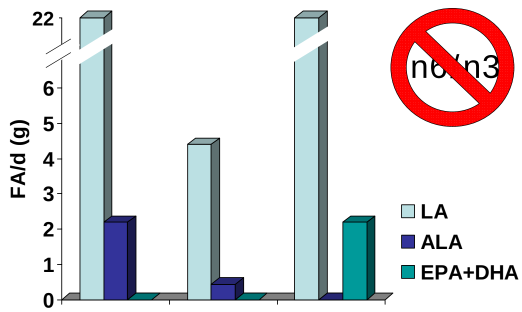


Faulty Assumptions Regarding the n6/n3 Ratio



- That ALA is physiologically equivalent to EPA and DHA
- That LA is physiologically equivalent to AA
- That amounts of consumed fatty acids is irrelevant; only the ratio is important
- That lowering tissue AA content can be achieved by lowering LA intake

Multiple Ways to Achieve a n-6/n-3 Ratio of 10



AHA Recommendations

- For patients with documented CHD, about 1g of EPA+DHA per day
  - Fish
    - About 3 oz sardines, salmon
    - About 4 oz white tuna (albacore)
    - About 12 oz light chunk tuna, clams, shrimp
    - Fast food fish sandwiches or breaded/fried fish are *not* recommended

AHA Recommendations

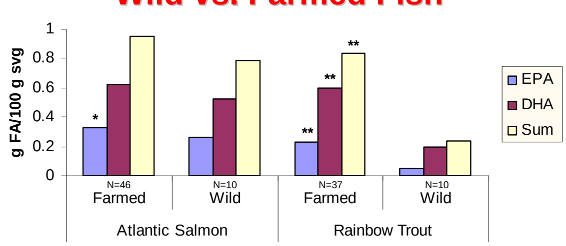
- For patients with documented CHD, about 1g of EPA+DHA per day
  - **Capsules**
    - *Low Potency* - 300 mg EPA+DHA/g (Typical drug store capsules)
    - *High Potency* – 500–700 mg EPA+DHA/g (CardioTabs, Triomega, OmegaRx)
    - *Pharmaceutical* – 850 mg EPA+DHA/g (Omacor®, Reliant Pharmaceuticals)
  - **Cod Liver Oil**
    - 1 tsp (RDA for Vit. D; 2x RDA Vit. A)

AHA Recommendations

For patients *without* CHD, "at least two (preferably oily) fish meals per week" (or about 500 mg of EPA+DHA per day)

- Fish
  - 8–9 oz sardines, salmon and/or albacore tuna per week
- Capsules
  - 2 "low potency," or 1 "high potency"
- Cod Liver Oil
  - 1 tbsp per week

Omega-3 Fatty Acid Content of Wild vs. Farmed Fish



Raw, skinless fillets analyzed; fat content varied from 1.3-16 g/100 flesh in both farmed and wild AS

*p<0.05; **p<0.005 vs. wild

Blanchet, C., et al., 2005. *Lipids* 40:529-531.

Consumer Reports, July 2003

Omega-3 Fatty Acids: The Basics

William S. Harris, University of Missouri-Kansas City School of Medicine

How REAL Men Get Their Omega-3s

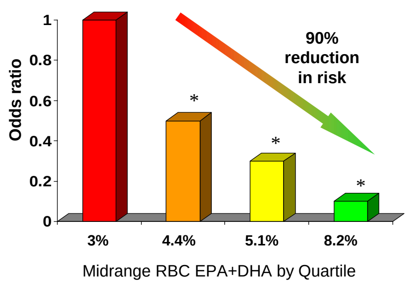
First Question:

Will increased omega-3 fatty acid intakes reduce risk for heart disease?

Next Question:

What blood level of omega-3 fatty acids is associated with the lowest risk for death from CHD?

Risk of Primary Cardiac Arrest and the RBC EPA+DHA



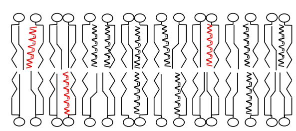
Risk after adjustment for age, smoking, family history of MI/SCD, fat intake, HTN, DM, PA, Ht, Wt, Edu.

* p<0.05 vs. Q1

Adapted from Siscovick, 1995. *JAMA.*

Omega-3 Index

A measure of the amount of EPA+DHA in red blood cell membranes expressed as the percent of total fatty acids



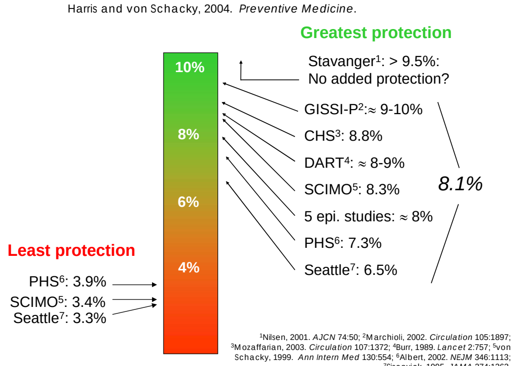
There are 64 fatty acids in this model membrane, 3 of which are EPA or DHA

3/64 = 4.6%

The omega-3 index = 4.6%

Omega-3 Index

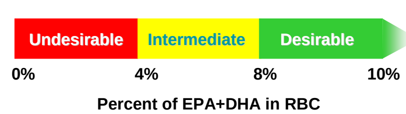
Harris and von Schacky, 2004. *Preventive Medicine.*



[1]Nilsen, 2001. *AJCN* 74:50; [2]Marchioli, 2002. *Circulation* 105:1897; [3]Mozaffarian, 2003. *Circulation* 107:1372; [4]Burr, 1989. *Lancet* 2:757; [5]von Schacky, 1999. *Ann Intern Med* 130:554; [6]Albert, 2002. *NEJM* 346:1113; [7]Siscovick, 1995. *JAMA* 274:1363.

Omega-3 Index Risk Zones

Relative Risk for Death from CHD



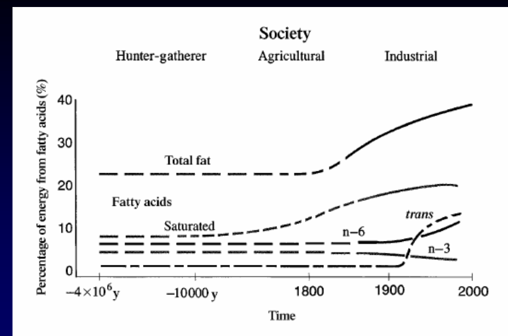
Harris and von Schacky, 2004. *Preventive Medicine.*

Adult Health Benefits of Fish Consumption

Eric B. Rimm, Harvard School of Public Health

Adult Health Benefits of Fish Consumption

Eric B. Rimm, Sc.D.
Associate Professor
Departments of Epidemiology and Nutrition
Harvard School of Public Health

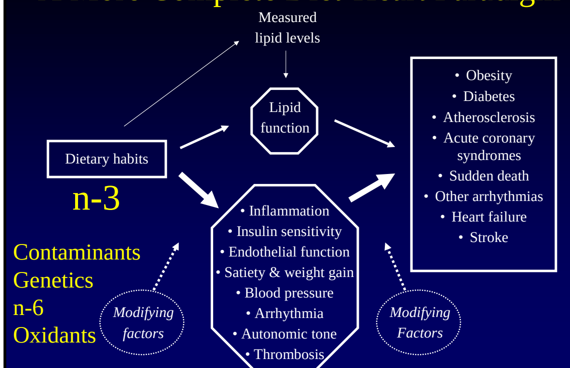


Simopoulos, AP., 1999. *Am J Clin Nutr* 70:560-9S.

The Traditional Diet-Heart Paradigm

Total Fat, Saturated Fat → Serum Total and LDL Cholesterol → Coronary Heart Disease

A More Complete Diet-Heart Paradigm

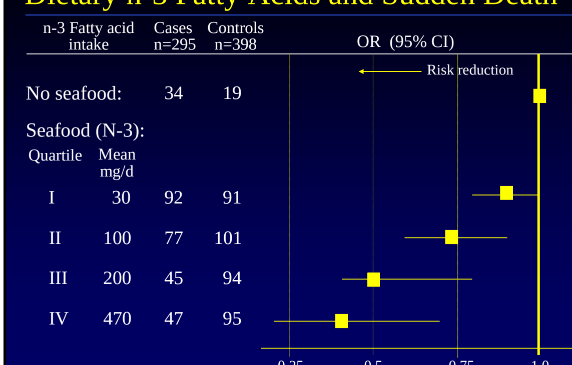


Mozaffarian, D., 2005. *Curr Atheroscler Rep.*

Other Health Outcomes

- Asthma
- Depression
- Diabetes
- Prostate cancer
- Rheumatoid arthritis
- Cognitive function

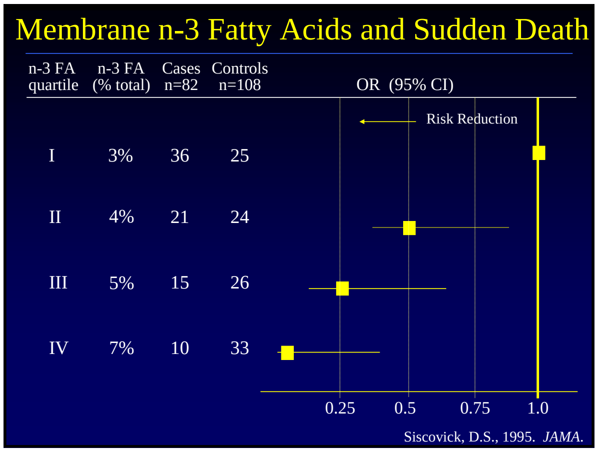
Dietary n-3 Fatty Acids and Sudden Death

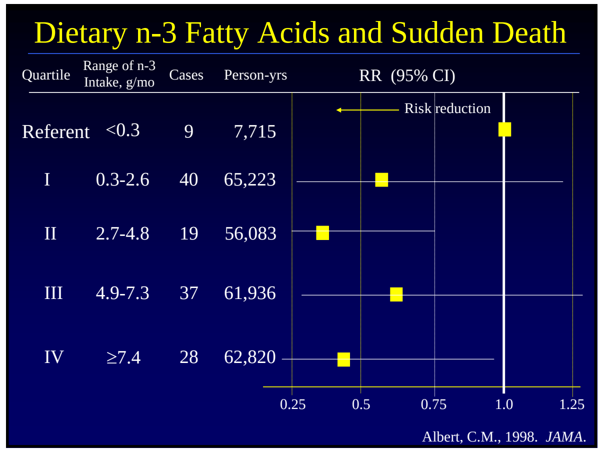


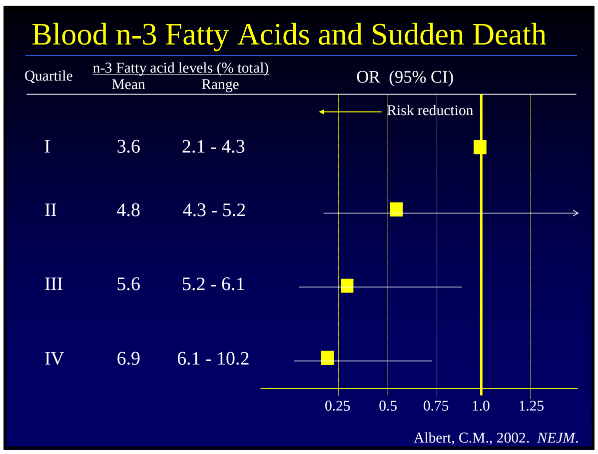
Siscovick, D.S., 1995. *JAMA.*

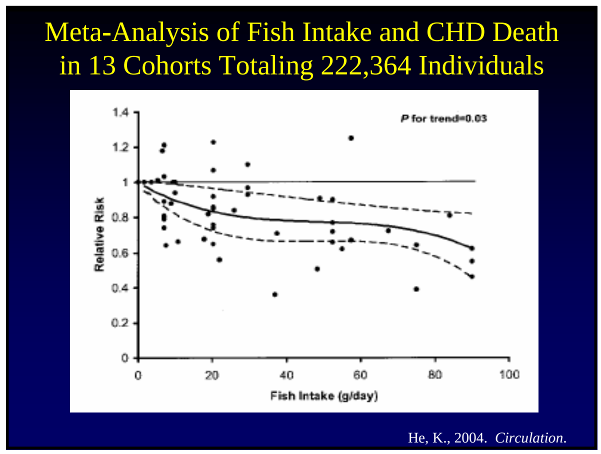
Adult Health Benefits of Fish Consumption

Eric B. Rimm, Harvard School of Public Health









Randomized Controlled Trials

- DART, 1989
  Fatty fish intake 1-2/week → CHD death ↓ 32%, p<0.01
- GISSI-Prevenzione, 1999
  Fish oil supplement 1 g/day → CV death ↓ 32%, p<0.001
  SCD ↓ 45%, p<0.001
- Burr et al., 2003
  Fatty fish intake 1-2/week
  or fish oil capsules → CHD death ↑ 26%, p=0.05

Lancet, 1989; *Lancet*, 1999; *Eur J Clin Nutr*, 2003.

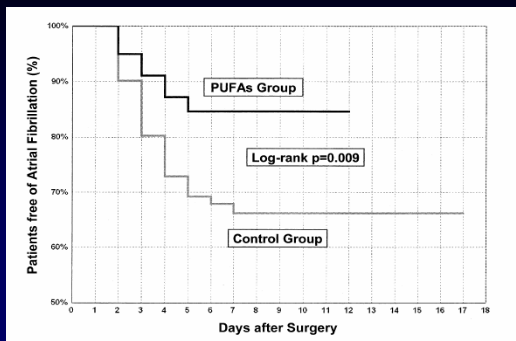
Other Cardiovascular Outcomes

- Nonfatal myocardial infarction
- Atrial fibrillation
- Congestive heart failure

Adult Health Benefits of Fish Consumption

Eric B. Rimm, Harvard School of Public Health

Randomized Controlled Trial Among 160 Patients Undergoing Coronary Bypass Surgery

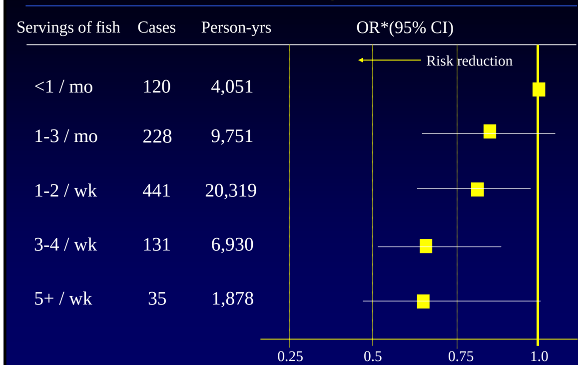


Calo, L.J., 2005. *Am Coll Cardiol.*

Other Cardiovascular Outcomes

- Nonfatal myocardial infarction
- Atrial fibrillation
- Congestive heart failure

Tuna/Other Fish and Congestive Heart Failure



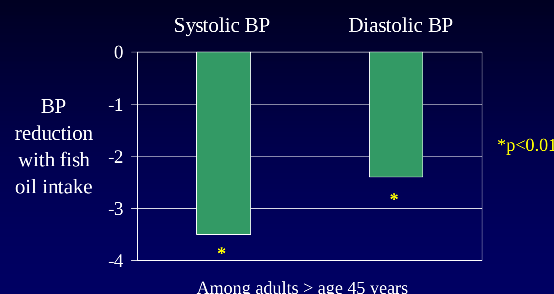
Mozaffarian, D., 2005. *J Am Coll Cardiol.*

Potential Mechanisms

Fish Intake and Cardiovascular Health – Potential Mechanisms

- Direct anti-arrhythmic
- Vascular resistance / blood pressure
- Heart rate / autonomic tone
- Left ventricular efficiency
- Anti-inflammatory effects
- Endothelial cell function

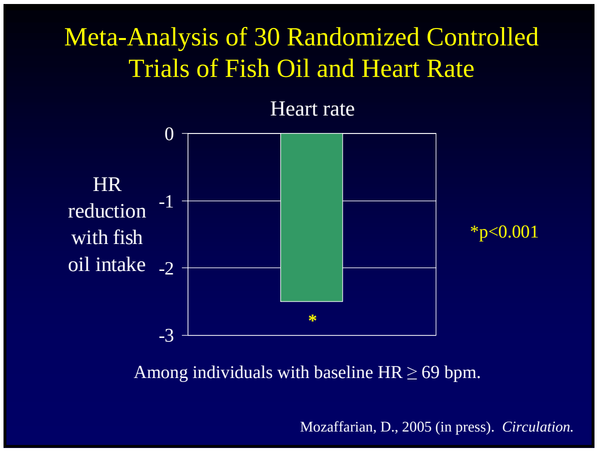
Meta-Analysis of 36 Randomized Controlled Trials of Fish Oil and Blood Pressure



Geleijnse, J.M., 2002. *J Hypertens.*

Adult Health Benefits of Fish Consumption

Eric B. Rimm, Harvard School of Public Health



Type of Fish Meal / Preparation Method

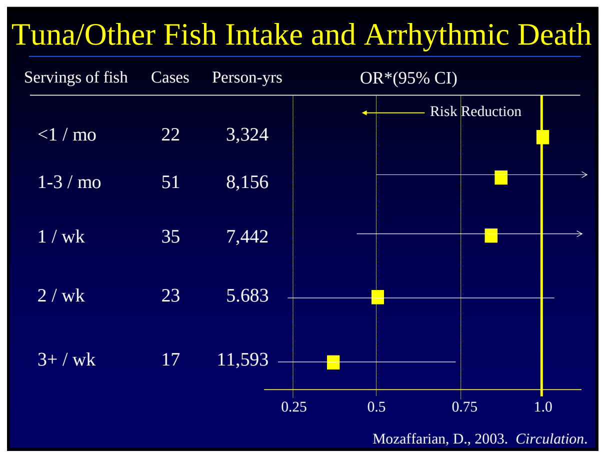
Correlations with Plasma Phospholipid EPA + DHA

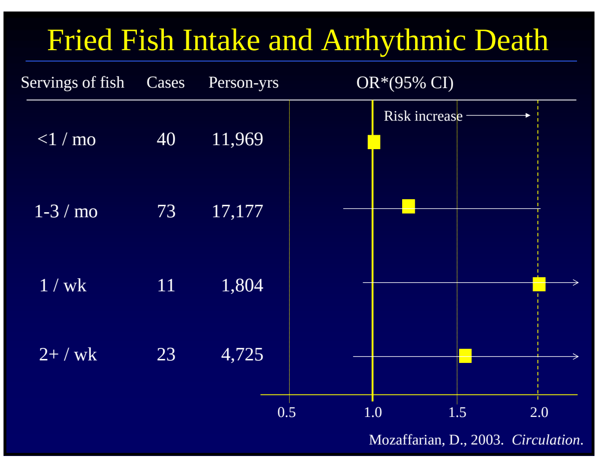
Tuna/other fish intake: r = 0.55, $p<0.001$

Fried fish intake: r = 0.04, $p=0.78$

Tuna/other fish = Fatty (oily) fish

Fried fish = Lean (white) fish





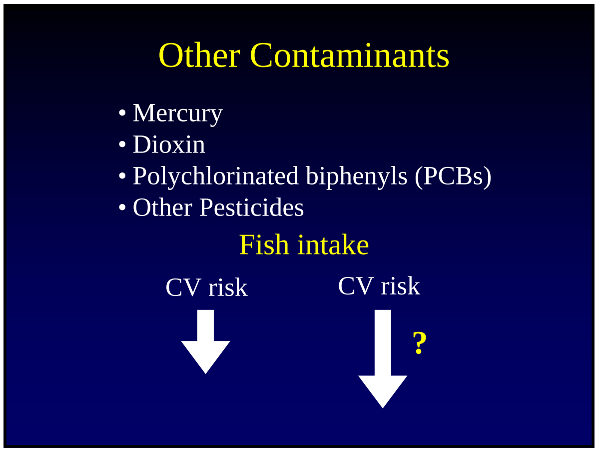
Fried Fish – Unfavorable Balance of Benefit vs. Harm?

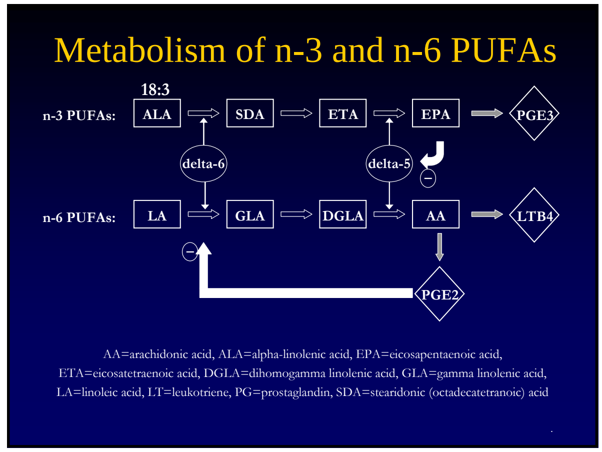
Fish type: Low in n-3 fatty acids

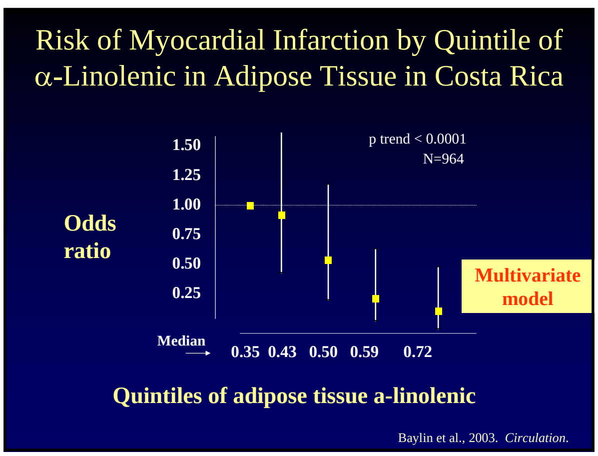
Frying: Trans-fatty acids

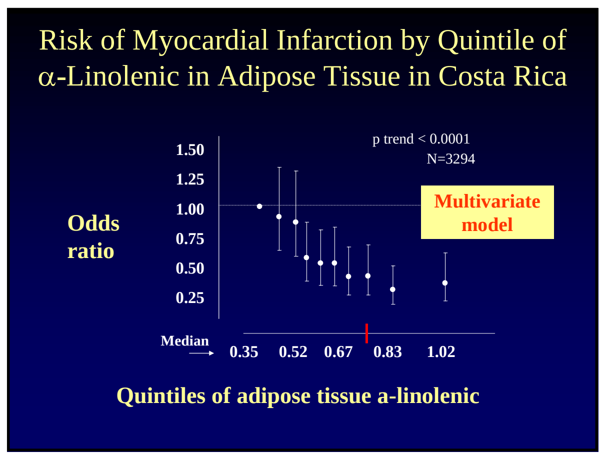
Other fats

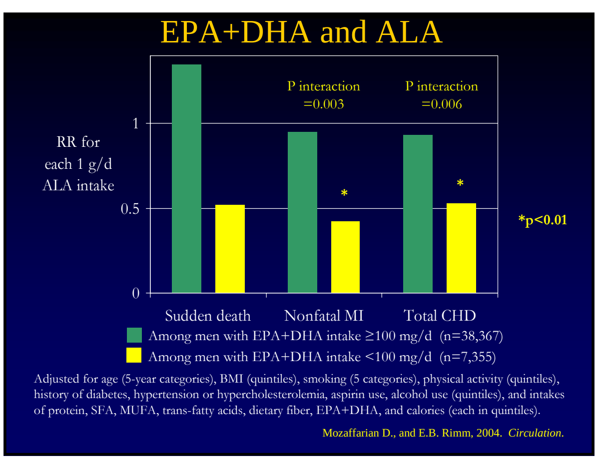
Oxidation products

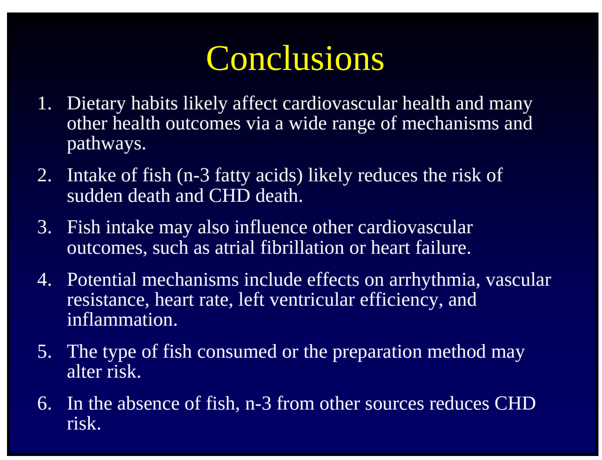

Other Contaminants
• Mercury
• Dioxin
• Polychlorinated biphenyls (PCBs)
• Other Pesticides
Fish intake
CV risk
CV risk
?


Metabolism of n-3 and n-6 PUFAs
18:3
n-3 PUFAs:
ALA
SDA
ETA
EPA
PGE3
delta-6
delta-5
n-6 PUFAs:
LA
GLA
DGLA
AA
LTB4
PGE2
AA=arachidonic acid, ALA=alpha-linolenic acid, EPA=eicosapentaenoic acid,
ETA=eicosatetraenoic acid, DGLA=dihomogamma linolenic acid, GLA=gamma linolenic acid,
LA=linoleic acid, LT=leukotriene, PG=prostaglandin, SDA=stearidonic (octadecatetranoic) acid


Risk of Myocardial Infarction by Quintile of α-Linolenic in Adipose Tissue in Costa Rica
p trend < 0.0001
N=964
Odds ratio
1.50
1.25
1.00
0.75
0.50
0.25
Multivariate model
Median
0.35 0.43 0.50 0.59 0.72
Quintiles of adipose tissue a-linolenic
Baylin et al., 2003. Circulation.


Risk of Myocardial Infarction by Quintile of α-Linolenic in Adipose Tissue in Costa Rica
p trend < 0.0001
N=3294
Odds ratio
1.50
1.25
1.00
0.75
0.50
0.25
Multivariate model
Median
0.35 0.52 0.67 0.83 1.02
Quintiles of adipose tissue a-linolenic


EPA+DHA and ALA
RR for each 1 g/d ALA intake
1
0.5
0
P interaction =0.003
P interaction =0.006
*
*
*p<0.01
Sudden death
Nonfatal MI
Total CHD
Among men with EPA+DHA intake ≥100 mg/d (n=38,367)
Among men with EPA+DHA intake <100 mg/d (n=7,355)
Adjusted for age (5-year categories), BMI (quintiles), smoking (5 categories), physical activity (quintiles), history of diabetes, hypertension or hypercholesterolemia, aspirin use, alcohol use (quintiles), and intakes of protein, SFA, MUFA, trans-fatty acids, dietary fiber, EPA+DHA, and calories (each in quintiles).
Mozaffarian D., and E.B. Rimm, 2004. Circulation.


Conclusions
1. Dietary habits likely affect cardiovascular health and many other health outcomes via a wide range of mechanisms and pathways.
2. Intake of fish (n-3 fatty acids) likely reduces the risk of sudden death and CHD death.
3. Fish intake may also influence other cardiovascular outcomes, such as atrial fibrillation or heart failure.
4. Potential mechanisms include effects on arrhythmia, vascular resistance, heart rate, left ventricular efficiency, and inflammation.
5. The type of fish consumed or the preparation method may alter risk.
6. In the absence of fish, n-3 from other sources reduces CHD risk.

DHA AND INFANT DEVELOPMENT

Susan Carlson, Ph.D.
Midwest Dairy Council Professor of Nutrition
Departments of Dietetics and Nutrition and Pediatrics
University of Kansas Medical Center
scarlson@kumc.edu

Key Points

- Fish (some sources) have the highest concentration of DHA found in foods
- DHA is a "conditionally essential" nutrient for the developing infant (RCTs)
- DHA may be equally or more important for the developing fetus (1 RCT/several observational studies/animal models)

Key Points (cont.)

- Based on human milk DHA, U.S. women's DHA intake is among the lowest in the world
- The best way to increase DHA intake to the fetus and breast fed infant is to increase DHA intake of their mothers
- The good news is that "clean" sources with DHA (e.g., fish oil, algal oil, high-DHA eggs) are marketed for use with women and infants

Key Points (cont.)

- The bad news is that evidence points to optimal intakes being much higher than current U.S. consumption, making it important to retain viable food (fish) and supplements as options for women and children to consume this nutrient

DHA Dietary Sources: Fatty Fish, Meat, Eggs

Food	DHA (mg)
3 oz pink salmon filet, baked/broiled	638
3 oz white tuna, canned in water	535
3 oz smoked salmon (lox)	227
3 oz crab, steamed	196
12 large shrimp, steamed	96
3 oz tuna salad	47
2 pieces chicken, fried	37
1 large egg, hard-boiled	19

U.S. Department of Agriculture, Agriculture Research Service, 2003. USDA Nutrient Database for Standard Reference. Release 16. Nutrient Data Laboratory. Available at http://www.nal.usda.gov/fnic/foodcomp. Accessed February 9, 2004.

N-6 and N-3 Fatty Acids Are Essential Nutrients

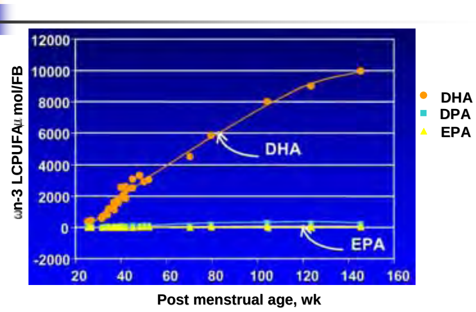
LA 18:2n-6 → GLA 18:3n-6 → DHGLA 20:3n6 → ARA 20:4n-6 → DPA 22:5n-6

ALA 18:3n-3 → → → → EPA 20:5n-3 → DHA 22:6n-3

Endoplasmic reticulum | Peroxisome

DHA and Infant Development
Susan E. Carlson, University of Kansas Medical Center

Human Brain DHA Accumulation



Martinez, M., 1992. *J Pediatr* 20:S129-S138.

Some Effects of Lower Brain DHA from Animal Models

- Lower visual acuity
- Changes in attention that suggest slower brain maturation
- Higher impulsivity and reactivity
- Increased stereotyped behavior
- Alterations in brain dopamine and serotonin

Randomized Trials of DHA and Infant Development

Pre-Term Infants
- Uauy et al.
- Carlson et al. (3)
- Fink et al.
- O'Connor et al.
- Clandinin et al.

Term Infants
- Makrides et al. (2)
- Carlson et al. (2+)
- Auestad et al.
- Willatts et al.
- Agostoni et al.
- Clausen et al.
- Birch et al. (4)
- Lucas et al. (2)
- Jorgensen et al.
- Hadders-Algra

Positive Effects in Children Supplemented with DHA as Infants

- Higher MFFT scores and speed at 6 yrs
- Higher Bayley PDI at 30 months of age and longer sustained attention at 5 yrs*
- Higher IQ at 4 yrs of age*
- Lower diastolic and mean BP at 6 yrs

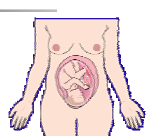
* Mother took DHA during pregnancy and/or lactation.

Where and When Do Infants Obtain DHA?

α-Linolenic acid
⇓
DHA

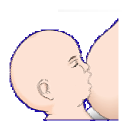
Convert from precursor

Highly variable
estimated 0.2-0.4% conversion



Preformed

In utero



Preformed

From human milk or DHA-supplemented infant formula

U.S. Dietary DHA Intake Is Low

	Recommended Daily DHA Intake*	Average Daily DHA Intake
Pregnant/ Lactating Women	300 mg	54 mg
Adult Women	220 mg	61 mg
Adult Men	220 mg	78 mg

* Expert panel convened by NIH/ISSFAL.

Simopoulos, A.P., et al., 1999. *J Am Coll Nutr* 18:487-489.
Benisek, D., et al., 1999. *J Am Coll Nutr* 18:543-544.
Benisek, D., et al., 2000. *Obstet Gynecol* 95:77S-78S.

DHA and Infant Development

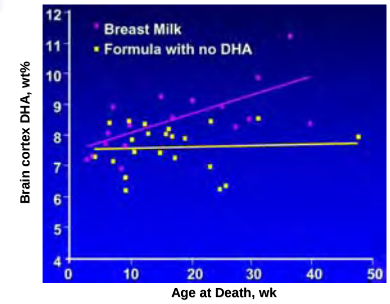
Susan E. Carlson, University of Kansas Medical Center

Human Milk DHA* Is Highly Variable

Diet/Location	% DHA
Sudan	0.07
U.S. Women	0.12
Pastoral China	0.14
Netherlands	0.19
Germany	0.23
Australia	0.26
France	0.32
Spain	0.34
Nigeria	0.34
Israel	0.37
Norway	0.45
Rural China	0.68
Urban China	0.82
Japan	1.00
Marine China	2.78

*Reflects intake of DHA

Postnatal Diet with DHA Positively Influences Cortex DHA Level



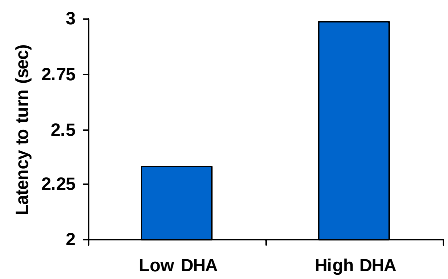
Makrides M, et al., 1994. *Am J Clin Nutr* 60:189-194 (mean milk DHA is 0.26% DHA in Australia).

Evidence that Prenatal DHA Exposure Is Positively Associated with Infant/Child Development

- Helland trial – Norway-Higher 4-yr. IQ. Milk DHA was increased from 0.45 to 1.4%.
- AVON trial – higher maternal fish intake and higher stereoacuity at 3.5 yr.
- University of Connecticut study showing more mature sleep behavior in newborns whose mothers' DHA were above median
- Studies from Kansas City* and Dundee showing more mature attention in infants/toddlers and lower distractibility with maternal DHA above median

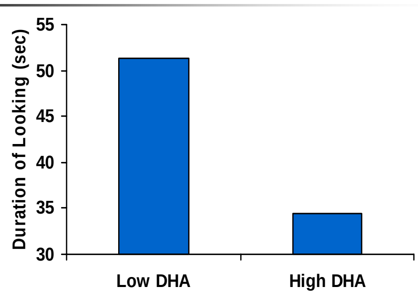
* Colombo et al., 2004. *Child Devel.*

Latency to Turn to Television Distracter at 18 Months (p<.05)



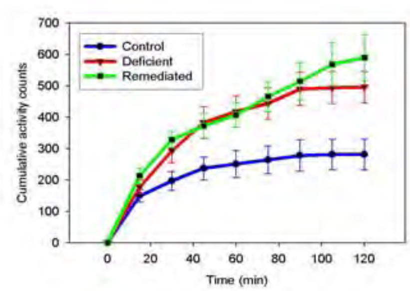
Colombo et al., 2004. *Child Devel.*

Duration of Looking at the Distracter at 18 Months (p<.05)



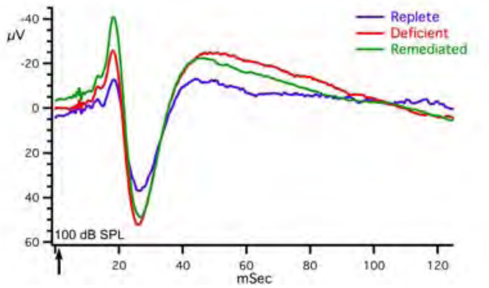
Colombo et al., 2004. *Child Dev.*

Basal Locomotor Activity in Rats in Relation to Modest Reductions in Brain DHA



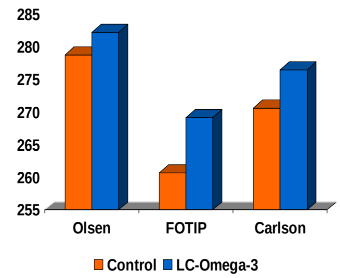
Levant et al., 2004. *Behav. Brain Res.*

Cortical Auditory Responses in Adult Rats in Relation to Dietary Treatment



Radel et al., 2003. *Neuroscience Abst.*

Increased Gestation Length with DHA: A Comparison Among Studies



Conclusions

- Converging evidence shows that DHA is critical for optimal central nervous system function.
- In human infants, there is strong evidence for benefit of postnatal DHA. Available evidence likely underestimates effects because in most cases observation stopped by 18 months.
- Results of a clinical trial and four observational studies suggest that higher prenatal DHA exposure enhances early development.
- Experimental studies of DHA-supplemented pregnant women and their infants/children are planned or underway.

DHA and Contaminants in Fish: Balancing Risks and Benefits for Neuropsychological Function

Rita Schoeny, U.S. Environmental Protection Agency

Disclaimer

- The opinions in this paper are those of the author and should not be interpreted to be the policies of the U.S. EPA.
- Actually, Deborah Rice did all the work on this presentation, and Rita is merely giving it on her behalf.

Evidence for Adverse Effects of Methylmercury

- MeHg affects multiple developmental processes in brain
- Large literature in rodents and monkeys documented adverse developmental effects
- Three longitudinal prospective studies and half a dozen cross-sectional studies documented adverse effects
- Sensory and motor deficits; deficits in learning, memory, and attention in animals and humans; decreased IQ and language processing in humans
- Cardiovascular effects discussed in other talks.

Dose-Response for Mercury

- U.S. EPA defined effect level based on NAS and independent panel: doubling of number of children performing in the abnormal range of multiple tests.
- U.S. EPA calculated a range of levels; example 58 μg/L mercury in cord blood (or 34 μg/L in maternal blood*).
- U.S. EPA calculated a RfD using BMDL and uncertainty factors: 0.1 μg/kg bw/day.
- But no evidence of a threshold within ranges of body burdens of epidemiological studies.

Exposure to Mercury in U.S. Women

NHANES 1999-2000, 1709 ♀16-49 years old (μg/L)

percentile	10th	25th	50th	75th	90th	95th
blood Hg	0.20	0.40	0.90	2.00	4.90	7.10

↑ 0.68 Lowest exposures in Faroe study

↑ 3.4 EPA RfD

↑ 34 Defined effect

Four-year data (1999–2002); 5.7% women above 5.8 μg/l.

Evidence for Adverse Effects of PCBs

- Multiple experimental studies in rodents and monkeys: adverse effects of developmental exposure
- Four longitudinal prospective studies documented adverse effects
- Decreased IQ and impaired language development in humans; adverse effects on memory and attention; increased impulsivity and perseveration; impaired executive function; effects on sexually dimorphic behavior in animals and humans
- Effects observed in humans and monkeys at same blood concentrations of PCBs.

Exposure to PCBs in U.S. Women

PCB congener 153, marker congener, ng/g lipid

		percentile		
		5th	50th	95th
NHANES 1999-2000	1,258 women 20 and older	<29	<29	122
Oswego 1991-1994	Umbilical cord blood	10	40	120

Results from Oswego study appear monotonic when data are divided into tertiles.

ω-3 Fatty Acids and Infant Development

- Susan Carlson just discussed
- At least 12 clinical trials of infants fed formula plus or minus DHA
  - Compared growth; visual, motor, and mental development
  - Interpretation is complicated by
    - Amount and ratio of linoleic and linolenic acids
    - Duration of supplementation
    - Age at testing
    - Tests used
    - Physiological significance of tests used.

IOM 2002

- "Clinical studies of growth or neurodevelopment with term infants fed formulas currently yield conflicting results on the requirements for n-3 fatty acids in young infants, but do raise concerns over supplementation [of infant formulas] with long-chain n-3 fatty acids without arachidonic acid."

What about Effects of DHA Associated with Prenatal Exposure?

- Three studies report beneficial effects on visual development associated with various measures (breast feeding, DHA, ingestion of oily fish)
  - DHA levels particularly high in retina
- Four studies of cognition and behavior
  - Effects observed on some endpoints but not others
  - Effects often associated with one marker and not others
  - One study completely negative.

Potential Confounding in DHA Studies

- Best predictor of child's IQ is mother's IQ
  - Maternal IQ and fish intake may be correlated
  - Only study measuring maternal IQ was negative for DHA effect
- HOME score may be particularly important for visual development
  - Development of the visual system is highly dependent upon visual input
  - Only one study measured HOME score
- Influence of maternal IQ and HOME score on neuropsychological function
  - Accounted for beneficial effects associated with breast feeding in PCB studies.

Randomized Study

- Norway – 100 infant-mother pairs (Helland *et al.*, 2003, 2001)
- 10 ml/day corn or cod-liver oil – 1.1 gm DHA
- No effect on memory (preferential looking) at 6 and 9 months
- Better performance on cognitive tests at 4 years associated with plasma DHA at 4 weeks, but not birth or 3 months.

DHA and Contaminants in Fish: Balancing Risks and Benefits for Neuropsychological Function

Rita Schoeny, U.S. Environmental Protection Agency

Gm Fish for Maternal Ingestion of 1.0 gm of DHA/day

	DHA (g/100g)	gm/day to get 1.0 gm DHA
Shrimp	0.14	714
Canned light tuna	0.22	454
Catfish	0.12	833
Salmon average	1.10	91
Atlantic	1.46	
Chinook	0.72	

Contamination in Selected Fish

	Hg (μg/g)	PCBs (μg/kg)
Shrimp	nd	low?
Canned light tuna	0.16	45
Canned albacore tuna	0.37	?
Catfish	0.05	25
Salmon		
Puget Sound	0.05	50
Alaska	0.05	3-90
Chile	0.05	10
Scotland	0.05	70

Maternal Ingestion of Contaminants Associated with 1.0 gm/day DHA

	Hg µg/kg/day	PCB µg/kg/day
Shrimp	low	?
Canned light tuna	1.25	0.35
Canned albacore	0.97	?
Catfish	0.72	0.07
Salmon	0.08	
Alaska		0.009-0.141
Puget Sound		0.078
Chile		0.016
U.S. EPA RfD	**0.10**	**0.02**

Inuit Study

- Prospective study of neuropsychological effects in children (Després *et al*., 2005)
  - Measured contaminants including PCBs, methylmercury, lead, and pesticides
  - Measured omega-3 fatty acids
- No beneficial effect of omega-3s on nervous system function
- No protective effects of omega-3s against contaminant-associated neurotoxicity
  - Motor effects published; cognitive not yet published.

Conclusions

- N-3 PUFA may enhance infant development when ingested by the mother pre-partum, during breast feeding or both
- Fish is a complex mixture
  - Contains essential nutrients for mother and infant
  - Contains contaminants harmful to both
  - Fish oils are less complex mixtures.

Fish Consumption and Reproductive and Developmental Outcomes

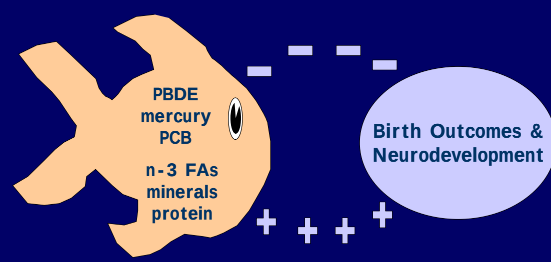
Julie L. Daniels, School of Public Health, University of North Carolina at Chapel Hill

Fish Consumption and Reproductive and Developmental Outcomes

Julie L. Daniels, M.P.H., Ph.D.

Departments of Epidemiology and Maternal and Child Health
University of North Carolina at Chapel Hill

2005 National Forum on Contaminants in Fish



Fish → Reproductive Outcomes

H_1: Fatty acids (FA) modulate prostaglandin production associated with labor onset.

	GA	BW	BW/GA	Other
Denmark – fish:	↑	↑	↑	↓PT, ↓LBW
Faroes – fish, whale:	↑		↓	↑DHA ↑Hg
Great Lakes – fish:	Ø, Ø	Ø, ↓		↑PCB, DDE
NY Anglers – fish duration:		Ø		Ø ln, ↑head
Iceland – fish:			↑	↑ln, ↑head (no/lo grp)
Mass – fish:	Ø	↓	↓	↑DHA

Olsen, 2002. *BMJ*; Grandjean, 2001. *J Epi*; Weisskopf, 2004. *Env Res*; Buck, 2003. *Envr Hlth*; Thorsdottir, 2004. *AJE*.

Fish → Developmental Outcomes

H_1: Contaminants insult brain development
H_2: FAs contribute to structure and function of brain

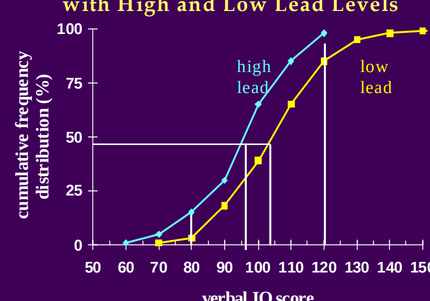
Seychelles: High intake of fish low in mercury and PCBs: ↑most developmental tests, ↓ Boston naming

Faroes: Whale high in mercury and PCB: ↓ motor, language, memory

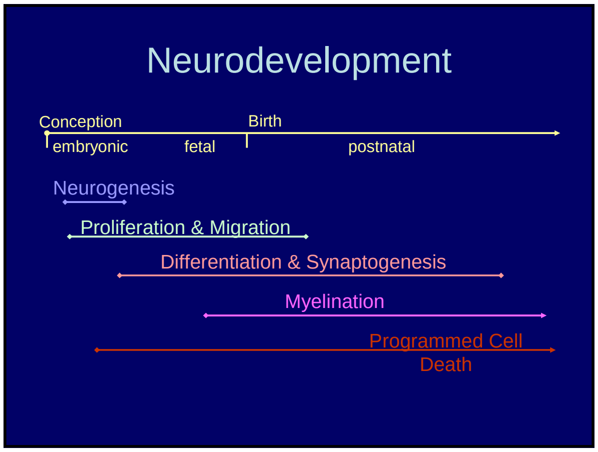
New Zealand: High fish intake: ↓ language, achievement, motor, intelligence

- Effect size for all epidemiologic studies is rather subtle
  - Measure variation in normal development, rather than clinical morbidity
  - Subtle effects can be dwarfed by random or systematic error
- Inconsistencies due to
  - Variation in type, source, and quantity of fish
  - Confounding by
    - Other contaminants
    - Lifestyle/social factors
    - Beneficial nutrients

Verbal IQ Scores in Subjects with High and Low Lead Levels

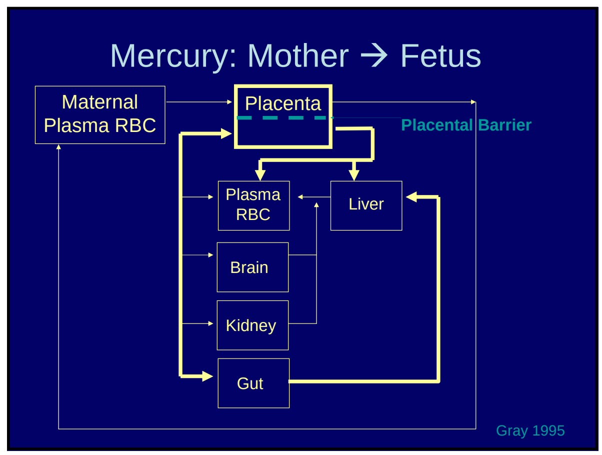


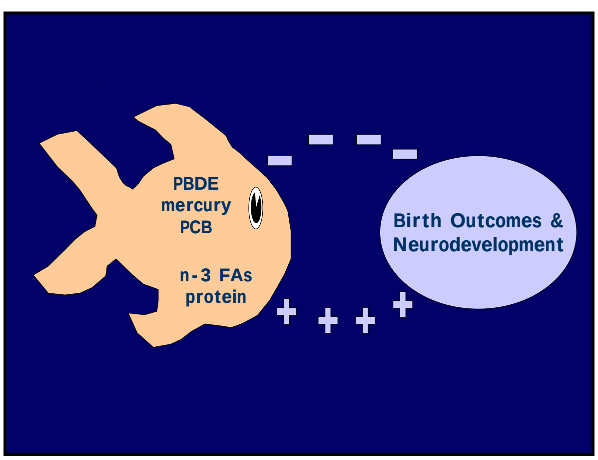
After Needleman 1982, 1994



The Role of Fatty Acids in Neurodevelopment

- Long chain n-3 fatty acids, specifically DHA, constitute 20-25% of total fatty acids in neuronal membranes. Sufficient DHA is needed for proper brain development (structure and function).
- Mom's circulating DHA increases through gestation, especially during the 3rd trimester.
- Infant brain DHA accumulates during 3rd trimester; is related to mom's dietary DHA intake.





The ALSPAC Study

Large population-based study in the United Kingdom.

Data on fish intake during pregnancy examined by three analyses:

- Fish, DHA, and stereoacuity – C. Williams
- Fish and reproductive outcomes – I. Rogers
  - Gestation duration, birth weight, intrauterine growth retardation
- Fish and neurodevelopment – J. Daniels
  - Fish and mercury
  - Mercury and neurodevelopment
  - Fish and language development at 15 & 18 months of age

Fish Consumption and Reproductive and Developmental Outcomes

Julie L. Daniels, School of Public Health, University of North Carolina at Chapel Hill

ALSPAC – Study Population

- Cohort born 4/91–12/92
- Bristol, United Kingdom health districts
- 85% regional participation
- 10,040 singleton births, 7,421 term

ALSPAC – Data Collection

Clinical records for birth outcomes (n=10,040)

Maternal questionnaire (n=7421)

- 32nd gestational week: Prenatal diet, lifestyle, and sociodemographic factors
- 6 & 15 months: Child's diet & social environment
- 15 & 18 months: Child's development

Maternal serum (n=4700)

Umbilical cord tissue (n=1054)

Maternal Prenatal Fish Intake

How often do you eat

- Any fish
- White fish – cod, haddock, plaice, fish sticks
- Other fish – salmon, sardines, mackerel, tuna, herring, kippers, trout, pilchards

Frequency

- Rarely or never
- Once every 2 weeks
- 1-3 times per week
- 4-7 times per week
- ≥ Once per day

(4-7 times per week and ≥ Once per day: ≥4 times per week)

Outcomes

Reproductive outcomes *(Rogers et al.)*

- Gestation and preterm (from LMP and ultrasound)
- Birth weight, low birth weight (medical record)
- IUGR (<10% for gestational age)

MacArthur Communicative Development Inventory*

- Vocabulary, social activity
- Mother completed 15 months after birth

Denver Developmental Screening Test*

- Total, language, social activity
- Mother completed 18 months after birth

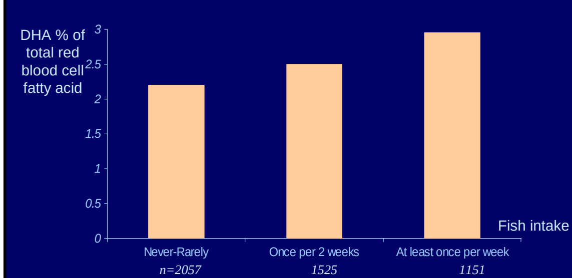
Adjusted for: Maternal age, education, prenatal dental treatment, smoking, alcohol, HOME score, paternal education. Child's age, sex, birth order, breastfeeding

Maternal Characteristics (% of 7,421)

Age (mean yrs)	29
Education	
Low	23
Moderate	62
Degree	16
Smoke	15
Alcohol	56
Dental treatment	90
Breastfed	67

Fish Intake	
Rarely/never	12
Once per 2 wk	18
1-3 times per wk	31
4+ times per wk	39
Oily fish	62
White fish	84
Child fish intake	
6 months	44
12 months	81

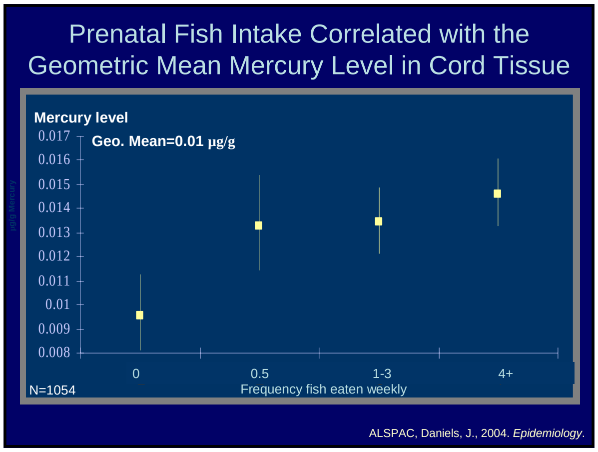
Prenatal Oily Fish Intake Correlated with DHA Level

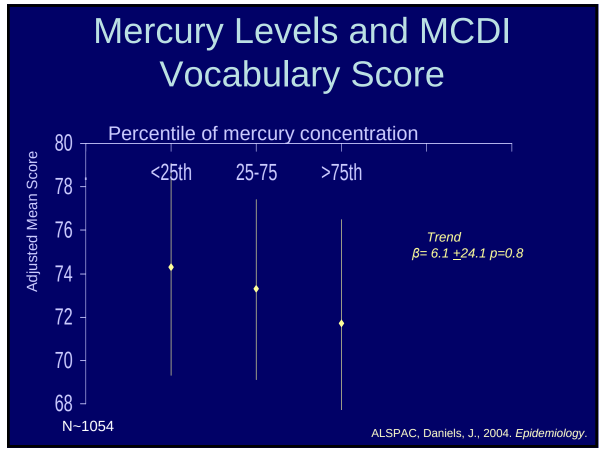


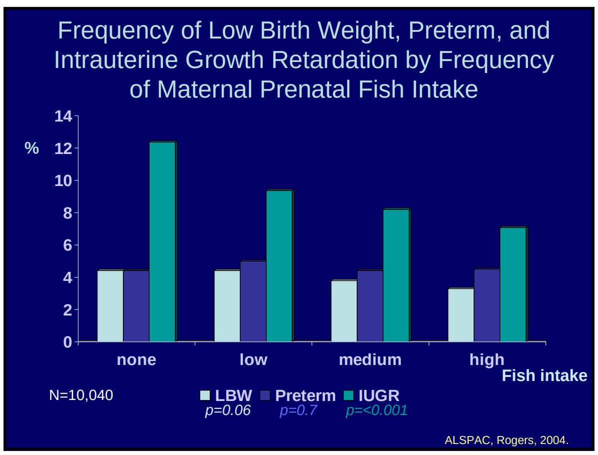
ALSPAC Study, Williams, C., 2001. *Am J Clin Nutr.*

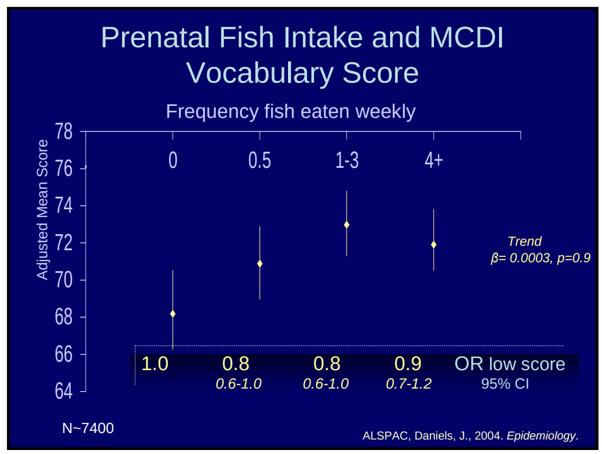
Fish Consumption and Reproductive and Developmental Outcomes

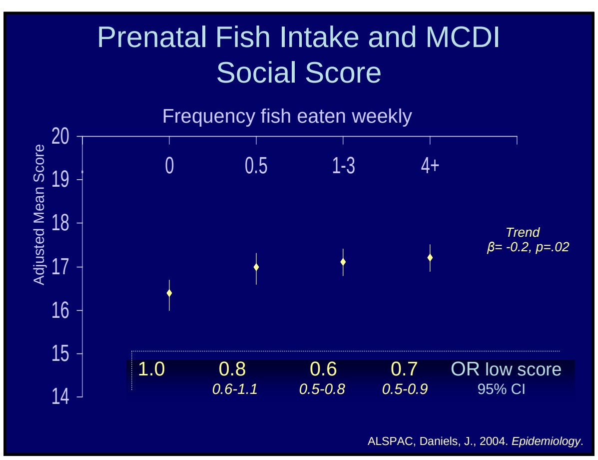
Julie L. Daniels, School of Public Health, University of North Carolina at Chapel Hill

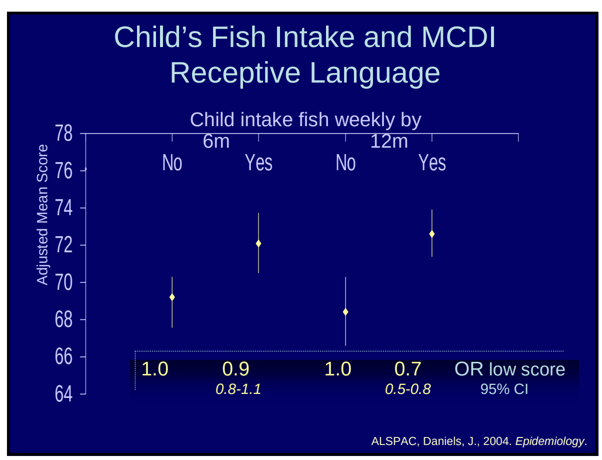


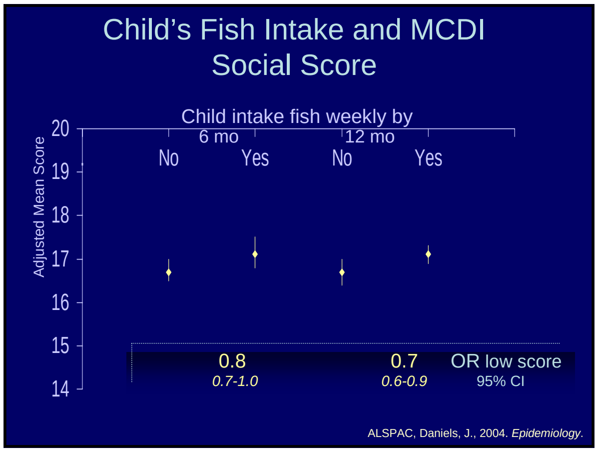


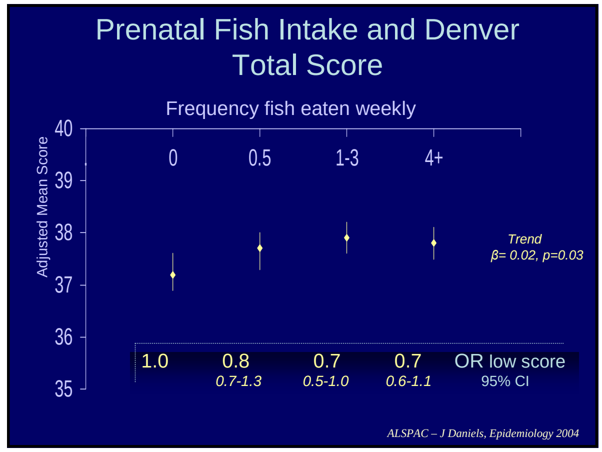












Summary: Maternal Fish Intake May Be Beneficial When Mercury Levels Are Low

- ↑ Gestation & birth weight, ↓IUGR, LBW *– I Rogers, 2004*
- ↑ Maternal circulating DHA *– C Williams, 2001*
- ↑ Umbilical cord mercury *– J Daniels, 2004*
- ↑ Language communication, 15 mo *– J Daniels, 2004*
- ↑ Visual acuity, 3.5 yrs
  [oily fish (OR1.6), breastfed (OR 2.8)] *– C Williams, 2001*

ALSPAC study

Other Findings

- No difference by oily vs. white fish, but much overlap.
- Threshold effect: Some fish may be beneficial, but more is not necessarily better.
- Adjustment for mercury did not alter results
  - Mercury level was relatively low.

Conclusions

- Intake of fish, which was low in mercury, was associated with *subtle* improvement in child's neurodevelopment
  - Effect for both mother's & child's diet
  - Effect apparent at 1 fish meal / 2 weeks.

Limitations:

- Sensitivity and focus of tests
- Relation may differ among older children
- Limited ability to measure variation of fish in diet
- Uncontrolled confounding: Social, contaminants

Strengths:

- Large study with high fish intake, low mercury
- Prenatal diet assessed during prenatal period
- Dietary report validated for DHA & mercury

Goals of the PIN Pediatric Study

To assess the effect of maternal fatty acid & PBDE profiles during pregnancy and breastfeeding on child's early cognitive and behavioral development. (n=500)

Measurement

- Child's cognitive and behavioral development at age 3, 12, & 24 months
- FA and PBDE levels in 3-month milk samples

Analysis

- Correlation between fish intake and FA or PBDE
- Relation between the maternal fatty acid levels during pregnancy and breastfeeding and the child's neurodevelopment.
- Preliminary relation between the PBDE levels in milk and child's neurodevelopment.

Preliminary Results…

- Population characteristics
  - 85% fish eaters
  - 68% white, 24% African American
  - Most low-mid income with varied education
  - Extensive prenatal and early postnatal information
- No effect of fish intake frequency with:
  - Gestational age (β=0.5, p=0.46)
  - Birth weight (β= - 0.8, p=0.36)
- Expect results for PBDE and neurodevelopment in 3 yrs

Challenges for All Observational Studies

Neurodevelopment difficult to define & assess
- Measurement is logistically difficult & labor intensive
- Variation in 'normal' development, not clinical morbidity

Exposure difficult to assess
- Dietary details are difficult to recall
- Biomarkers are expensive and difficult in large population
  - Source, type, timing, and frequency of fish intake
  - Dose of contaminants or nutrients
  - Combinations of contaminants

Subtle effects may be dwarfed by random or systematic error
- Confounding by SES
- Non-fish eaters differ from fish eaters
- Exposure misclassification

Needs from Observational Studies

- Consistency among *multiple* studies
- Improved exposure assessment
- Evaluation of diverse developmental domains
- Long-term follow up
- Evaluation of both *FA and contaminants* in the same population, considering *prenatal and early childhood* exposure
- Careful control for confounding
- Consideration of other health outcomes

Caveats to Using Epidemiologic Data to Support Public Advisories

- Must consider the source and quantity of fish when determining risks and benefits
  - Often unknown in population-based studies
- Fish high in FA and high in contaminants are not mutually exclusive.
- Threshold effect for quantity of fish should be considered
  some=good, more ≠ better
- Recommendations should be as specific as possible, address + and -, and rely on multiple studies.

Acknowledgments

Collaborators:

- M.L. Longnecker, A.S. Rowland, J. Golding
- Daniels, J.L., 2004. *Epidemiology* 15:394-402.

For other analyses from the ALSPAC Study Team:

- J. Golding, C. Williams, I. Rogers
- Williams, C., 2001. *Am J Clin Nutr* 73:316-322.
- Rogers, I., 2004. *J Epidemiol Comm Health* 58:486-492

Nutrient Relationships in Seafood: Selections to Balance Benefits and Risks

Ann L. Yaktine, Institute of Medicine, The National Academies

Nutrient Relationships in Seafood

Selections to Balance Benefits and Risks

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Advisers to the Nation on Science, Engineering, and Medicine

The National Academies Washington, DC

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Origin of the National Academies

- In 1863, President Lincoln and Congress created the National Academy of Sciences.
- It was set up as a separate entity from the government that would honor top scientists with membership.
- The Academy serves the nation without compensation beyond expenses.

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The National Academies

- National Academy of Sciences
- National Academy of Engineering
- Institute of Medicine
- National Research Council

The Institute of Medicine

- As an independent scientific adviser, the Institute of Medicine strives to provide advice that is unbiased, based on evidence, and grounded in science.

The Academy Process

- National Academy committees deliberate in an environment free of political special interest and agency influence.
- Checks and balances are applied at every step in the study process to protect the integrity of the reports and to maintain public confidence.

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Nutrient Relationships in Seafood: Selections to Balance Benefits and Risks

Ann L. Yaktine, Institute of Medicine, The National Academies

- Data-gathering meetings are open to the public.
- The study task, committee biographies, meeting dates, and summaries are posted on the Academy Web site: (www.nationalacademies.org).

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Public comments can be made through the "Current Projects" link on the National Academies Web site.

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"Nutrient Relationships in Seafood"

Sponsored by:

- U.S. Department of Commerce
- National Oceanic and Atmospheric Administration
- National Marine Fisheries Service

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Background for the Study

- Seafood contributes a variety of nutrients to the diet
  - Protein, calcium, iodine, copper, zinc, omega-3 fatty acids.
- Some nutrients may affect bio-availability, toxicodynamics, and target organ transport of contaminants.

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- Contamination of marine resources is a concern for consumers.
- Some population groups have been identified as being at greater risk from exposure to compounds in seafood.
- Consumers, particularly those at increased risk who include seafood in their diets, need authoritative information to inform their choices.

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Study Objectives

- Assess evidence on availability of specific nutrients in seafood compared to other food sources.
- Evaluate consumption patterns among the U.S. population.

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- Examine and prioritize exposure to naturally occurring and introduced toxicants through seafood.
- Determine the impact of modifying food choices to reduce exposure.

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- Develop a decision path, appropriate to the needs of U.S. consumers, for guidance in selecting seafood to balance nutrient benefits against exposure risks.
- Identify data gaps and recommend future research.

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Projected Timeline

- November 2004 – Committee appointments
- February 2005 – First meeting
- April 2005 – Public workshop
- October 2005 – Draft report
- March 2006 – Release report

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  University of Florida
- Madeline Sigman-Grant
  University of Nevada Extension
- Nicolas Stettler
  Children's Hospital of Philadelphia

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Maternal Fish Consumption, Hair Mercury, and Infant Cognition in a U.S. Cohort

Emily Oken, Harvard Medical School

Maternal Fish Consumption, Hair Mercury, and Infant Cognition in a U.S. Cohort

Emily Oken, M.D., M.P.H.

Department of Ambulatory Care and Prevention
Harvard Medical School and
Harvard Pilgrim Health Care

Outline

- Fish consumption during pregnancy
- Fish, mercury, and cognition
- Future directions

Fish and Seafood Are Primary Sources of Elongated n-3 FA

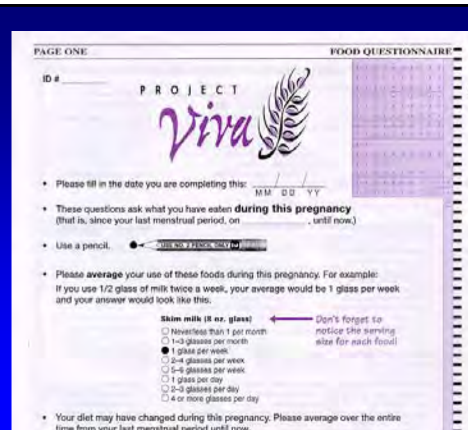
- Contain high amounts of elongated n-3 FA (EPA and DHA)
- Fatty fish in particular have the highest levels of n-3 FA
- Higher levels of EPA and DHA among those who eat more fish
  - Also higher levels in cord blood and breast milk

n-3 FA and Pregnancy

- Pregnancy complications
  - Preeclampsia and gestational hypertension
- Gestation length
  - Some observational studies and trials suggest that n-3 FA prolong gestation and reduce the risk of pre-term birth
- Fetal growth
  - Higher fish and FA intake in pregnancy associated with higher birth weight, likely from longer gestation, but fetal growth not well studied
- Offspring cognition.

Project Viva

- Prospective longitudinal cohort of 2,100+ women
- Prenatal diet, maternal and offspring health
- Enrollment at first obstetric visit
- 8 urban and suburban obstetric practices in eastern MA
- Recruitment 4/1999 - 7/2002
- Ongoing follow-up through age 5 years.



PAGE ONE FOOD QUESTIONNAIRE

ID # ________

PROJECT Viva

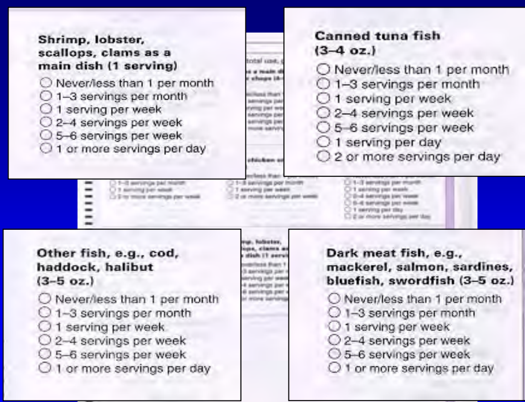
- Please fill in the date you are completing this: __/__/__ (MM DD YY)
- These questions ask what you have eaten **during this pregnancy** (that is, since your last menstrual period, on ________, until now.)
- Use a pencil.
- Please **average** your use of these foods during this pregnancy. For example: If you use 1/2 glass of milk twice a week, your average would be 1 glass per week and your answer would look like this.

Skim milk (8 oz. glass) ← Don't forget to notice the serving size for each food!
- Never/less than 1 per month
- 1–3 glasses per month
- 1 glass per week
- 2–4 glasses per week
- 5–6 glasses per week
- 1 glass per day
- 2–3 glasses per day
- 4 or more glasses per day

- Your diet may have changed during this pregnancy. Please average over the entire time from your last menstrual period until now.

Maternal Fish Consumption, Hair Mercury, and Infant Cognition in a U.S. Cohort

Emily Oken, Harvard Medical School


Shrimp, lobster, scallops, clams as a main dish (1 serving)
Never/less than 1 per month
1–3 servings per month
1 serving per week
2–4 servings per week
5–6 servings per week
1 or more servings per day

Canned tuna fish (3–4 oz.)
Never/less than 1 per month
1–3 servings per month
1 serving per week
2–4 servings per week
5–6 servings per week
1 serving per day
2 or more servings per day

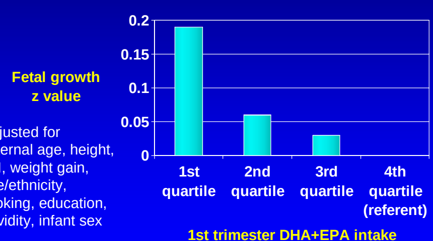
Other fish, e.g., cod, haddock, halibut (3–5 oz.)
Never/less than 1 per month
1–3 servings per month
1 serving per week
2–4 servings per week
5–6 servings per week
1 or more servings per day

Dark meat fish, e.g., mackerel, salmon, sardines, bluefish, swordfish (3–5 oz.)
Never/less than 1 per month
1–3 servings per month
1 serving per week
2–4 servings per week
5–6 servings per week
1 or more servings per day

Maternal n-3 FA Intake and Pregnancy Outcomes – Viva

- No association with preeclampsia or gestational hypertension
  Oken et al., 2005. *Circulation* 111(4):e40.
- No association with gestation length or risk of pre-term.
  Oken et al., 2004. *Am J Epidemiology* 160(8):774-783.

Maternal n-3 Fatty Acid Intake Inversely Associated with Fetal Growth



*Adjusted for maternal age, height, BMI, weight gain, race/ethnicity, smoking, education, gravidity, infant sex

Oken et al., 2004. *Am J Epidemiology* 160:774-83

n-3 FA and Infant Cognition (Prenatal Data)

- DHA is an essential component of eye and brain cell membranes
  - Most fetal brain uptake occurs in late pregnancy and early infancy
- One RCT showed higher intelligence at age 4 among children of mothers given prenatal cod liver oil (2.0 mg/day DHA+EPA) versus corn oil (n-6 FA). (Helland, 2003, *Pediatrics*)

n-3 FA and Infant Cognition (Postnatal Data)

- Breastfed babies 'smarter' in a number of studies
  - Breast milk contains DHA; formula did not
  - (Caveat about sociodemographic confounding)
- Postnatal RCTs
  - No consistent benefit of formula supplemented with n-3 FA among term or pre-term infants
- Thus, perhaps n-3 FA promote infant cognitive development?

But …There's Always a Down Side

- Mercury (Hg), which may contaminate fish, may harm brain development
  - Prenatal mercury exposure in high levels is toxic
  - Moderate Hg exposure from fish and whale consumption in Faroe Islands inversely associated with cognition
  - No association of Hg levels and cognition among children in the Seychelle Islands (similar exposure levels to Faroes).

Maternal Fish Consumption, Hair Mercury, and Infant Cognition in a U.S. Cohort

Emily Oken, Harvard Medical School

Fish and Cognition

- Unclear whether maternal fish consumption during pregnancy is on balance beneficial or harmful for offspring cognition
  - Limited data about associations of fish intake and child development (one exception is Daniels et al., 2004)
  - Many populations in the United States not at high risk from local contamination
  - Many women in the United States do not rely on fish as primary source of protein, unlike island populations.

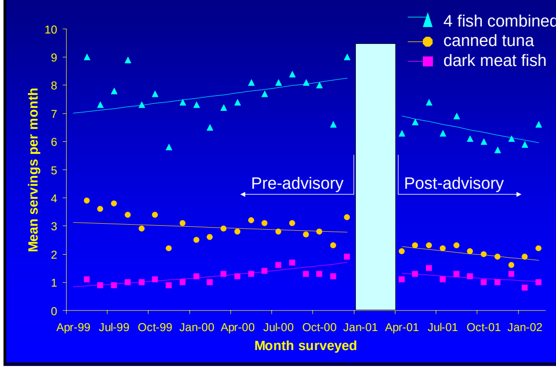
U.S. Federal Mercury Advisory, January 2001

- Women who are pregnant, nursing mothers, and children < 12 should:
  - Avoid shark, swordfish, king mackerel, and tilefish
  - Consume ≤12 oz per week of all other commercially caught fish.

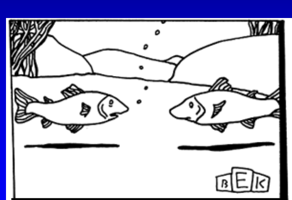
Did the 2001 Federal Mercury Advisory Influence Pregnant Women's Diets?

Oken, E, K.P. Kleinman, W.E. Berland, S.R. Simon, J.W. Rich-Edwards, and M.W. Gillman. 2003. Decline in fish consumption among pregnant women after a national mercury advisory. *Obstet Gynecol* 102(2):346-51.

Decline in Fish Consumption After 2001 Federal Mercury Advisory



Does Fish Consumption Harm or Benefit Infant Cognition?



"With all these omega-3 fatty acids, you'd think I'd feel better."

Oken, E., R.O. Wright, K.P. Kleinman, D. Bellinger, C.J. Amarasiriwardena, H. Hu, J.W. Rich-Edwards, and M.W. Gillman. 2005. Maternal fish consumption, hair mercury, and infant cognition in a US cohort. *Environmental Health Perspectives* (in press).

Maternal Hair Collection

- Hair collection 2/2002 – 2/2003
  - ~100 strands from occiput, tied and stored in envelope
- 409 deliveries during this period
  - 107 not approached (weekend or no RA)
  - 302 approached for hair collection
    - 32 ineligible (hair too short or in braids)
    - 270 eligible
    - 211 consented
    - 135 with available data on maternal second trimester fish intake and 6-month infant cognition.

Maternal Fish Intake

- Second trimester SFFQ, administered ~28 weeks of gestation
- Asked about intake over the previous 3 months (thus covers months 4-6)
- Used 4 fish questions combined (canned tuna + dark meat + shellfish + other) to provide an adequate range of exposure.

Mercury Assay

- Proximal 3 cm length assayed
  - Represents pregnancy months 6-8
- Total Hg assayed with Direct Mercury Analyzer 80 (Milestone Inc., Monroe, CT)
- Recovery of standard 90-110%
- >95% precision.

6-month cognitive test: VRM


6-month cognitive test: VRM


Outcome: % of time spent looking at novel stimulus
Correlated with later IQ
Mean score in Viva = 60, range = 10-90

Participant Characteristics
n=135 Mother/Child Pairs

Mothers	Percent	VRM score (95% CI)
<30 years	16	60 (51, 68)
30-34 years	53	61 (57, 65)
≥ 35 years	31	59 (52, 67)
White	82	60 (56, 63)
Nonwhite	18	61 (54, 67)
Married or cohabitating	92	60 (57, 63)
Single	8	61 (51, 70)
College graduate	80	59 (56, 62)
Not college graduate	20	63 (58, 68)

Participant Characteristics

Children	Percent	VRM score (95% CI)
Male	51	59 (55, 62)
Female	49	61 (56, 66)
<37 weeks gestation	4	65 (50, 79)
37-38 weeks	22	58 (51, 65)
39-40 weeks	54	61 (57, 65)
≥ 41 weeks	19	58 (50, 65)
SGA (<10^{th} percentile)	2	53 (28, 70)
AGA (10^{th}–90^{th} percentile)	85	60 (57, 63)
LGA (> 90^{th} percentile)	13	59 (49, 69)
Breastfed < 2 months	19	54 (47, 62)
2-4 months	23	60 (53, 67)
≥ 5 months	58	61 (57, 66)

Fish and Mercury in Viva
n=135 Mother/Child Pairs

- Fish (maternal second trimester total 4 fish types)
  - Mean 1.2 servings/week, range 0-5.5
  - 7% > 2 servings/week
- Mercury (maternal hair at delivery)
  - Mean 0.54 ppm, geometric mean 0.45 ppm
  - 10% > 1.2 ppm.

Fish and Mercury in Viva
n=135 Mother/Child Pairs

- Fish & mercury
  - Spearman r = 0.47
  - Hair Hg 0.17 ppm (95% CI 0.10, 0.24) higher for each weekly fish serving consumed.

Statistical Analysis

- Exposures
  - Fish, mercury, fish and mercury both
- Outcome
  - VRM score (novelty preference, continuous)
- Covariates
  - Maternal age, race, education, marital status; and infant sex, gestational age, fetal growth, breastfeeding, age at testing
- Analysis
  - Linear regression.

	Maternal second trimester fish intake (per svg/wk)	Maternal hair mercury at delivery (per ppm)
	Change in VRM score	
Fish *	2.8 (0.2, 5.4)	–
Mercury*	–	-4.0 (-10.0, 2.0)
Fish and mercury*	4.0 (1.3, 6.7)	-7.5 (-13.7, -1.2)

* Adjusted for maternal age, race, education, marital status; and infant sex, gestational age, fetal growth, breastfeeding, age at testing.

Mean VRM Score by Fish Intake and Hg Level

	Hair mercury <= 1.2 ppm	Hair mercury > 1.2 ppm
>2 weekly fish servings	72 (n=7)	55 (n=2)
<= 2 weekly fish servings	60 (n=114)	53 (n=12)

Unadjusted analysis

Summary

- Higher second trimester fish intake associated with higher Hg in moms' hair
- Higher Hg associated with lower cognition at age 6 months
- But … increased fish intake associated with ***higher*** cognition (especially in low Hg group)
- → Moms should eat fish during pregnancy, but choose ones with low Hg (and presumably high n-3 fatty acids).

Cautions

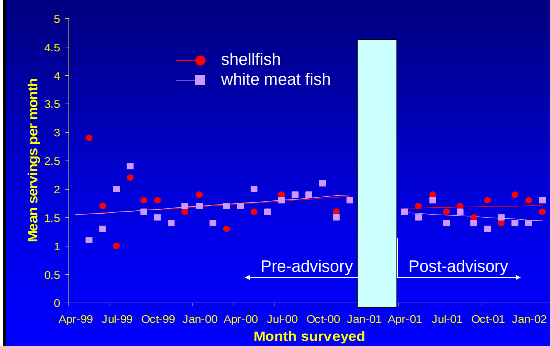
- No measure of PCBs or other toxins
- Total not organic Hg
- Can't tease out which fish types most important
- No measure of parental IQ or home stimulation
- Small sample, may not be representative of larger U.S. population.

Next Steps – Viva

- Associations with child development at 3 years of age
- Maternal RBC n-3 fatty acids
- Maternal RBC mercury levels.

Questions?

"How do we tell the kids that we're edible again?"



Maternal Dietary Patterns

- 4 fish questions constitute
  - 96% of EPA intake
  - 86% of DHA intake
- Project Viva women who ate more fish while pregnant are more likely to be:
  - Black or Asian
  - Older
  - College graduates

Fish and Elongated n-3 PUFA Intake Among Project Viva Moms

	Total fish (servings/month)	DHA+EPA (g/day)
First trimester diet	Mean (range)	
Quartile 1 (lowest)	0	0.02 (0-0.05)
Quartile 2	3.1 (2-4)	0.09 (0.06-0.12)
Quartile 3	6.9 (6-8)	0.18 (0.12-0.24)
Quartile 4 (highest)	15.8 (10-96)	0.36 (0.24-2.53)

Oken et al., 2004. *AJE* 160:774.

Fish and n-3 FA Intake Are Fairly Stable Across Trimesters

	Mean (SD) intake 1st trimester	Mean (SD) intake 2nd trimester	% change in mean	Individual correlation (r)
Fish (servings/ week)	1.7 (1.5)	1.7 (1.6)	-0.9	0.61
n-3 fatty acids (% of energy)	0.5 (0.2)	0.5 (0.2)	4.0	0.45

Rifas-Shiman et al., 2005. *PPE* (in press).

Viva Fatty Acid Intake Similar to Other Populations … But Is It Adequate?

- 1987-88 USDA survey: mean DHA+EPA consumption of 0.1g/day in U.S. women of childbearing age (in our second quartile)
- Among pregnant women in Canada and Holland, mean DHA+EPA consumption was 0.22 g/day (our third quartile)
- ISSFAL recommends at least 0.65 g/day for pregnant and lactating women.

Hair Hg and Development

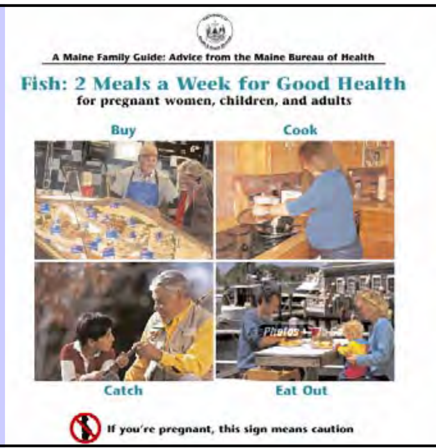
Study	N	Hg exposure	Outcomes
Faroes	917	Mean 4.3 ppm 25th percentile - 2.6 75th percentile - 7.7	Some lower test scores, less strong c/w cord blood
Seychelles	779	Mean 6.8 ppm (SD 4.5) Range 0.5-26.7	1/46 endpoints to 107 months
New Zealand	237	73/1000 with>6.0 ppm matched with 3 controls	5/26 tests showed harm if hair Hg>6 ppm
Peru	131	Mean 7.1 ppm (SD 2) Range 0.9-28.5	No effect on neurodevelopment

Maternal Hair Hg Levels in the United States

Study	N	Hg measures	Other
NHANES (non-pregnant)	702	Median 0.2 ppm 90th percentile 1.4 ppm	75% detectable
Lake Ontario	247	Median 0.5 ppm 25th percentile 0.4, 75th percentile 0.7	No association with Fagan test, but lower score with higher PCBs
NJ	189	Mean 0.53 ppm range <0.2-9.1, 97th percentile 2.0	80% detectable

“Eating Fish for Good Health”: A Brochure Balancing Risks and Benefits

Eric Frohmberg, Maine Bureau of Health



Motivation

- Sportfish focus on brochure
- Multiple brochures circulating

Methods

- Multiple key informant and focus group tests
- Written in “easy to read” format

What Did We Learn?

- Folks want commercial and sport-caught fish advice in one spot
- Folks pretty aware about mercury and omega-3 fatty acids
- Strong barriers to eating fish
- Everyone in the family needs to be addressed

Goals

- Focus on commercial fish
- Discuss health benefits
- Identify what TO DO, not what not to do
- Address barriers
- Deal with conflicting information, e.g., salmon

Tell Folks What to Do

- Identify fish “high” in omega-3 fatty acids and low in Hg
- Identify fish low in Hg

Healthy Fish for Pregnant Women and Families:
Eat 2 Meals a Week of Different Fish

Best Choices
Seafood High in Omega 3 Oils and Low in Mercury
- Salmon – fresh and canned
  Try **budget friendly** canned salmon. See recipe on page 10.
- Shrimp – fresh, frozen, canned, from Maine and away
- Sardines and Herring
- Smelt
- Atlantic Mackerel
- Mussels

Next Best Choices
Other Seafood Low in Mercury, but Not as High in Omega 3 Fish Oils
- **Light** Canned Tuna
- Scallops and Clams
- Flounder and Sole
- Haddock, Hake, Pollock, and Cod
- Imitation Crab or Lobster (This is made from various fish.)
- Lobster – but do not eat tomalley, the green stuff inside the body

Why are Omega 3 fish oils important? Omega 3 fish oils are “brain food” for babies in the womb and babies who are nursing. These oils also help protect adults from heart attack deaths. Fish high in Omega 3 oils are best for the whole family, including pregnant and nursing women and children.

Most farm raised fish are safe to eat. See page 9. For farm raised salmon, see page 10.

Limits

- Fish to avoid
- Fish to limit
- Advice for others

High Mercury Fish to Limit or Avoid

Advice for Pregnant and Nursing Women, Women Who May Get Pregnant, and Children Under Age 8

Fish to Avoid: Pregnant and nursing women, women who may get pregnant, and children under age 8 should NOT eat these 4 fish. They're too high in mercury:
- **Swordfish**
- **Shark**
- **King Mackerel**
- **Tilefish**

These fish are high in mercury because they eat other fish or live a long time. Mercury can damage a brain starting to form or grow. That's why babies in the womb, nursing babies, and young children are at most risk.

Fish to Limit: Pregnant and nursing women and children under age 8 may safely eat **one meal per week** of one of these fish. Choose **other** fish listed on page 3 for the 2nd fish meal that week.
- **Tuna steak**
- **White canned tuna (see page 9)**
- **Halibut steak**

Advice for Everyone Else

Fish to Limit: Other adults and children over age 8 may safely eat up to **2 meals per month** of swordfish, shark, king mackerel, and tilefish. These fish are high in mercury because they eat other fish or live a long time. Too much mercury lowers the heart healthy benefits of Omega 3 fish oils.

Limits on Fish You Catch: See eating limits for sport caught fish (fish from Maine rivers, lakes, oceans) on page 11.

"Eating Fish for Good Health": A Brochure Balancing Risks and Benefits

Eric Frohmberg, Maine Bureau of Health

Sport-Caught Fish

- Low Hg fish
- Fish with limits
- Fish to avoid

Barriers to Behavior Change

- How to buy
- How to store

Barriers to Behavior Change (cont.)

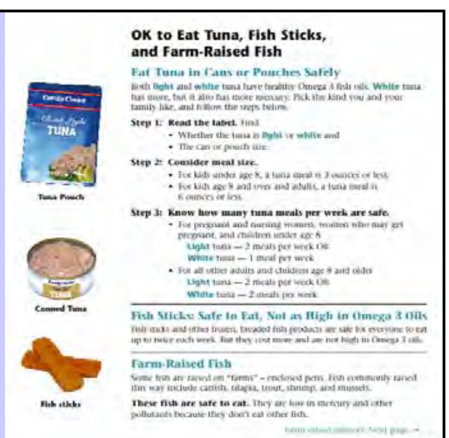
- How to cook fish
- What to eat at a restaurant

Barriers to Behavior Change (cont.)

- Scheduling – Model behavior
- Cost
- How large is a fish meal?

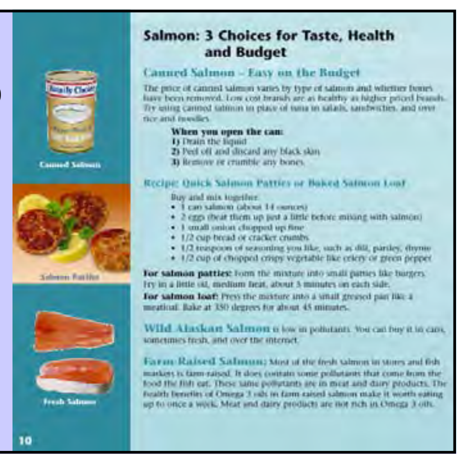
Commonly Consumed Fish

- Tuna
- Fish sticks
- Farm-raised fish



Commonly Consumed Fish (cont.)

- Canned salmon
- Wild salmon
- Farm-raised salmon "advice"



"Eating Fish for Good Health": A Brochure Balancing Risks and Benefits

Eric Frohmberg, Maine Bureau of Health

Centerpiece:

- Post or save
- Testing suggests folks use to validate current practice
- Mercury is the easy part – what about PCBs/dioxins?
- Are omega-3 fatty acids good for babies or not?

A Comprehensive Risk Framework Presented to the Mohawks of Akwesasne

Anthony M. David, Environment Division, St. Regis Mohawk Tribe

A Comprehensive Risk Framework
Presented to the Mohawks of Akwesasne

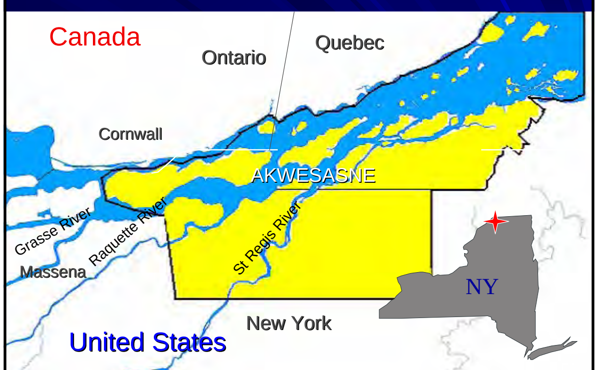
Tony Teharatats David
Water Quality Program Manager
St. Regis Mohawk Tribe
Environment Division

2005 National Conference
on Contaminants in Fish

Presentation Topic

The application of the conventional risk paradigm has excluded the many abstract and multidisciplinary aspects of environmental contamination and its cost to indigenous lifeways.

2



3

Mohawk Nation

- Kahniakehaka (possessors of the flint)
- Nation within the Haudenosaunee Confederacy
- Traditional Homeland: Mohawk Valley of central NY state
  - Occupied St. Lawrence River ~3,000-yr
- Current Settlements: NY, ON, and PQ
- Agriculture-, hunting-, and fishing-based culture

4

Mohawks of Akwesasne

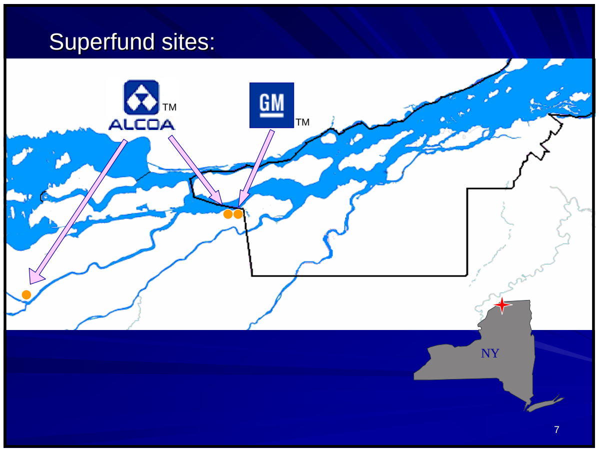
- Traditional government system
- Catholic mission (est. circa 1756)
- Tribal government (est. circa 1934)
- 12,000 residents
- 37,000 ac (U.S. ~15,000 ac)
- Growing economic development
- Tribally owned casino

Mike Galban © 2004

5

A Comprehensive Risk Framework Presented to the Mohawks of Akwesasne

Anthony M. David, Environment Division, St. Regis Mohawk Tribe



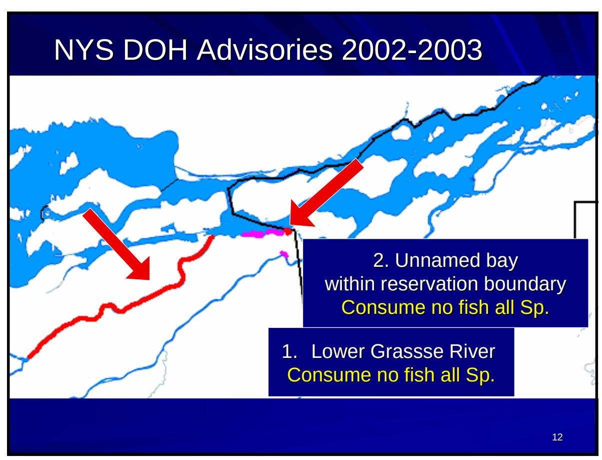
Primary Pollutant of Concern:

Polychlorinated Biphenyls (PCBs)

Other contaminants

- PAHs (polycyclic aromatic hydrocarbons)
- PCDD/DF (polychlorinated dibenzo dioxins/furans)
- Phenyls
- Cyanides
- Aluminum
- VOCs (volatile organic compounds)
- Fluorine
- Other organics

8



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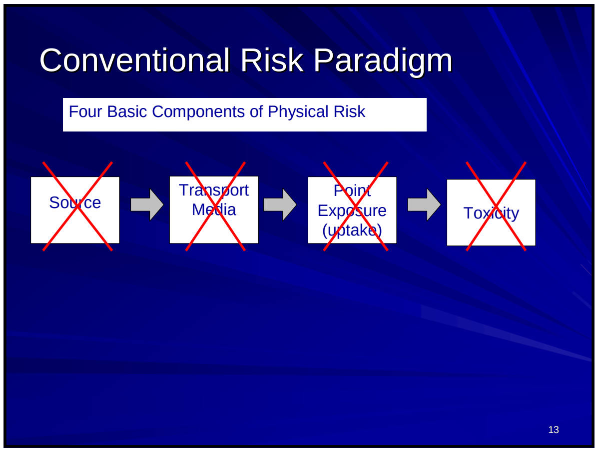
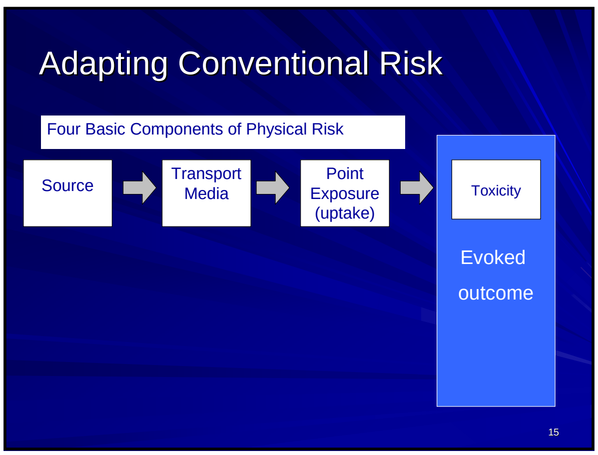
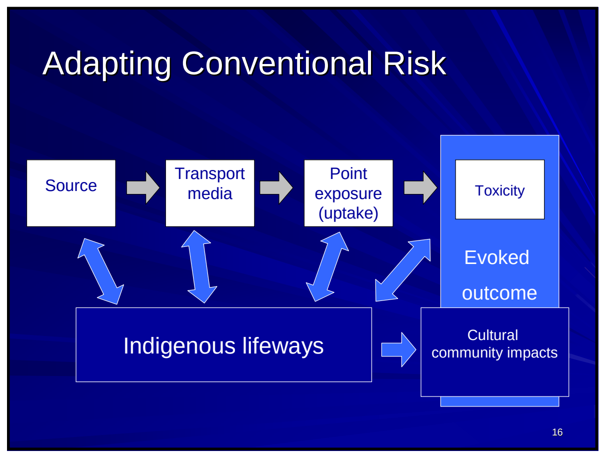
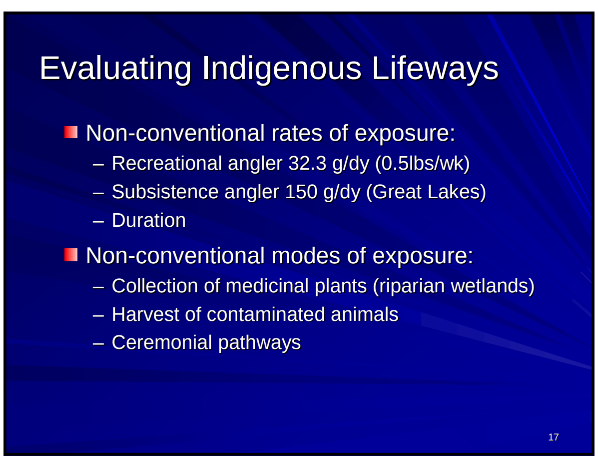
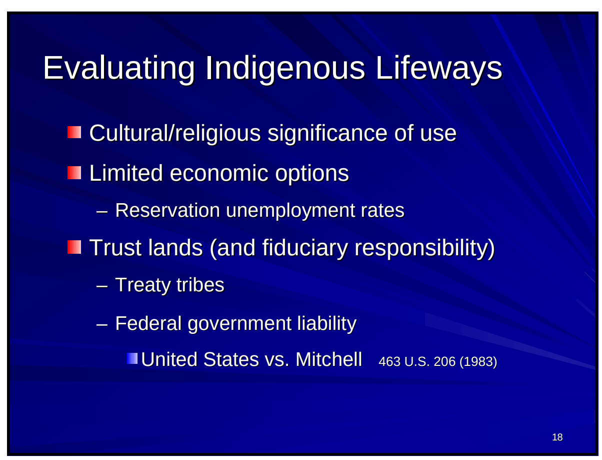
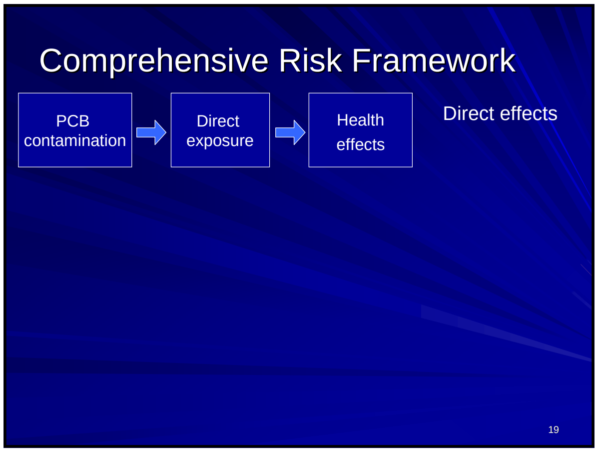


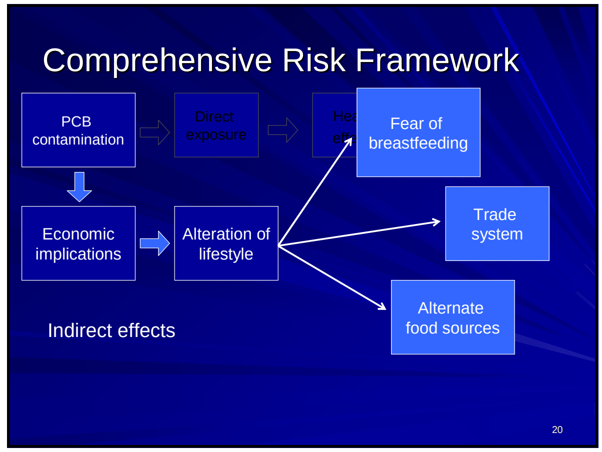


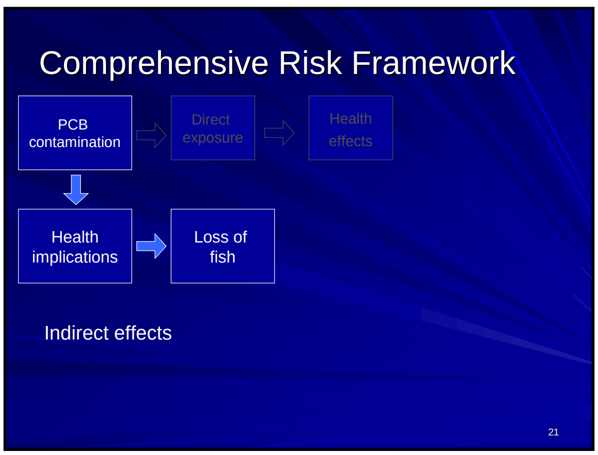


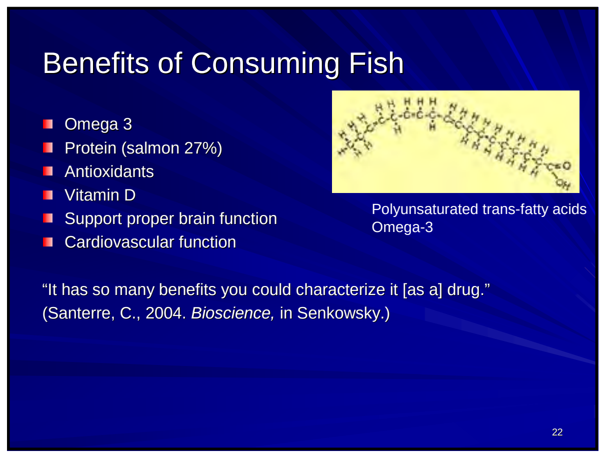


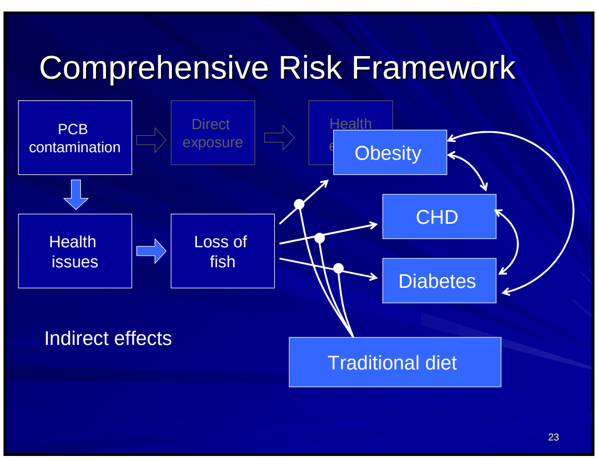


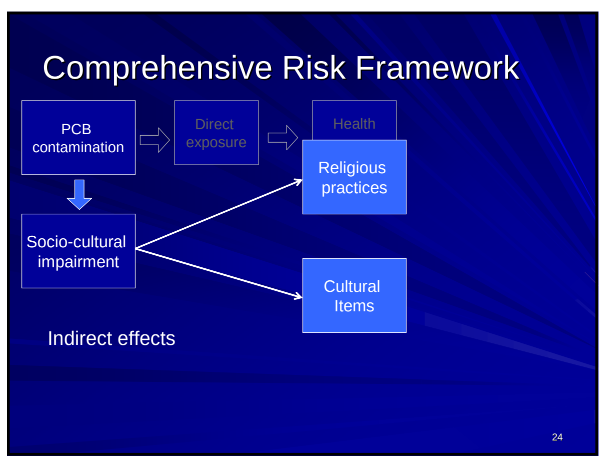

Comprehensive Risk Framework
PCB contamination
Direct exposure
Health effects
Direct effects
19


Comprehensive Risk Framework
PCB contamination
Direct exposure
Fear of breastfeeding
Economic implications
Alteration of lifestyle
Trade system
Alternate food sources
Indirect effects
20


Comprehensive Risk Framework
PCB contamination
Direct exposure
Health effects
Health implications
Loss of fish
Indirect effects
21

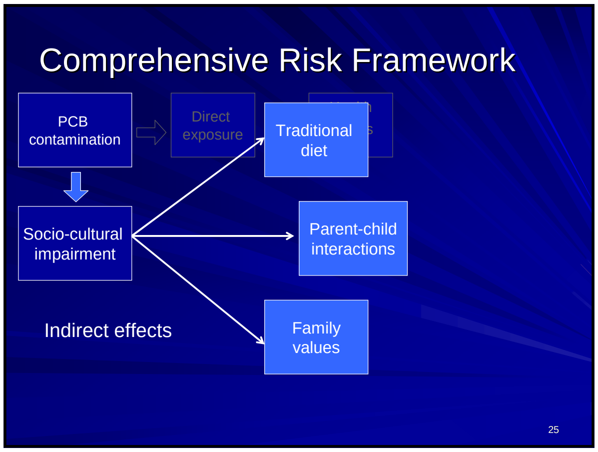

Benefits of Consuming Fish
Omega 3
Protein (salmon 27%)
Antioxidants
Vitamin D
Support proper brain function
Cardiovascular function
Polyunsaturated trans-fatty acids
Omega-3
"It has so many benefits you could characterize it [as a] drug."
(Santerre, C., 2004. Bioscience, in Senkowsky.)
22

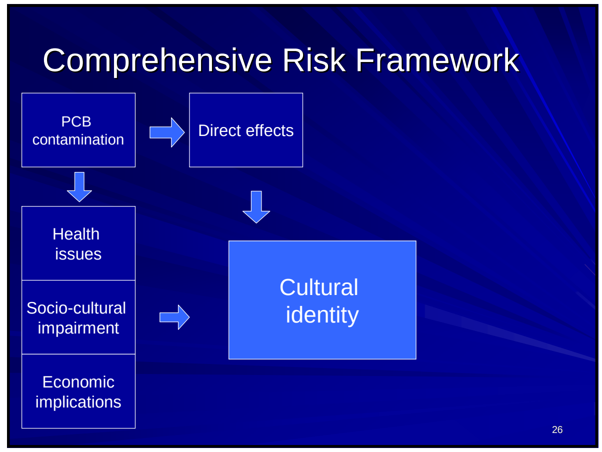

Comprehensive Risk Framework
PCB contamination
Direct exposure
Health
Obesity
CHD
Diabetes
Health issues
Loss of fish
Traditional diet
Indirect effects
23


Comprehensive Risk Framework
PCB contamination
Direct exposure
Health
Religious practices
Socio-cultural impairment
Cultural Items
Indirect effects
24

A Comprehensive Risk Framework Presented to the Mohawks of Akwesasne

Anthony M. David, Environment Division, St. Regis Mohawk Tribe





Summary

- Importance of utilizing a CRF
- Original instructions organized these impacts
- Need for comprehensive impacts (costs) in risk characterization and risk management
- Consequences and outcomes

27

Next Steps

- U.S. EPA acknowledgment
- Redefining risk: Direct and indirect cost
- Early incorporation within assessment process
- Further research: Evaluation of native lifeways
- Formulation of a standardized process

28

Acknowledgments

- U.S. EPA
- St. Regis Mohawk Tribe
- SUNY Minority Fellowship
- American Indian Program, Cornell University
- Department of Natural Resources, Cornell University
- James Gillett, Marianne Krasney, and Jery Sedinger

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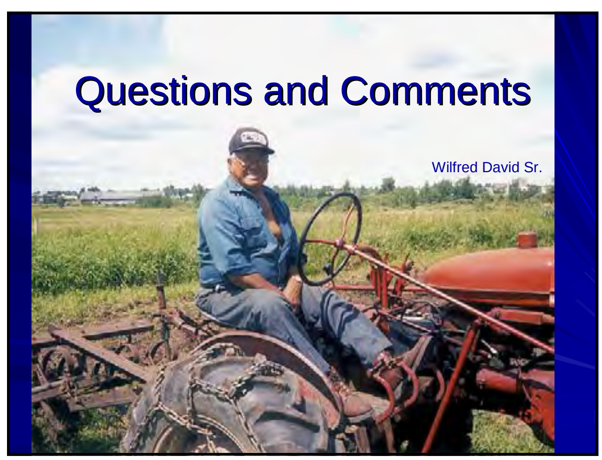
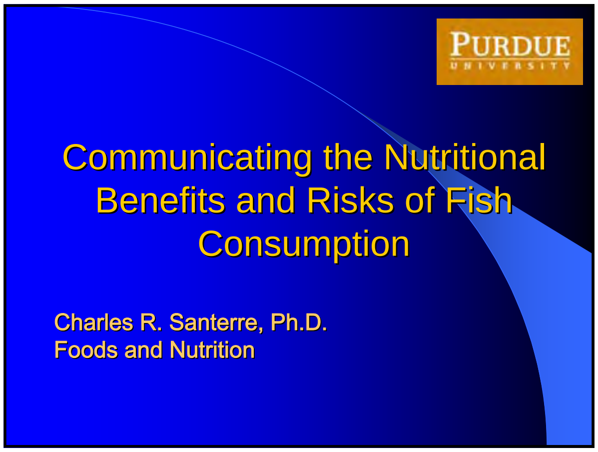
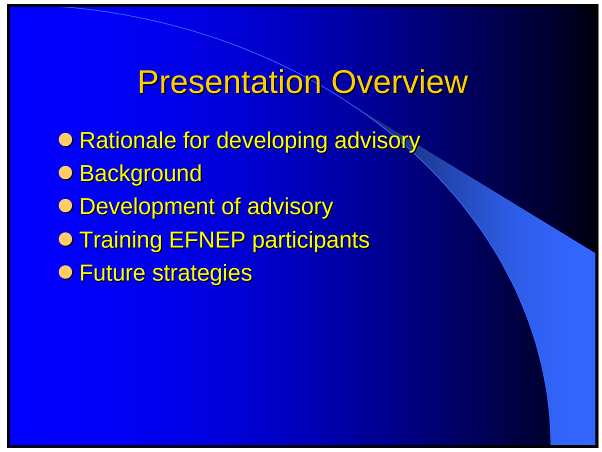
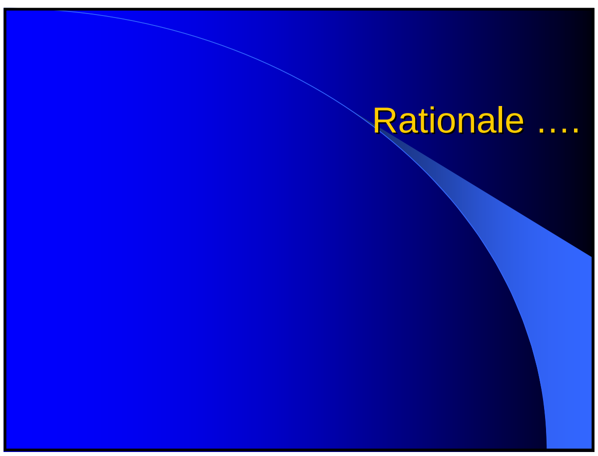


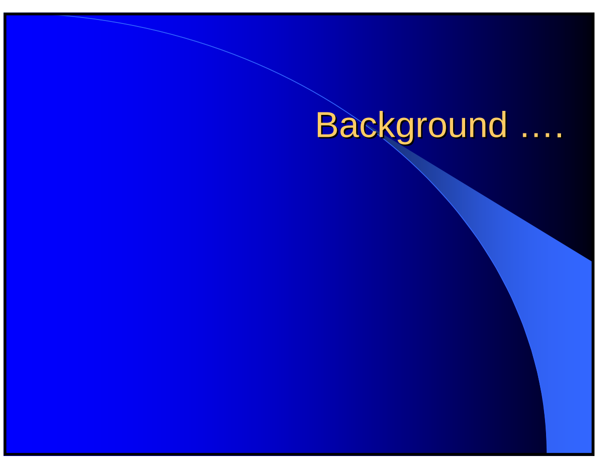
Communicating the Nutritional Benefits and Risks of Fish Consumption

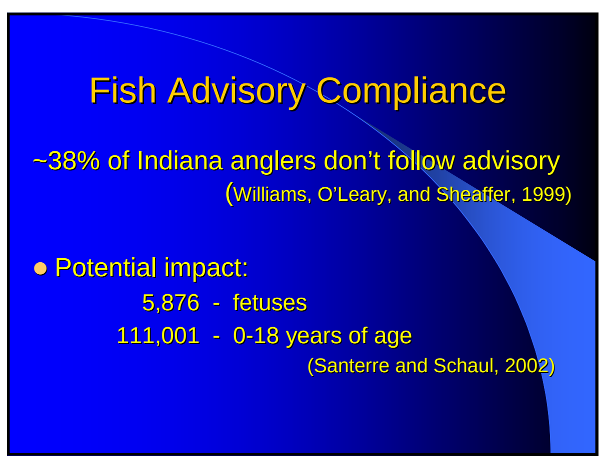
Charles R. Santerre, Purdue University











Healthy Fats in Fish

- DHA - important for brain/eye development.
  NAS, 2002
- An estimated 250,000 Americans die each year from sudden cardiac death.
  AHA, 2005
- "Consumption of long-chain omega-3 fatty acids [as found in fatty fish] may reduce the risk of coronary heart disease."
  ISSFAL, 1994

Possible Mechanisms

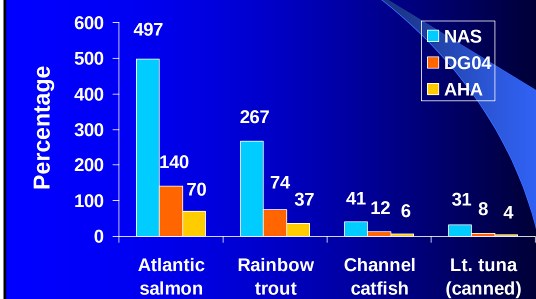
- Preventing arrhythmias
- Decreasing platelet aggregation
- Decreasing plasma triglycerides
- Moderately decreasing blood pressure
- Reducing atherosclerosis
- Small increase in HDL cholesterol
- Modulating endothelial function
- Decreasing pro-inflammatory eicosanoids.

NAS, 2002

Dietary Guidelines

- National Academy of Sciences (NAS) - 2002
  - EPA + DHA ~ 0.14 g/d (nursing/pregnant)
- Dietary Guidelines Advisory Committee Report - 2004
  - 8 oz fish/wk
  - EPA + DHA = 0.5 g/d
- American Heart Association (AHA)
  - 2 servings (2-3 oz per serving) of fatty fish/week
  - EPA + DHA = 1 g/d (heart disease patients).

If You Consume 8 Ounces/Week, What Percentage of Recommended Levels Do You Get?



How Will Mercury Exposure Change If Consumers Follow the Dietary Guidelines Advisory Committee's Recommendation of 8 Ounces/Week of Fish?

U.S. Fish Consumption – 2003

Shrimp	4.0 lbs/person
Canned Tuna	3.4
Salmon	2.2
Pollock	1.7
Catfish	1.1
Cod	0.6
Crab	0.6
Tilapia	0.5
Clams	0.5
Scallops	0.3
Flatfish	0.3
Per capita	16.3

H.M. Johnson & Assoc., 2004

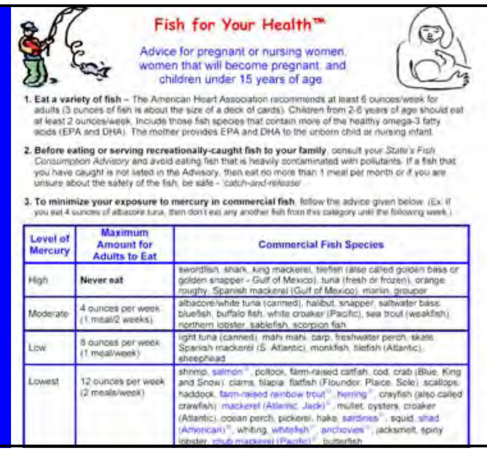
Development ….

Development of the Advisory

- Fish consumption – AHA
  - 6 oz/wk for adults
  - 2 oz/wk for 2-6 yrs old
- Sportfish – consult local agency
- Allergies – S. Taylor, U. of Nebraska
- Raw versus cooked fish – FDA food code
- Omega-3 fatty acids – USDA nutrient database
- Omega-3 intake – NAS recommendations.

Mercury Advice

- Meal frequency – max. 1 meal / 2 wks
- Maximum fish consumption – 12 oz / wk
- Mercury residue data – FDA
- Exception – all tuna products were bumped to a lower consumption rate due to the popularity of these products



Fish for Your Health™

Advice for pregnant or nursing women, women that will become pregnant, and children under 15 years of age

1. **Eat a variety of fish** – The American Heart Association recommends at least 6 ounces/week for adults (3 ounces of fish is about the size of a deck of cards). Children from 2-6 years of age should eat at least 2 ounces/week. Include those fish species that contain more of the healthy omega-3 fatty acids (EPA and DHA). The mother provides EPA and DHA to the unborn child or nursing infant.
2. **Before eating or serving recreationally-caught fish to your family**, consult your *State's Fish Consumption Advisory* and avoid eating fish that is heavily contaminated with pollutants. If a fish that you have caught is not listed in the Advisory, then eat no more than 1 meal per month or if you are unsure about the safety of the fish, be safe - *'catch-and-release'*.
3. **To minimize your exposure to mercury in commercial fish**, follow the advice given below. (Ex: if you eat 4 ounces of albacore tuna, then don't eat any another fish from this category until the following week.)

Level of Mercury	Maximum Amount for Adults to Eat	Commercial Fish Species
High	Never eat	swordfish, shark, king mackerel, tilefish (also called golden bass or golden snapper - Gulf of Mexico), tuna (fresh or frozen), orange roughy, Spanish mackerel (Gulf of Mexico), marlin, grouper
Moderate	4 ounces per week (1 meal/2 weeks)	albacore/white tuna (canned), halibut, snapper, saltwater bass, bluefish, buffalo fish, white croaker (Pacific), sea trout (weakfish), northern lobster, sablefish, scorpion fish
Low	8 ounces per week (1 meal/week)	light tuna (canned), mahi mahi, carp, freshwater perch, skate, Spanish mackerel (S. Atlantic), monkfish, tilefish (Atlantic), sheephead
Lowest	12 ounces per week (2 meals/week)	shrimp, salmon, pollock, farm-raised catfish, cod, crab (Blue, King and Snow), clams, tilapia, flatfish (Flounder, Plaice, Sole), scallops, haddock, farm-raised rainbow trout, herring, crayfish (also called crawfish), mackerel (Atlantic, Jack), mullet, oysters, croaker (Atlantic), ocean perch, pickerel, hake, sardines, squid, shad (American), whiting, whitefish, anchovies, jacksmelt, spiny lobster, chub mackerel (Pacific), butterfish

Level of mercury	Maximum amount	Commercial fish species
High	Never eat	Tilefish (Gulf of Mexico), swordfish, shark, king mackerel, tuna (fresh or frozen), orange roughy, Spanish mackerel (Gulf of Mexico), marlin, grouper
Moderate	4 oz per wk (1 meal/2 wk)	Albacore/white tuna (canned), halibut, snapper, saltwater bass, bluefish, buffalo fish, white croaker (Pacific), sea trout, northern lobster, sablefish, scorpion fish
Low	8 oz per wk (1 meal/wk)	Light tuna (canned), mahi mahi, carp, freshwater perch, skate, Spanish mackerel (S. Atlantic), monkfish, tilefish (Atlantic), sheephead
Lowest	12 oz per wk (2 meals/wk)	Shrimp, salmon, pollock, farm-raised catfish, cod, crab, tilapia, flatfish (flounder, plaice, sole), scallops, haddock, farm-raised trout, herring, crayfish, mackerel (Atlantic, Jack), mullet, oysters, croaker (Atlantic), ocean perch, pickerel, hake, sardines, squid, shad (American), whiting, whitefish, anchovies, jacksmelt, spiny lobster, chub mackerel (Pacific), butterfish

Training ….

Sportfish Advisories

- Telephone survey across 12 states
- 3,015 women, ages 18-45
  - 87% ate fish during past year
  - 29% ate sportfish during past year
  - 20% aware of state's sportfish advisory

Anderson et al., 2004. *Envir. Res.*

Training Low-Income Females

- 721 Hoosier women (10-49 yrs of age)
- 253 (35%) pregnant and 39 (5%) nursing
- Enrolled in Expanded Food and Nutrition Education Program (EFNEP)
- Completed pre- and post-tests
- Received a ~1-hour face-to-face training.

Santerre (2005)

Training Low-Income Women

- 39% had not eaten fish in past 30 days
- 10% had eaten higher mercury fish
- 33% understood that n-3s as found in fish are important for the fetus/infant advisory; after training 87%
- 6-7% had used Indiana fish consumption advisory; after training 69-79% intend to use.

Santerre (2005)

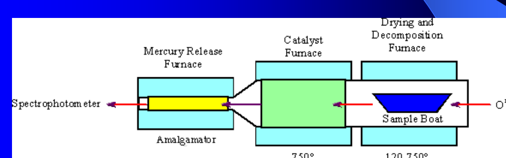
Future ….

Recommendations

- Encourage fish consumption - 8 oz/week
- Use rapid, low-cost methods for measurement of PCBs and mercury
- Consumer and health professional education to:
  - County health departments
  - Pediatricians, obstetricians, dietitians, family practice
  - County cooperative extension offices
  - WIC clinics
- Focus educational efforts on at-risk populations
- Replace albacore/white tuna in WIC and school lunch programs with *Kid Healthy* tuna.

Rapid Measurement of Mercury

- Total mercury in 5 minutes
- Hair, blood, fish tissue



Lasrado et al., 2005

Estimated Costs for PCB Methods

Total PCB - ELISA (Aroclor™ Equivalents)	$ 40
Total PCB (GC/ECD) (Aroclor Equivalents)	$ 200
TEQ - Indicator PCBs (PCB-118, PCB-138, PCB-153)	$ 200
TEQ (12 PCBs, 7 furans, 10 dioxins)	$ 1,000

Light tuna in water
Hg < 80 ppb
DHA 300 mg/oz (max 500)
582 mg DHA /serving (55 g)

'Healthy'

- Total fat < 5 g/RA (55 g) and /100 g
- Saturated fat < 2 g/RA and /100 g
- Sodium ≤ 360 mg/RA and /label serving
- Cholesterol < 95 mg/RA and /100 g
- 10% DV for vitamins A, C, calcium, iron, *protein* or fiber

21CFR101.13(h)

Mercury (µg/kg bw/d)

Amount	Albacore	'Healthy'
4 oz/wk	0.09	0.02
8 oz/wk	0.18	0.04
12 oz/wk	0.28	0.07
16 oz/wk	0.37	0.09

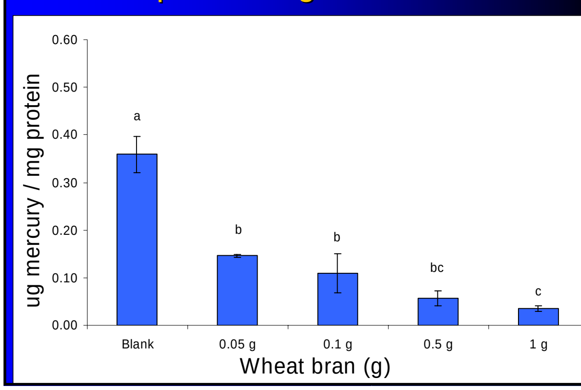
U.S. EPA RfD = 0.1 µg/kg bw/d

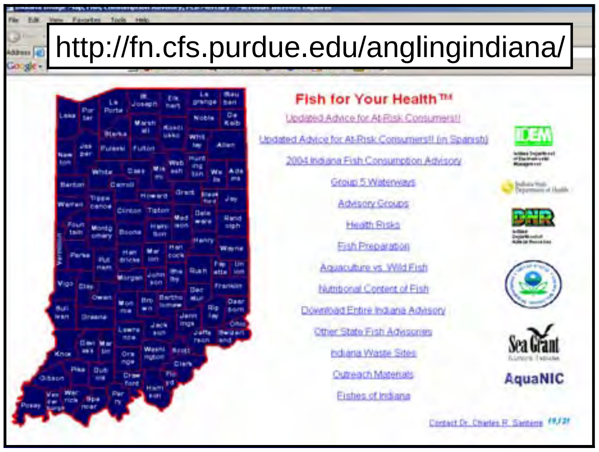
DHA (mg/d)

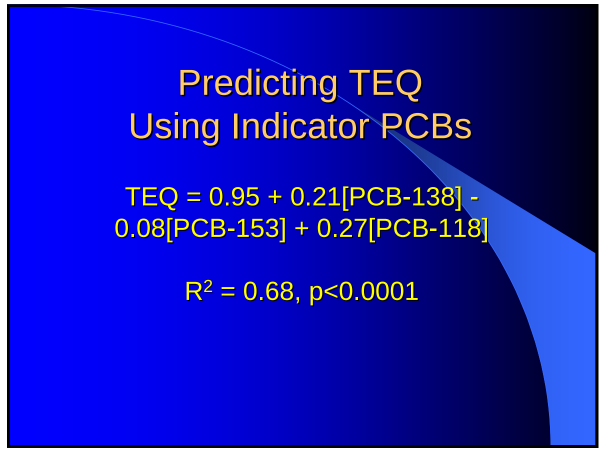
Amount	Light	'Healthy'
4 oz/wk	30	171
8 oz/wk	59	343
12 oz/wk	88	513
16 oz/wk	118	686

Effective AI = 140 mg/d for pregnant women

Absorption of Hg – Wheat Bran




http://fn.cfs.purdue.edu/anglingindiana/
Fish for Your Health™
Updated Advice for At-Risk Consumers!!
Updated Advice for At-Risk Consumers!! (in Spanish)
2004 Indiana Fish Consumption Advisory
Group 5 Waterways
Advisory Groups
Health Risks
Fish Preparation
Aquaculture vs. Wild Fish
Nutritional Content of Fish
Download Entire Indiana Advisory
Other State Fish Advisories
Indiana Waste Sites
Outreach Materials
Fishes of Indiana
Contact Dr. Charles R. Santerre
AquaNIC


Predicting TEQ
Using Indicator PCBs
TEQ = 0.95 + 0.21[PCB-138] - 0.08[PCB-153] + 0.27[PCB-118]
R2 = 0.68, p<0.0001

Implementation of the FDA/U.S. EPA Joint Advisory

2005 Fish Forum

September 21, 2005

David W. K. Acheson M.D.
Chief Medical Officer, Director, Office of Food Safety, Defense and Outreach
Center for Food Safety and Applied Nutrition
Food and Drug Administration

Overview

- Background
- Broad food-safety considerations
- Specific examples that require a "risk/benefit" approach to achieve the correct balance for public health
  - Mercury in fish

Background

- FDA regulates 80% of the food supply, which includes dietary supplements and bottled water.
- The mission of FDA is to protect public health.
- FDA has a variety of tools to achieve the mission
  - Regulations
  - Guidance
  - Risk communication.

What Is The expectation?

- FDA provides the correct interpretation of science to offer optimal public health protection.
- The traditional approach has been to look only at the risk related to consumption of a particular product
  - In many instances, the risk is clear.

Risk

- Food is contaminated with an agent
- That agent causes harm to consumers
- There is a risk from consuming the food
- Clear risk message that can be generated

Risk From Consumption Is Clear

- Foodborne pathogens
  - E. coli O157:H7
- Chemical agents
  - Cyanide
- Physical
  - Broken glass

Increasing Number of Situations Where There is a Need to Consider a "Balance"

- Food is contaminated with an agent
- That agent causes harm to consumers
- There is a risk from consuming the food
- BUT –
  - There are benefits associated with consuming the food that contain the agent of concern
- Risk message needs to be balanced between the degree of risk and the degree of benefit.

Mercury in Fish

- Risks from mercury
  - Neurotoxin
  - Developing brain is most susceptible (fetal exposure, young children)
  - Cardiovascular?
- Benefits of eating fish
  - High protein
  - Low in fat
  - Contains important nutrients
  - Affordability.

Mercury in Fish – Important Considerations

- Virtually all fish have some level of mercury present.
- The risk of exposure depends on the amount and type of fish consumed.
- The risk will vary with age.
- Methylmercury has a half-life of about 70 days; therefore, exposure prior to conception is important.

Mercury in Fish – Who is at Risk?

- Women who may become pregnant
- Pregnant women
- Nursing mothers
- Young children

Risk/Benefit of Mercury in Fish – Some Questions

- What are the levels of mercury in fish?
- What are the levels at which there are health concerns?
- How much of what type of fish it is safe to consume?
- What are the health benefits of consuming fish?
  - Heart health
  - Children's growth and development
- Are all fish equally beneficial?

The Balance

- Risks of mercury in fish is to the developing brain, hence the target group of:
  - Women who may become pregnant
  - Women who are pregnant
  - Nursing mothers
  - Young children
- The nutritional benefits of eating fish.

Problems

- Pregnant women are very risk-averse.
- The "wash-over effect"
  "If my wife should not eat these types of fish, then they are probably not good for me either."
- How do you define "young child"?
- Regional differences in mercury levels in fish.

2004 Joint Advisory Has Three Main Elements

Risk/benefit message
Consumer advice
Additional information

Risk/Benefit Message

Who Is At Risk?

WOMEN WHO MIGHT BECOME PREGNANT, WOMEN WHO ARE PREGNANT, NURSING MOTHERS, AND YOUNG CHILDREN

Risk/Benefit Message (cont.)

What Are The Benefits?

Fish and shellfish are an important part of a healthy diet. Fish and shellfish contain high-quality protein and other essential nutrients, are low in saturated fat, and contain omega-3 fatty acids.

Why They Are At Risk?

Some fish and shellfish contain higher levels of mercury that may harm an unborn baby or young child's developing nervous system. The risks from mercury in fish and shellfish depend on the amount of fish eaten and the levels of mercury in the fish and shellfish.

Consumer Advice

Benefits and Risk

If you follow advice given by the FDA and U.S. EPA, women and children will receive the benefits of eating fish and shellfish and be confident that they have reduced their exposure to the harmful effects of mercury.

Consumer Advice

How Much Fish?

Three Recommendations

1. *Do not eat shark, swordfish, king mackerel, or tilefish because they contain high levels of mercury.*




Consumer Advice (cont.)

How Much Fish?

2. *Eat up to 12 oz (2 average meals) a week of a variety of fish and shellfish that are lower in mercury.*

- *Five of the most commonly eaten fish, low in mercury: shrimp, canned light tuna, salmon, pollock, catfish*
- *Another commonly eaten fish, albacore ("white") tuna, has more mercury than canned light tuna. So, when choosing your two meals, you may eat up to 6 oz (one average meal) of albacore tuna per week.*

Consumer Advice (cont.)

How Much Fish?

3. *Check local advisories about the safety of fish caught by family and friends in your local rivers and coastal areas. If no advice is available, eat up to 6 oz (one average meal) per week of fish you catch from local waters, but don't consume any other fish during that week.*

Consumer Advice (cont.)

How Much Fish For Children?

Follow these same recommendations when feeding fish and shellfish to your young child, but serve smaller portions.

Additional Information

1. What is mercury and methylmercury?
2. I'm a women who could have children, but I'm not pregnant – so why should I worry?
3. Is there mercury in all fish and shellfish?
4. I don't see the fish I eat in the advisory.
5. What about fish sticks and fast-food sandwiches?
6. What about tuna steaks?
7. What if I eat more than the recommended amount in a week?
8. Where do I get more information?

Focus Group Conclusions – Balance Will Be A Challenge

- Women will not exceed the safe fish consumption advice.
- The concern is to ensure that women, and the children they care for, continue to eat fish as an important protein and nutrient source of their diet.

Education and Outreach

- General and specialized media
  - More than 9,000 electronic and print outlets contacted with information reaching millions of women.
  - Editors of pregnancy books urged to include advisory in next editions.

Education and Outreach (cont.)

- More than 50 organizations of health care providers to women and their families contacted:
  - American Academy of Pediatrics
  - American College of Obstetrics and Gynecology
  - American College of Nurse-Midwives
  - Women, Infant, and Children (WIC) program, etc.

Education and Outreach (cont.)

- More than 4 million brochures distributed through medical offices in English and Spanish; more than 30,000 requested each week
  - Target pediatricians and obstetricians
  - Available soon in additional languages.

Education and Outreach (cont.)

- MOMS TO BE food-safety education program for pregnant women launched in September 2005:
  - Food-safety messages
  - Three specific agents (Listeria, Toxoplasma, mercury)
  - Provide tools for training programs for use by health care workers, with video, CD, and handouts for pregnant women.

Education and Outreach (cont.)

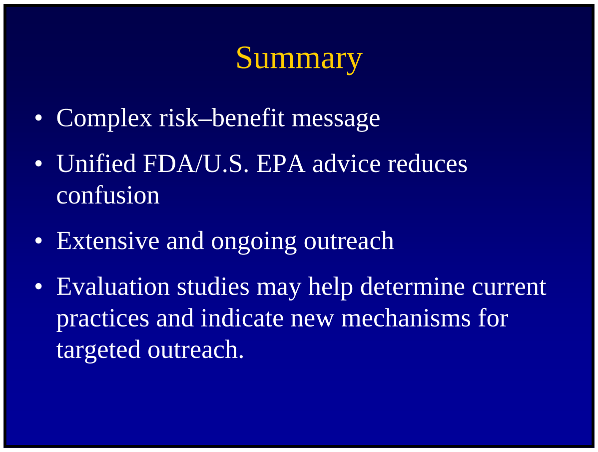
- Funding provided for special populations
  - Outreach to Asian and Native American women in communities with high fish-eating practices.

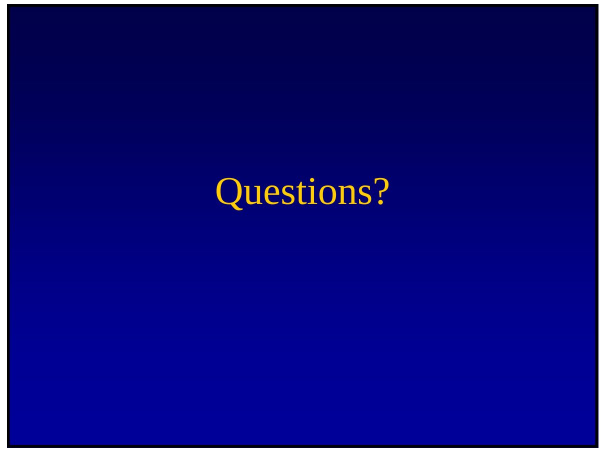
Impact of Advisory

- Decline in fish consumption among pregnant women in obstetrics practice in Massachusetts After 2001 Advisory [Oken et al., 2003. Obstet Gynecol. *102*(2): 346-51]
- Anecdotal evidence of decrease in fish sales after 2004 advisory, particularly tuna
- Introduction of new product lines (low methylmercury tuna).

Evaluation

- FDA Survey of Consumer Knowledge, Attitudes, and Behaviors
  - General consumer survey, but includes questions about fish consumption
  - Plan to start in November 2005
- Infant Feeding Practices study
  - Survey of pregnant women and mothers of toddlers
  - Currently underway.


Summary
• Complex risk–benefit message
• Unified FDA/U.S. EPA advice reduces confusion
• Extensive and ongoing outreach
• Evaluation studies may help determine current practices and indicate new mechanisms for targeted outreach.

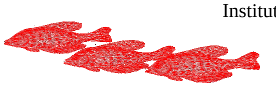

Questions?

Risk Communication: Lessons Learned About Message Development and Dissemination

Joanna Burger
Michael Gochfeld

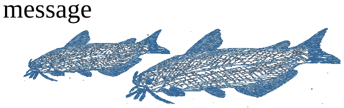
Fish Forum – September 21, 2005

Consortium for Risk Evaluation with Stakeholder Participation
Environmental and Occupational Health Science Institute
Institute of Marine and Coastal Sciences
Rutgers University

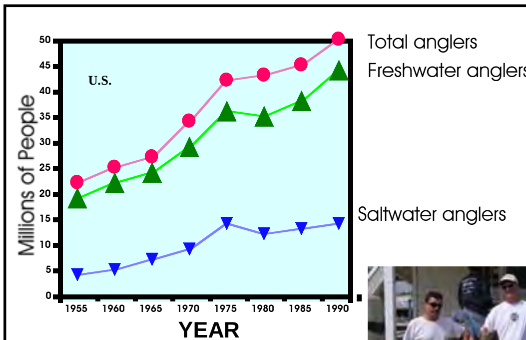


Outline

- How important is fishing?
- Is there benefit? – Do we need a message?
- Is there risk? – Do we need a message?
- Ethnic and socioeconomic factors
- Generality of findings
- Choosing the message
- Evaluation



How Important Is Fishing?

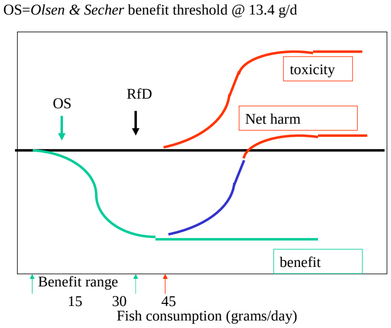


2001
34 million total fisherman
28.4-freshwater 9.1 Saltwater

Is There Risk – Do We Need a Message?

Hypothetical Composite Curves

↓RfD=30 g →0.09 μg/kg/d for a 65 kg woman eating fish at 0.2 ppm
↓OS=*Olsen & Secher* benefit threshold @ 13.4 g/d

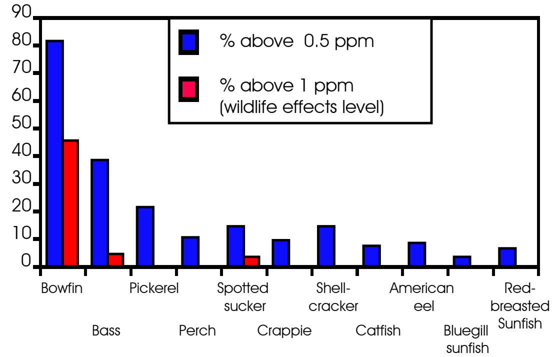


Source: Gochfeld and Burger, 2005. *NeuroToxicology.*

Risk Communication: Lessons Learned About Message Development and Dissemination

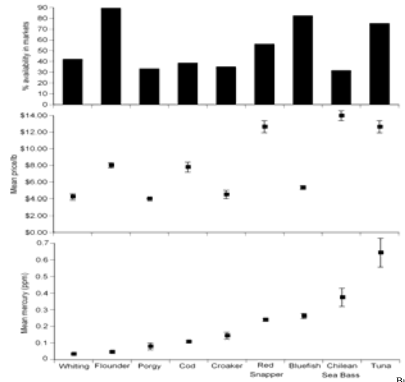
Joanna Burger, Rutgers University

Mercury Levels in Fish from the Savannah River with Percent of Samples above 0.5 ppm and above 1 ppm



Burger et al., 2001.

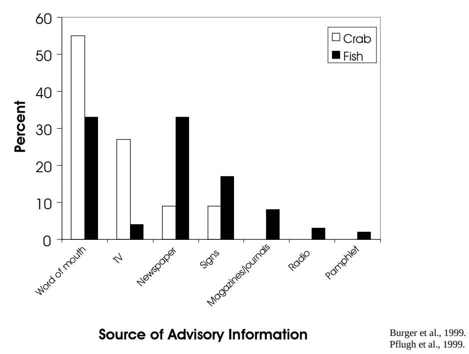
Commercial Fish in New Jersey



Burger et al., 2004, 2005.

The Information Base

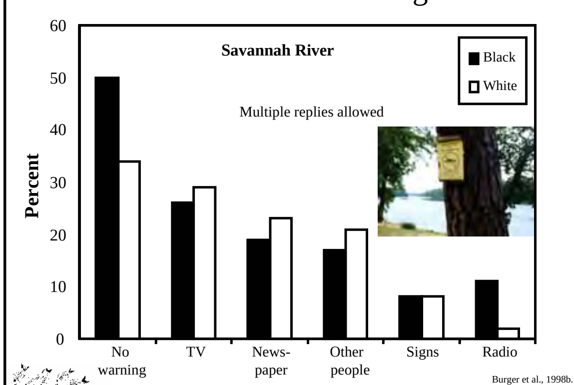
New York Harbor



Burger et al., 1999.
Pflugh et al., 1999.

Pflugh et al., 1999.

Information Sources for Fishing Advisories



Burger et al., 1998b.

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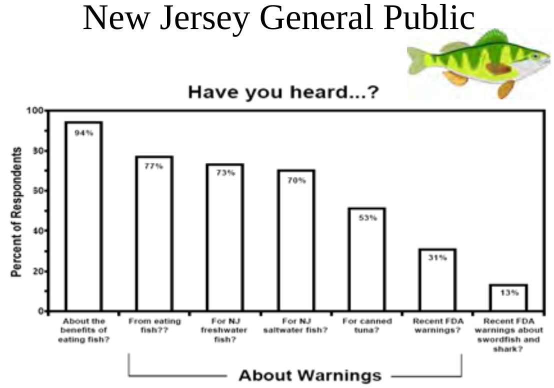
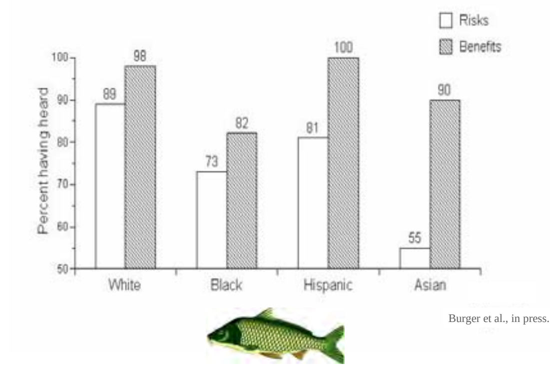
Joanna Burger, Rutgers University

New Jersey General Public

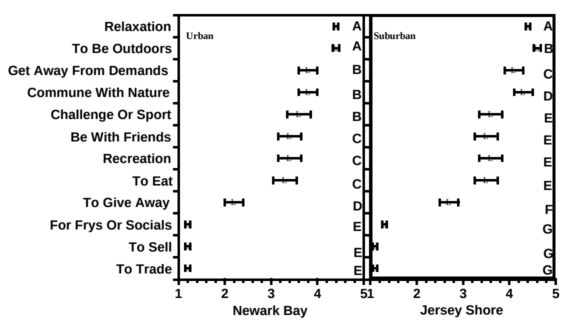


New Jersey General Public



Burger et al., in press.

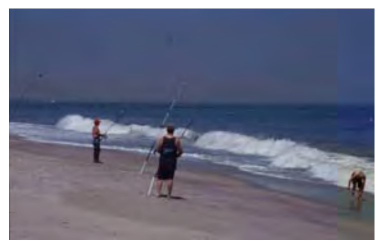
Why People Fish in New Jersey



Different letters indicate statistically significant differences by Duncan Multiple Range Test

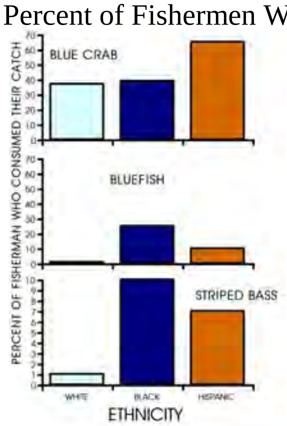
Burger, 2002.
Burger, in press.

Ethnic and Socioeconomic Factors in Risk and Knowledge



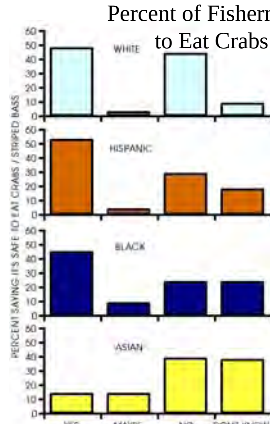
What does the public know?
What do we know?

Percent of Fishermen Who Consume Catch



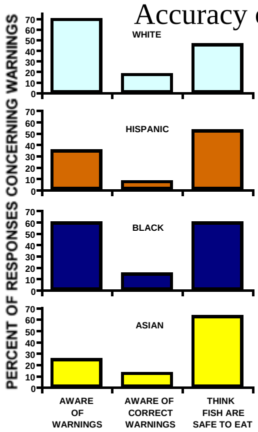
Burger et al., 1999a.

Percent of Fisherman Saying It Is Safe to Eat Crabs or Striped Bass



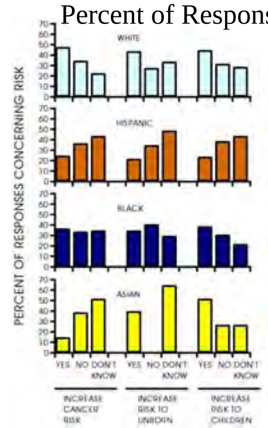
Burger et al., 1999a.

Accuracy of Knowledge



Burger et al., 1999a.

Percent of Responses Concerning Risk



7-yr-old girl in NJ

9-yr-old girl in Aleutians

Burger et al., 1999a.

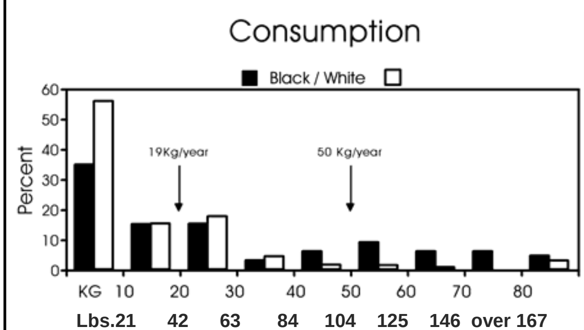
South Carolina General Public

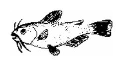
CONSUMPTION (KG/Year)

	BLACK	WHITE
All meat & fish		
Mean	125 ± 103	83 ± 2.9
Range	0 – 268	0 – 403
Wild-caught fish & game		
Mean	63 ± 11	26 ± 1.8
Range	0 – 265	0 – 232

Burger, 2000b.

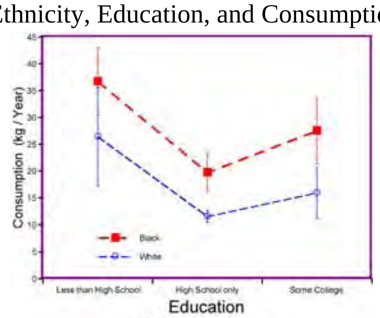
Savannah River Fishers

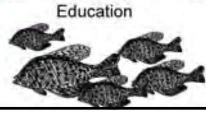




Burger et al., 1999b.

Savannah River Fishers: Ethnicity, Education, and Consumption





Burger et al., 1999b.

Generality of Findings

Risk Communication: Lessons Learned About Message Development and Dissemination

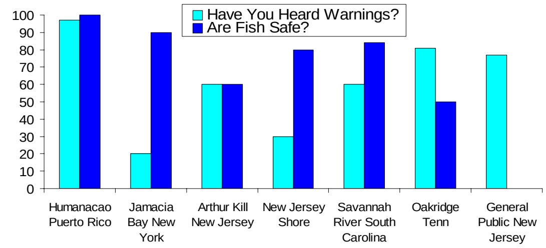
Joanna Burger, Rutgers University

Number of Fish Meals Per Month

--------------------------Among Fishers--------------------------

Burger, 2000c.
Burger and Gochfeld, 1991.
May and Burger, 1996.
Burger et al., 1999a,b.
Burger, 2005.
Burger et al., in press.
Campbell et al., 2002.

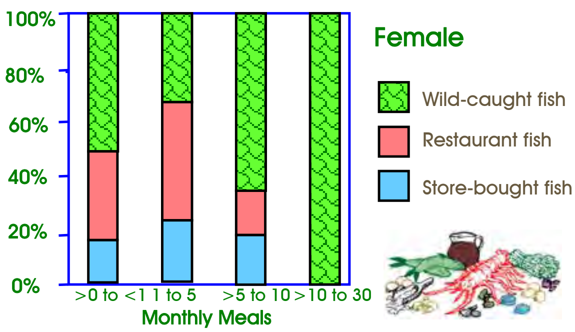
Generality of Perceptions



Burger, 2000c.
Burger, 2005.
Campbell et al., 2002.

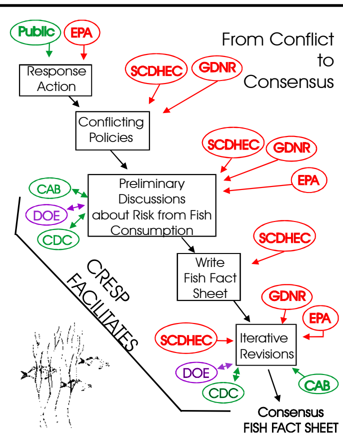
Percent Monthly Meals for 3 Types of Fish (Whites Only)

(South Carolina General Public)



Choosing the Message

Collaborative Development of fish fact sheet for Savannah River involving South Carolina and Georgia, DOE, EPA and CRESP



Burger et al., 2001c.

Evaluation

Major Message

	% Black	% White
Don't eat fish from river	35	25
Limit fish or species	21	21
Identify the contaminant	21	22
Can you reduce the risk? % saying yes	91	92
How can you reduce risk? Limit fishing in some way	86	81

Savannah River fishers

Burger and Waishwell, 2001.

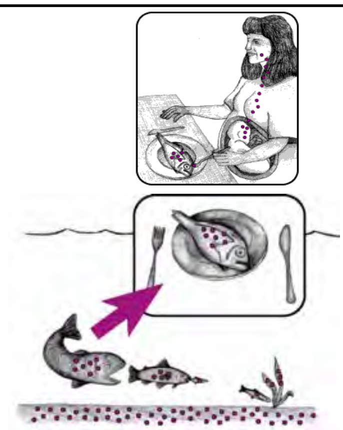
Additional Information Requested

	% Black	% White
Clean up river	8	12
Ecological pathways	12	6
Exposure	3	0
How to get fish sheet when available	17	10
Levels in fish	6	18
Risk levels	17	4
Source of contamination	6	10
Who has gotten sick	0	10
What is cesium/strontium	3	1
Other	28	30

x^2 (P) = 64.8 (0.0001)

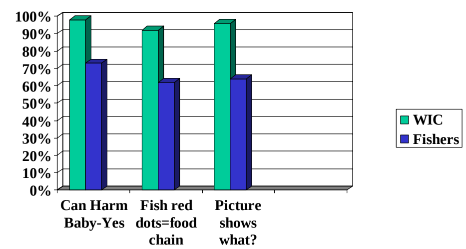
Savannah River Fishers

Burger and Waishwell, 2001.



Program Developed for W.I.C. Tested with Fishermen

"Do you think a woman can harm baby by eating fish from Port?"
"What does fish with red dots show?
"What does picture of pregnant woman show?



Risk Communication Issues

- Historical
- Interagency conflict
- Agency mandate and structure
- Risk assessment disagreement
- Political considerations
- Public involvement

After Burger, 2000.
Chess et al., 2005.

Collaborators

- Joanna Burger, Rutgers University
- Michael Gochfeld, UMDNJ
- Caron Chess, Rutgers University
- Karen F. Gaines, University Of Georgia
- Joel Snodgrass, Towson
- Kerry Kirk Pflugh, NJDEP

Others

- Shane Boring
- I.L. Brisbin, Jr.
- Carline Dixon
- B.D. Goldstein
- Justin Leonard
- Chris Lord
- R. Manning
- R. Manning
- Charles Powers
- Robert A. Ramos II
- Carl Schopfer
- Sheila Shukla
- W.C. Stephens
- Lynn Waishwell

Funding:
CRESP, NJDEP, EOHSI, EPA, SCDHEC, GDNR

Maine's Moms Survey – Evaluation of Risk Communication Efforts

Eric Frohmberg, Maine Bureau of Health

Maine's Mom Survey

Evaluation of Risk Communication Efforts

Eric Frohmberg

Maine Environmental and Occupational Health Program

Brochure Development and Evaluation

- "Easy to Read" brochure
- Target pregnant women
  - WIC, OB/GYN, FP/OB, CNM
- Targeted mailings to sport-fishing households
- Baseline survey in 1999
- Evaluation survey in 2000.

Maine DHHS Public Health • Environmental and Occupational Health Program

Design/Methods

- 24 pages, 75 questions
- Pre-tested
- Mail survey
- Sample drawn from Birth Certificate Registry
- ~60% response rate (n=768)
- Asked for hair sample.

Maine DHHS Public Health • Environmental and Occupational Health Program

Comparison of Studies

	1998/9 Pre-Survey	2000 Post-Survey	2004 Moms
Target Population	Women of childbearing age	Women of childbearing age	Moms
Sample Size	535	493	768
Mean Age	34 ± 7.5	34 ± 8.6	27 ±
Race	95% white	96% white	96% white
Fishing License	39%	40%	44%
Aware State Has Advice	32%	41%	60%

Maine DHHS Public Health • Environmental and Occupational Health Program

2004 Moms: Total Surveyed Population

- 31% of the total sample reported getting our brochure
- Of the total surveyed population
  - 4% received the survey in the mail
  - 24% received the survey from doctor/CNM
  - 9% received the survey from WIC
- 41% of the sample were on WIC
  - 29% of those in WIC remember getting it from WIC.

Maine DHHS Public Health • Environmental and Occupational Health Program

2004 Moms: Who Reported Getting Brochure

- Of those who reported getting brochure
  - 93% read it
  - 46% kept the brochure
  - 91% reported trying to follow advice.

Maine DHHS Public Health • Environmental and Occupational Health Program

Maine's Moms Survey – Evaluation of Risk Communication Efforts

Eric Frohmberg, Maine Bureau of Health

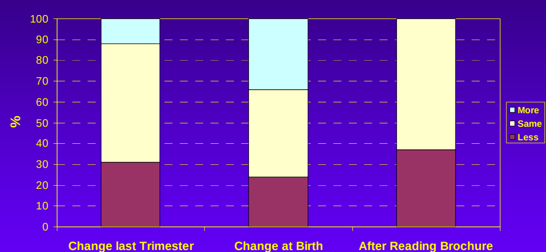
2004 Moms: Who Reported Getting Brochure

	Got Brochure	Did Not Get Brochure	p Value
1st Pregnancy	51% (46-57)	40% (36-44)	<0.01
Education <=High School	35% (29-41)	35% (31-40)	0.99
Income <=$25,000	33% (28-40)	33% (29-37)	0.88

2004 Moms: Who Reported Getting Brochure

	Got Brochure	Did Not Get Brochure	p Value
Eat Any Fish While Pregnant	93% (90-96)	82% (79-85)	<0.01
Told Hg in Fish Bad for Baby	97% (94-98)	86% (83-89)	<0.01
Told Fish Good for You	60% (54-66)	49% (45-53)	<0.01
Told Fish Good for Baby	35% (30-41)	28% (24-32)	0.04

2004 Moms: Behavior Change



2004 Moms: Ate Fish and Got Brochure

The Fish — Safe Eating Guidelines

Fresh Water Fish

- Brook trout and landlocked salmon .... Limit: • For pregnant and nursing women, women who may get pregnant, and children under 8, 1 meal per month • For all others, 1 meal per week
- All other fish species .... Limit: • For pregnant and nursing women, women who may get pregnant, and children under 8, NO meals • For all others, 2 meals per month

Ocean Fish and Shellfish

- Striped bass and bluefish .... Limit: For everyone, 2 meals per month

	Ate Fish and Got Brochure	Ate Fish and Did Not Get Brochure	p Value
Ate Any Sportfish	3% (2-6) n=6	5% (3-7) n=18	0.35

2004 Moms: Ate Fish and Got Brochure

- Canned tuna (the 6 ounce size) "White" tuna has more mercury *than "light" tuna.* .... Limit: • For pregnant and nursing women, women who may get pregnant, and children under 8, 1 can of "white" or 2 cans of "light" tuna per week

No limits for all others as part of a balanced diet

	Ate Fish and Got Brochure	Ate Fish and Did Not Get Brochure	p Value
Ate White Tuna	54% (48–60)	64% (59–68)	0.02
Ate Light Tuna	39% (33–46)	30% (25–35)	0.02

2004 Moms: Ate Fish and Got Brochure

	Ate Fish and Got Brochure	Ate Fish and Did Not Get Brochure	p Value
Ate Forbidden Fish	8% (5–12) n=16	8% (6 –11) n=34	0.84

Of Total Surveyed Population		
Swordfish	2%	n=15
Shark	<1%	n=6
Tilefish	1%	n=10

2004 New Moms: Hair Samples

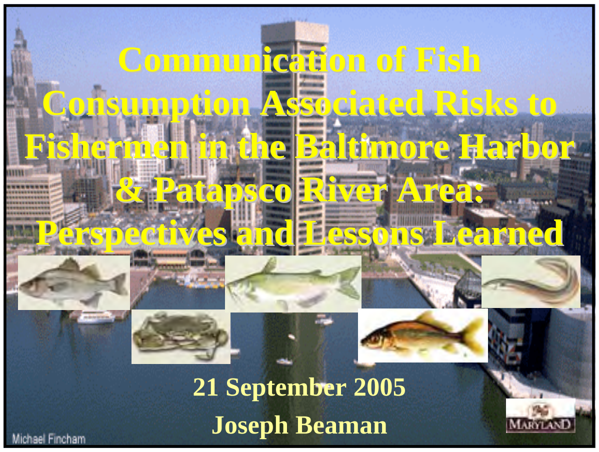
Hair Mercury – ppm	Got Brochure	Did Not Get Brochure	p Value
Mean	0.39 (0.31–0.47)	0.42 (0.35–0.61)	0.22
90^{th} Percentile	0.75 (0.59–[?])	0.99 (0.60–1.18)	

	Of Those Requesting Hair Test		
	Supplied Hair	Did Not Supply Hair	p Value
Ate Fish While Pregnant	93% (87–96)	84% (82–87)	<0.01

Maine DHHS Public Health • Environmental and Occupational Health Program

Communication of Fish Consumption Associated Risks to Fishermen in the Baltimore Harbor & Patapsco River Area: Perspectives and Lessons Learned

Joseph R. Beaman, Maryland Department of the Environment



Outline

- Background
  - Monitoring Summary
    - PCB Sediment Mapping
    - Fish Tissue Monitoring Map
  - Risk Assessment Summary
    - Methods
    - Current Advisory
- Advisory Communication & Outreach Efforts
  - History
  - Recent Actions

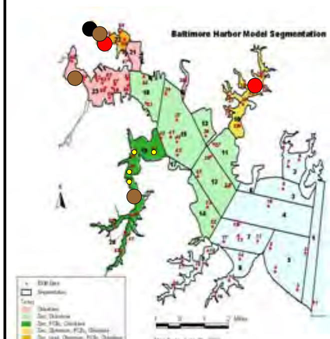
2

Polychlorinated Biphenyls

- The Problem: PCBs!!!
  - Drive all of the Chesapeake Bay associated fish consumption advisories
  - Highest levels in urban areas (Baltimore Harbor; Potomac River below Washington DC), and Northeast Bay tributaries — Elk River, C&D Canal etc.

3

Patapsco River Baltimore Harbor – Total PCBs Distribution



- **Mean = 262 ppb**
- **Range = 8 – 2150 ppb**
- **Total 27/73 > ERM**
- **(36.9 %)**
- 10 Sites = > 2 ERM
- 4 Sites = > 3 ERM (Yellow)
- 3 Sites = > 4 ERM (Brown)
- 2 Sites = > 5X ERM (Red)
- 1 Site = > 10X (Black)

4

Risk Assessment & Advisory Summary

5

MD Risk Assessment Policies:

- **Provide Guidance for Three Populations:**
  - General population, women of child-bearing age (18-45), and children (6)
- **Consider Carcinogenic/Non-carcinogenic Effects**
- **Meal Size (Wet Weight in oz)**
  - 8 oz. - General population; 6 oz. - women of child-bearing age; and 3 oz. - children 0-6 years of age
- **Meal Thresholds For Allowable Fish Consumption**
  - Do Not Eat (Less than 4 meals/year)
  - 4 – 96 meals per year
  - >96 meals per year (8 meals per month) = No advisory

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Communication of Fish Consumption Associated Risks to Fishermen in the Baltimore Harbor & Patapsco River Area: Perspectives and Lessons Learned

Joseph R. Beaman, Maryland Department of the Environment

MDE Risk Assessment

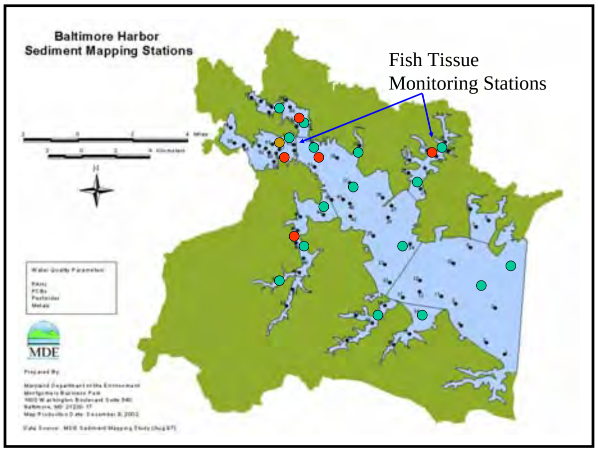
- Use U.S. EPA Risk-Based Methods
- RA Methodology has been reviewed by MD stakeholders (2001)
- Use Standard U.S. EPA Risk Assumptions
- Use Population Specific Health Endpoints
  - Cancer for adults
  - Neurological development for young children
- Protection For Sensitive Populations
  - No cooking loss for women of child-bearing age or young children (PCBs and other lipophilic compounds)

7

Consumption Thresholds - PCBs

Meals/Month	General Population	Women 18-45	Children 0-6
8 meals/month	< 22 - 38	17 - 32	13 - 25
4 meals/month	39 - 77	33 - 66	26 - 51
2 meals/month	78 - 155	67 - 133	52 - 103
1 meals/month	156 - 312	134 - 266	104 - 207
< 1 meal/month	> 352	> 267	> 208

8



T- PCB levels in tissue (Σ 120 C)

- **White Perch**
  - 20 Composite Samples (1997-2001)
  - [T PCBs] -104-1621 ppb; Avg - 505
  - GP up to 5/year; Sensitive – AVOID

- **Blue Crab**
  - 5 Composite Samples ('01)
  - [T PCBs] -104-1621 ppb; Avg – 505
    - Crabmeat - 27-78 ppb; Avg - 36
    - Hepatopancreas ("Mustard")
      - 448-1311 ppb; Avg - 889 ppb
  - GP – 96 /yr; Sensitive – 24-96/yr Mustard – All populations AVOID

- **Catfish (also Carp and A. Eel) – AVOID** – all > ~1000 ppb

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Patapsco River FCA Activity History

- 1988 – First Advisory Released
  - Due to chlordane (exceeded FDA action level)
- 1995-6 – BUERI Study
  - Baltimore Urban Environmental Risk Initiative
- 2001 – First Updates due to PCBs
  - Risk-based
  - First advisories on crabs
- 2004 – Revised Recommendations due to PCBs
  - New recommendations for carp, eel, catfish, crabs, and white perch
  - Separate recommendations for crab meat and mustard

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Advisory Communication

- 1988 Advisory – Limited Communication – Press release
- BUERI Study – Release of first brochures to fishermen and their families
  - Phase 1 – 1995-1995 by Sojourner-Douglas College
  - Phase 2 – 1997-1998 by UMAB
  - 1999 – Additional outreach by MDE
- 2001 - Limited Communication – Web site and press release – More public interest due to 1st advisory for crabs – fielded ~ 1000 phone calls in following 12 months
- 2003 – Pilot Interview survey of Baltimore Harbor conducted by JHU

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Communication of Fish Consumption Associated Risks to Fishermen in the Baltimore Harbor & Patapsco River Area: Perspectives and Lessons Learned

Joseph R. Beaman, Maryland Department of the Environment

Advisory Communication Cont'd

- 2004 – Expanded Effort
  - **May 2004** - Press release, story covered by Baltimore Sun
  - **May 2004** - Posted signs at various fishing locations (**11 sites – 2 signs per site**) around Harbor – repeat posting monthly (57)
  - **May/June 2004** – Published and distributed **~ 5000 brochures** to Baltimore City, Baltimore County, and Anne Arundel County Health Departments for distribution to health related services
  - **June –October 2004** - Began weekly outreach to fishermen at fishing access points – **273 brochures** distributed for 2004
  - **Summer 2004** – Regions of Concern Fish Consumption Survey (VA Tech) – Sponsored by Fish Advisory Workgroup –Chesapeake Bay Program
  - **August 2004** – Baltimore County Health Department – Press Release –Produces simplified brochure & distributed to health clinics

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Survey: Major Findings

- Advisory Awareness Rate was 83% among fishermen who answered interview
- Overall. 53% said they ate at least some of the fish they caught
  - For whites, 45% consumed catch
  - For African Americans, rate was 65%
- 78% consumed more than the recommended amount.

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OUTREACH

15

Workgroup Focus for Fish Consumption Guidelines

- Mid-Summer 2004 – Patapsco River Advisory Workgroup formed
  - Patapsco River and Baltimore Harbor
  - Community recommendations
    - Health Providers
    - Citizen Groups
  - Effective and sustainable outreach
    - Distribution of materials – ID available networks and outlets
    - Clear, understandable message (reading level testing)

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Product(s)

- New Brochures
  - English and Spanish
  - Ensured language consistency and readability with State WIC program
  - Distributed to both WIC clinics and Environmental Health Offices
  - ID'd future partnerships to include community clinics, managed care organizations, community groups, and doctors offices (e.g., OB/GYN, pediatrics, family practice)

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New Brochure

- **Collaborative Effort**
- **Production:**
  - **120,000 English**
    - **80,000 MDE**
    - **40,000 DHMH**
  - **10,000 Spanish (MDE)**
- **MDE Costs: ~$6300.00**
- **Incorporates U.S. EPA-FDA recommendations for commercially-caught fish**

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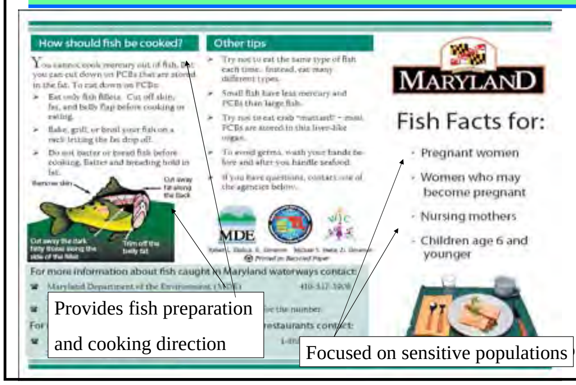
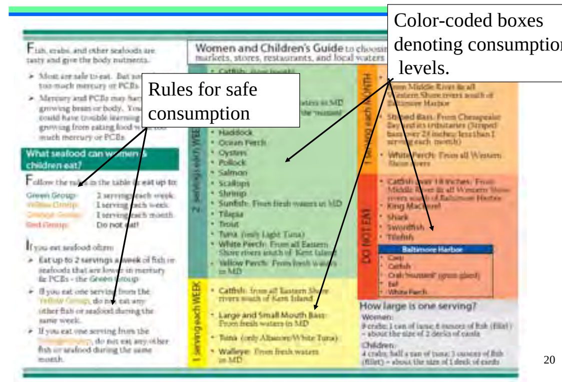
Communication of Fish Consumption Associated Risks to Fishermen in the Baltimore Harbor & Patapsco River Area: Perspectives and Lessons Learned

Joseph R. Beaman, Maryland Department of the Environment

New Brochure Front



New Brochure Back



20

Health Advisory Signs

- **12" x 24" laminated paper**
- **Full color with pictures**
- **Unit Cost: ~ $12.00 per poster – Annual ~ 750.00 for Baltimore Harbor**
- **Posted in English and Spanish**
- **Color-coded consumption levels**
- **Phone # and Web site provided for more info**

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Poster (cont.)

- **Uses symbols (i.e., plate with knife and fork) and pictures (i.e., fish, anatomical crab, meal on plate) to help convey important messages and concepts**
- **Prominent "Do Not Eat" symbols overlaid on species of special concern**
- **Special message to avoid crab "mustard" (hepatopancreas)**

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Baltimore Harbor Sign Posting

- 2004–2005 Efforts
- 18 Locations ID'd (See map)
  - 15 Sites Posted – 2 with no access or place to post
- Public Access Sites Only
- Sites are maintained regularly (checked monthly from March through November)
- 2004 – 273 brochures distributed June–October – 7 field days – No weekends

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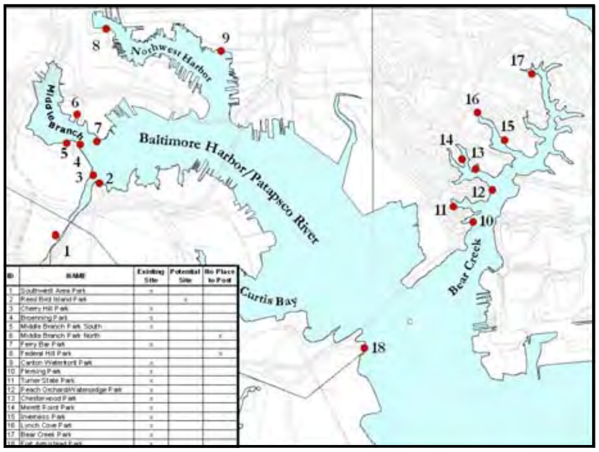
Communication of Fish Consumption Associated Risks to Fishermen in the Baltimore Harbor & Patapsco River Area: Perspectives and Lessons Learned

Joseph R. Beaman, Maryland Department of the Environment



ID	NAME	Existing Site	Potential Site	No Place to Post
1	Southwest Area Park	x		
2	Reed Bird Island Park		x	
3	Cherry Hill Park	x		
4	Broening Park	x		
5	Middle Branch Park South	x		
6	Middle Branch Park North			x
7	Ferry Bar Park	x		
8	Federal Hill Park			x
9	Canton Waterfront Park	x		
10	Fleming Park	x		
11	Turner State Park	x		
12	Peach Orchard/Watersedge Park	x		
13	Chesterwood Park	x		
14	Merritt Point Park	x		
15	Inverness Park	x		
16	Lynch Cove Park	x		
17	Bear Creek Park	x		
18	Fort Armistead Park	x		

Harbor Posting Pictures (cont.)

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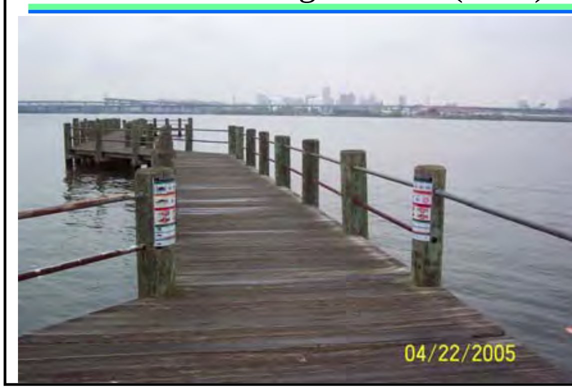
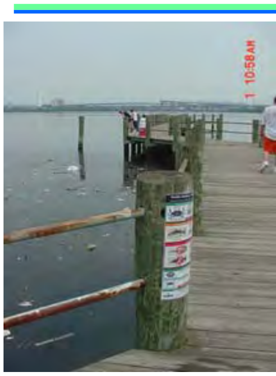
Harbor Posting Pictures (cont.)



Harbor Posting Pictures (cont.)

Harbor Posting Pictures (cont.)



Partnering

- MDE seeking partnerships with local groups
  - Watershed groups, fishing clubs, churches, etc.
- Baltimore Harbor Watershed Organization
- Ways to partner:
  - ID new sites for posting signs
  - Help with posting and maintaining signs
  - Getting the word out to fishermen
  - ID new outlets for brochure distribution within the community

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Communication of Fish Consumption Associated Risks to Fishermen in the Baltimore Harbor & Patapsco River Area: Perspectives and Lessons Learned

Joseph R. Beaman, Maryland Department of the Environment

Lessons Learned

- MDE outreach and communication techniques were effective in for "getting the word out" – 80% awareness rate in VA Tech survey.
- Survey indicated limited behavior change – Why??
  - Newness of message – Lack of repetition
  - Lack of outreach on previous advisories (remember- fish advisories continuously in Harbor since 1988)
  - Lack of understanding by population at risk or necessity to continue consumption despite contamination
- MDE hypothesis – Combination of the three
- Actions – Continue expanded outreach program, then re-evaluate behavior change in 3 to5 years – provide adequate opportunity for message repetition and reception

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More Information

- MDE Web site with links
  http://www.mde.state.md.us/CitizensInfoCenter/Health/fish_advisories/index.asp
- Joe Beaman
  410-537-3633, jbeaman@mde.state.md.us
- Phil Heard, M.D.
  410-537-3601, pheard@mde.state.md.us
- Anna Soehl
  410-537-3509, asoehl@mde.state.md.us

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QUESTIONS???

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Fish Consumption Patterns and Advisory Awareness Among Baltimore Harbor Anglers

Karen S. Hockett, Conservation Management Institute,
Virginia Polytechnic Institute and State University

Fish Consumption Patterns and Advisory Awareness Among Baltimore Harbor Anglers

Results of Angler Interviews, Summer 2004

Joshua C. Gibson
Julie A. McClafferty
Karen S. Hockett*

Conservation Management Institute,
Virginia Tech

For full report:
http://www.cmiweb.org/hdd.htm

Objectives

To identify populations at greatest risk for consuming contaminated fish, and…

1. Assess their fishing behaviors and consumption patterns,
2. Evaluate their perceptions of risk and levels of advisory awareness, and
3. Identify ways to better reach these at-risk groups.

Survey Protocol

- A team of 2 interviewers was on-site for 40 sampling days June 1–August 10, 2004.
- Interviewers rotated between 9 sampling sites along the Baltimore Harbor, Patapsco River, and Back River.
- Each site was sampled for 8-hour shifts both in the morning (6am–2pm) and evening (12pm–8pm) and on weekdays and weekends.
- Boat, pier, and shore anglers were approached and interviewed using a pre-tested questionnaire.
- When a group was encountered, only one member was interviewed.

Types of Questions Asked

- How far did you travel to get here today? How frequently do you fish?
- Why do you fish?
- Do you eat the fish you catch? How often? What species?
- Do you provide the fish to others in your home or give it away to others?
- How do you usually clean/cook the fish you catch?
- Are you aware of advisories in this area? How/when did you find out about them, and what do you recall?
- Demographics (gender, age, race/ethnicity, education, income)

Advisory Status

- Different advisories for Baltimore Harbor and surrounding waters
- Outreach campaign launched for new Harbor advisory approx. 1 month before interviews began.

Sampling Sites

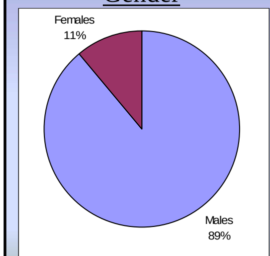
Site Name	n
1. Cox's Point	37
2. Rocky Point	0
3. Inverness	10
4. Merritt Point	29
5. Turner's Station	16
6. Canton Waterfront	6
7. Middle Branch	14
8. Broening Park	6
9. Fort Armistead	17
Total	***135***

Fish Consumption Patterns and Advisory Awareness Among Baltimore Harbor Anglers

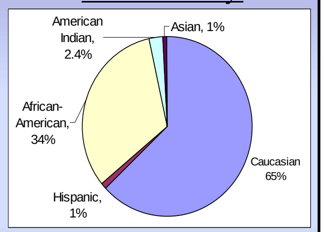
Karen S. Hockett, Conservation Management Institute,
Virginia Polytechnic Institute and State University

Respondent Demographics

Gender

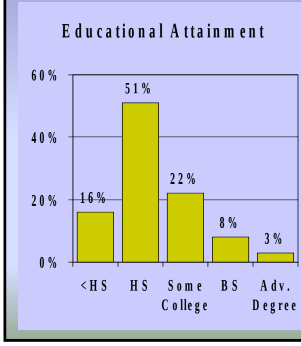


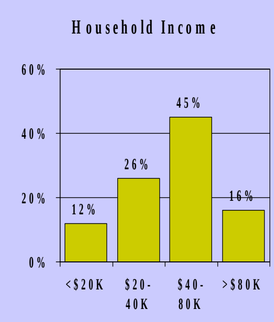
Race/Ethnicity*



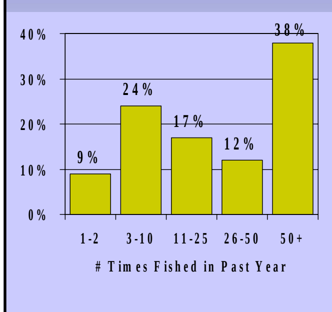
* 6 interviews could not be completed due to language barriers.

Respondent Demographics





Respondent Demographics



Travel Distance:

- Anglers are local; 79% traveled less than 10 miles to reach their fishing spot.

Experience Level:

- Anglers are experienced; 80% had fished or crabbed in the area for more than 10 years. (Average age = 48)

Motivations for Fishing

Fishing Motivation	Very Important	Somewhat Important	Total
Fresh Fish Dinner*	31%	28%	59%
Relaxation	96%	4%	100%
Time Outdoors	85%	13%	98%
Reduce Food Expenses*	12%	16%	28%
Challenge/Sport	57%	28%	85%

*Fishing as a means of getting food is an important motivation for many Baltimore anglers.

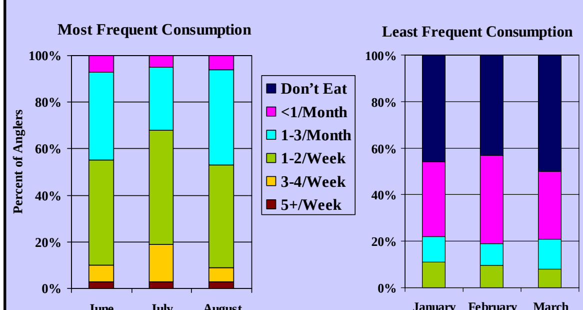
Fish Consumption

53% of Baltimore anglers eat the fish they catch; 62% give their fish to others.

Most Often Consumed Species:

Striped Bass
White Perch
Catfish
Blue crab
(all four species were under advisory)

Consumption Rates by Season



Fish Consumption Patterns and Advisory Awareness Among Baltimore Harbor Anglers

Karen S. Hockett, Conservation Management Institute,
Virginia Polytechnic Institute and State University

Consumption Rates by Species

➢ **What types of self-caught fish or crabs do you most often eat, and how often do you eat them? (Anglers listed up to 4 species.)**

Most Frequently Consumed Advisory Species	Meals Consumed (Annual Average)					
	5+/wk	3-4/wk	1-2/wk	1-3/mo	<1/mo	Total
Back River						
Striped bass	0	0	0	5	3	8
White perch	0	0	0	8	4	12
Catfish	0	0	0	4	0	4
Blue crab	0	0	0	2	1	3
Harbor/Patapsco						
Striped bass	0	2	8	9	14	33
White perch	0	0	9	8	11	28
Catfish	0	0	3	0	8	11
Blue crab	1	1	3	4	10	19

Advisory Compliance

	# Eat	Exceeding Advisory	General Pop. Advisory
Back River: 37 anglers, 17 (46%) eat their catch			
Striped bass	8	Up to 5 (63%)	12 meals/yr trophy; 24 meals/yr non-trophy
White perch	12	Up to 8 (75%)	22 meals/yr
Catfish	4	4 (100%)	6 meals/yr
Blue crab	3	0	No advisory
Harbor/Patapsco: 98 anglers, 54 (55%) eat their catch			
Striped bass	33	Up to 19 (58%)	12 meals/yr trophy; 24/yr non-trophy
White perch	28	Up to 28 (100%)	5 meals/yr
Catfish	11	11 (100%)	No consumption
Blue crab	19	2 (11%)	96 meals/yr

Advisory Compliance

Summary

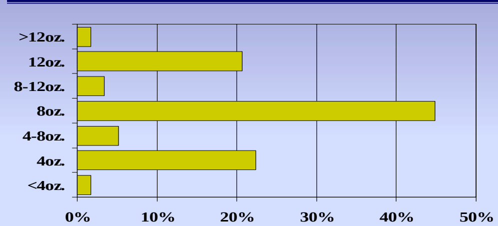
- 42–65% of all species consumption reports for advisory species exceeded advisory recommendations.
- Up to 69% of Harbor/Patapsco River anglers exceed advisory recommendations for at least 1 species (37% for 2 species, 4% for 3 species).
- Up to 53% of Back River anglers exceed advisory recommendations for at least 1 species (35% for 2 species, 18% for 3 species).

Higher Risk Populations

How often do other members of your household eat the fish you catch?

Household Members	n	n (%) Eat	n (%) Eat Same or More
Children 5 or younger*	11	10 (91%)	1 (9%)
Children 6–15	26	24 (92%)	14 (54%)
Adults 60 or older	15	13 (87%)	12 (92%)
Pregnant/nursing*	3	3 (100%)	1 (33%)
Other women 18–44*	37	36 (97%)	26 (72%)

Meal Sizes



Typical reported meal sizes were consistent with the 8 oz. used in general population advisory development, though 26% of anglers reported larger meals.

Preparation Methods

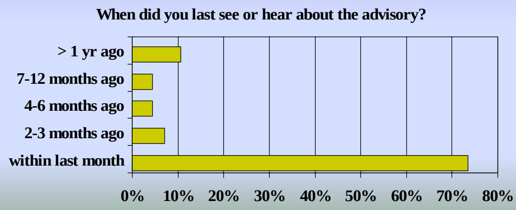
	MOST OF TIME	SOMETIMES	TOTAL
Eat mustard from crabs	40%	19%	59%
Eat fish whole (skin and fat)	24%	9%	32%
Eat fish raw	0%	1%	1%
Pan fry/deep fry	52%	30%	83%
Re-use fat/cooking oil	9%	18%	27%
Steam, poach, or boil	19%	39%	58%
Broil, grill, bake, or roast	48%	36%	84%
Filet fish	64%	20%	84%
Trim fat before cooking	45%	16%	61%
Puncture/remove skin before cooking	54%	22%	76%
Make soup or chowder	4%	26%	30%
Freeze or can for later	51%	26%	77%

Fish Consumption Patterns and Advisory Awareness Among Baltimore Harbor Anglers

Karen S. Hockett, Conservation Management Institute,
Virginia Polytechnic Institute and State University

Advisory Awareness

- 84% of anglers were aware of the advisories
- Large majority (74%) had seen them in the last month (when new advisory was issued).



Advisory Dissemination Mode

Racial Differences

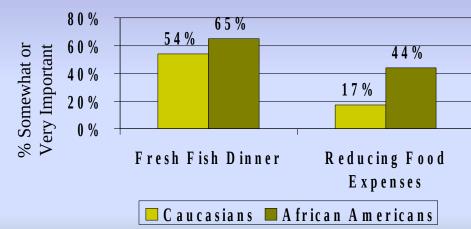
African Americans are more at-risk than Caucasians for a variety of reasons…

1. Blacks were more likely to consume their catch than Whites (65% vs. 45%).
2. Of those, Blacks were more likely to provide it to their households than Whites (100% vs. 43%).
3. Blacks were less likely to use risk-reducing preparation methods than Whites. For example…

- Puncture or remove skin before cooking most of the time: 27% of Blacks vs. 67% of Whites
- Pan or deep fry fish most of the time: 69% of Blacks vs. 41% of Whites

Racial Differences (cont.)

4. Blacks placed more importance on fishing as a means of obtaining food than Whites.



Racial Differences (cont.)

5. Blacks were slightly <u>more</u> aware (88%) of advisories than Whites (81%).
6. Consumption frequencies and meal sizes did not differ by race.

Key Points

1. Most anglers (84%) are aware of advisories and have seen them recently (74%).
2. Still, advisory species are among the most frequently consumed, usually at a rate greater than is suggested in the advisory.
3. A substantial proportion of anglers (28%) give some importance to the reduction of family food expenses as a reason for fishing.
4. African Americans appear to be at greater risk than Caucasians, primarily based on needs (motivations) and cultural differences (preparation).

Potential Improvements

1. Increase use of the most effective/preferred dissemination modes: Signs and personal communication.
2. Consider going out into community and/or training community members in advisory outreach – Word of mouth often better received than "official" statements.
3. Target communities of at-risk populations.
4. Simplify advisories as much as possible (e.g., range of meal frequencies, meal sizes).

For more information:
http://www.cmiweb.org/human/CBP_fishadvisory04.html
(Download full report and/or data)

Or contact:
Julie McClafferty
jmcclaff@vt.edu
540-231-8709

Problems with Media Reports of Fish-Contaminant Studies: Implications for Risk Communication

Barbara A. Knuth for Judy D. Sheeshka, Department of Family Relations and Applied Nutrition, University of Guelph

Problems with Media Reports of Fish Contaminant Studies: Implications for Risk Communication

Judy Sheeshka, Ph.D. R.D.
September 21, 2005

Outline

- Contaminants in farmed vs. wild salmon
- Media coverage
- Health Canada's response
- Consumer reaction
- Implications for risk communication

Wild vs. Farmed Salmon

- Analysis of PCBs in raw fish collected from 7 countries (Hites et al., 2004. *Science* 303)
- Analysis used U.S. EPA cut-points
- Health Canada uses FDA values.

Study Confirms Farmed Salmon More Toxic Than Wild Fish

- CBC News, Friday, January 9, 2004
  - "We are certainly not telling people not to eat fish," said study co-author David Carpenter of the University at Albany, NY. "We're telling them to eat less farmed salmon."

In Depth: Salmon Something Fishy About Farmed Salmon?

- CBC News Online, January 9, 2004
  - "Officials at Health Canada and the Canadian Food Inspection Agency say the dangers of eating contaminated farmed salmon are overstated, as is the suggestion that intake of farmed salmon be severely restricted."

Problems with Media Reports of Fish-Contaminant Studies: Implications for Risk Communication

Barbara A. Knuth for Judy D. Sheeshka, Department of Family Relations and Applied Nutrition, University of Guelph

Scientists Defend Farmed Salmon

- CBC News, Friday, January 9, 2004
  - "A controversy over farmed salmon is making consumers pay attention … but not all scientists agree with the study's findings and are questioning the validity of the claims of the study."

Consumer Reactions

- "I was buying salmon or trout once or twice a week, but after that [Hites et al. study] I just stopped eating it. I know it's good for you, but just the thought of eating fish now makes me sick."

Salmon Farming Industry Reeling

- *Globe and Mail*, January 11, 2004
  - "Canada's $700-million Atlantic salmon farming industry have been handed a sharp reminder that when it comes to the business of food, public perception is everything."

Plummeting Fish Sales Could Risk Public Health

- *Globe and Mail*, February 16, 2004
  - "While this is an economic blow to the industry, nutritionists believe it also has the makings of a public-health disaster."
  - Consumers reported giving up fish and taking omega-3 FA supplements.

More Bad News About Farmed Salmon

- "Flame-retardant chemicals that may harm human health are found in higher levels in farmed salmon than in wild salmon, says a new study." (August 10, 2004)
- "The cancer-causing chemical malachite green has been found in a second Vancouver Island salmon farm."

UK Consumers Seem to Have Ignored the Latest Health Scare over Scottish Farmed Salmon

- "There had been fears that shoppers would be put off buying salmon after a damning report last week … but initial figures from the major supermarkets suggest sales have actually continued to increase."

Barbara A. Knuth for Judy D. Sheeshka, Department of Family Relations and Applied Nutrition, University of Guelph

What Went Wrong? Can We Learn from This?

What Went Wrong?

- Journalists did not understand that the study used U.S. EPA cut-off values, while Health Canada uses FDA values.
- Scientists were confused and appeared to disagree.
- Risk-reduction strategies were absent.

What Can We Learn from This?

- Different populations react differently.
- Information on risk-reduction strategies helps people to make informed choices.
- Environmental scientists and toxicologists might consider greater efforts to educate dietitians, physicians, and nutrition researchers.

Wild vs Farmed Salmon – Raw

Fish ≠ Omega-3 Fatty Acids

- Equating fish with omega-3 fatty acids will backfire – people will take supplements!
- Fish has the highest quality protein, second only to egg protein in digestibility and supporting growth.
- From a public health perspective, other nutrients in fish (selenium, vitamin D, etc.) are important.

The Presentation of Fish in Everyday Life: Seeing Culture through Signs in the Upper Peninsula of Michigan

Melanie Barbier, Departments of Fisheries and Wildlife and Sociology, Michigan State University

Preserving our past… Creating our future

The Presentation of Fish in Everyday Life: Seeing Culture Through Signs in the Upper Peninsula of Michigan

Geoffrey Habron and Melanie Barbier
Michigan State University

MSU Personnel

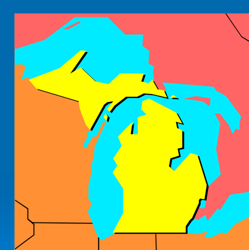
- Principal Investigator:
  - Geoffrey Habron, Fisheries and Wildlife/Sociology/Bailey Scholars
- Project Coordinator:
  - Ron Kinnunen, Sea Grant
- MSU Extension FNP Liaisons:
  - Joan Vinette
- Graduate Student:
  - Melanie Barbier, Ph.D. student

Agency for Toxic Substances and Disease Registry Identified

- U.P. as region of particular concern on the uncertain effectiveness of fish advisories
- Vast rural and isolated nature of the area
- Relatively large presence of Native American populations who may consume large amounts of fish.

Upper Peninsula Advisories

- Great Lakes: PCBs> chlordane> dioxin> mercury
- Inland lakes: mercury> PCBs> chlordane> dioxin.



Introductions…

The Presentation of Fish in Everyday Life: Seeing Culture through Signs in the Upper Peninsula of Michigan

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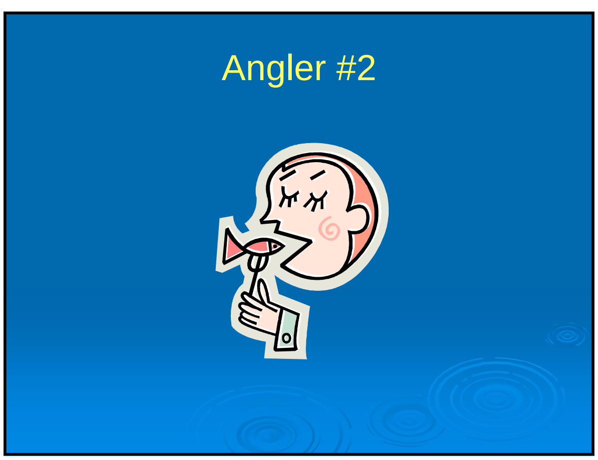

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Match Game

- Cisco Lake – unlimited walleye
- St. Mary's River – monthly walleye limit
- Deer Lake – no fish consumption

- Angler #1 – eats all fish
- Angler #2 – monthly fish consumption
- Angler #3 – catch and release only

Mismatch Reality

- Cisco Lake – unlimited walleye
- St. Mary's River – monthly walleye limit
- Deer Lake – no fish consumption

Explanation?

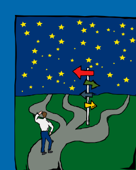
Post-normal Risk

Agency

Culture

Structure

Post-normal Risk



Culture

http://www.touchoffinland.com/images/yooper-man.gif

The Presentation of Fish in Daily Life

- Symbols/Imagery
  - Fishermen retailing
  - Local restaurants
  - Restaurant chains
  - Pristine environment/traditional ties to natural resource use

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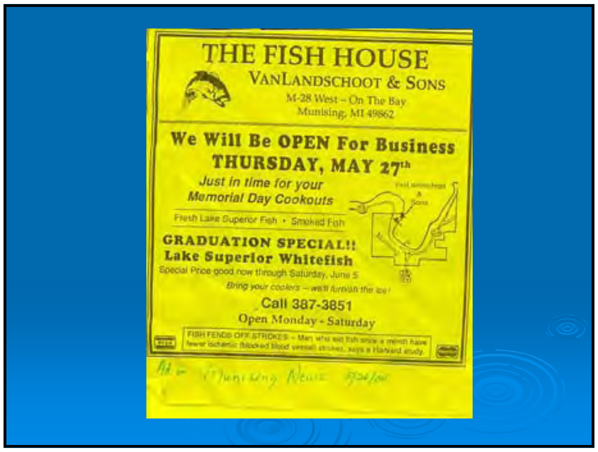

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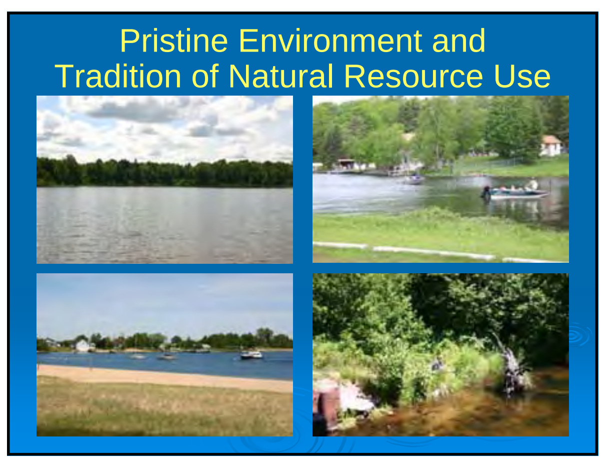


Methods and Procedures

Site Design

County	Lake Superior	Impaired	Inland
Alger	Munising Bay	West Branch Lakes (SW of Grand Marais)	Au Train Lake
Baraga	Baraga/L'Anse	Unamed Lake (west of Craig Lake State Park)	Worm Lake (Covington)
Chippewa	Tahquamenon	St. Mary's River (Sault Ste. Marie)	Caribou or Frenchman Lake
Gogebic	Black River harbor	Langford>Pomeroy= Duck Lakes (Watersmeet)	Cisco Lake (Watersmeet)
Marquette	Marquette	Deer Lake	Independence or Shag Lakes

Data Collection Per Site

Demographic Group	Data Collection Methods	Outcome Indicators
• Anglers • Community Residents • Women • Youth	• Interviews • Surveys (phone, mail) • Focus groups • Community gatherings • Creel surveys • Search conferences • Observation (fish fry, store) • Photographs (access sites, signs)	• Awareness • Knowledge • Understanding • Behavior • Trust • Community capacity

Summary of Findings

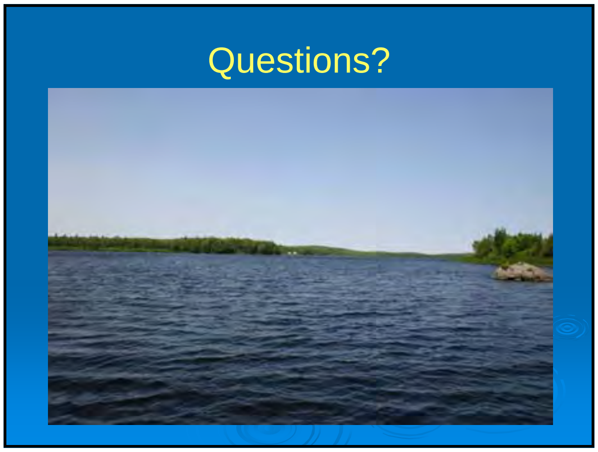
(+) Knowledge of fish advisory
- Large, fatty fish risk

(–) Knowledge of fish advisory
- Infrequent reading
- Fish-eating fish consumption risk
- DNR vs. DCH advisory responsibility
  - Most people report trusting the DNR as the most as a reliable source of fish consumption advisory information

Summary of Findings

- Uncertainty
  - Conflicting science and media reports
- U.P. fish consumption > non-U.P. fish consumption
- Best way to reach people
  - Television
  - Newspaper/fishing license
  - In grocery stores next to where they sell fish
  - Schools/radio
  - Doctors' offices

Conclusion


Questions?

Promoting Fish Advisories on the Web: WebMD Case Study

Michael Hatcher for Susan Robinson, Centers for Disease Control and Prevention

Promoting Fish Advisories on the Web: WebMD Case Study

September 21, 2005

Susan J. Robinson, M.S., NCEH/ATSDR
Jennifer Dyer-Herrick, WebMD
Michael T. Hatcher, Dr.PH, ATSDR

U.S. EPA & ATSDR Traditional Collaboration

Dissemination/Outreach To

- Infomediaries:
  - Healthcare providers rather than to a target audience
- Traditional Channels
  - Conferences, presentations, brochures in multiple languages, direct mail, etc.

Pilot Project Concept

- Dissemination/Outreach
  - Direct to consumer
- Channel – Web: Selection Criteria
  - Users/Audience: Must match desired demographic
  - Reach: Traffic volume, syndication
  - Content focus: Health site or channel
  - Protocols: Past collaboration with CDC.

Project Overview

- Objective
  - To educate users about the potential risks of mercury in fish
- Target Audiences
  - Women who are trying to become pregnant
  - Women who are already pregnant or nursing
  - Parents of young children

Mini-Health Zone: Content Offering

Four timely and relevant WebMD articles reflecting the latest U.S. EPA / FDA guidelines

New WebMD article based on U.S. EPA / FDA brochure

Links to relevant U.S. EPA and FDA Web sites

Links to related WebMD message boards

Eating Fish: A Primer

WebMD created a new article based on the latest U.S. EPA / FDA guidelines on mercury and fish.

Promoting Fish Advisories on the Web: WebMD Case Study

Michael Hatcher for Susan Robinson, Centers for Disease Control and Prevention

Links to U.S. EPA, FDA

- Links to U.S. EPA & FDA Fish Advisory Information

WebMD Health Network

CDC ATSDR

Promotion

- Across the WebMD Consumer Network and Relevant WebMD Consumer Newsletters
- Promotional Areas
  - WebMD Splash/Home Page
  - WebMD Consumer Home Page
  - Channels
    - Pregnancy Center, Parenting Center, Diet and Nutrition, Healthy Women, and Healthy Men
  - eNewsletters
    - Pregnancy and Family, Trying to Conceive, Diet and Nutrition, Women's Health, Men's Health, and Living Better

WebMD Health Network

CDC ATSDR

WebMD Splash Page

The campaign was promoted within high traffic areas and featured as the top story on the WebMD Splash & Consumer Home Pages.

WebMD Health Network

CDC ATSDR

WebMD Splash Page

WebMD Splash page featured a rotating contextual link to the campaign.

WebMD Health Network

CDC ATSDR

WebMD Health Home Page

WebMD Home Page also featured a rotating contextual link to the campaign.

WebMD Health Network

CDC ATSDR

WebMD Health Centers

The campaign was promoted within several relevant condition / wellness areas, including the Pregnancy Center.

WebMD Health Network

CDC ATSDR

Promoting Fish Advisories on the Web: WebMD Case Study

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WebMD Newsletters

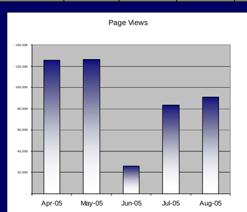
Several WebMD newsletters also featured contextual links to the campaign.

Metrics Topline Summary

- Campaign Duration: 4/12/05 – 8/31/05 (5 months of data)
- Traffic: 155,508 unique visitors; 451,577 page views
- 3:1 Ratio of Page Views to Unique Visitors: Users clearly engaged with the content.
- Performance Declined in June: Was elevated with increased promotion in last 2 months.
- Most Viewed Article: The new WebMD article based on the U.S. EPA/FDA brochure.

Metrics: Page Views

Program Summary	Sum	Apr-05	May-05	Jun-05	Jul-05	Aug-05
Page Views	451,577	125,670	126,250	25,823	83,265	90,569
Unique Visitors	155,508	39,769	41,876	9,113	31,357	33,393
Sessions	162,389	41,792	43,889	9,380	32,499	34,829



Metrics: Unique Visitors

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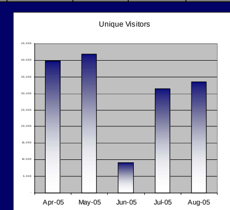
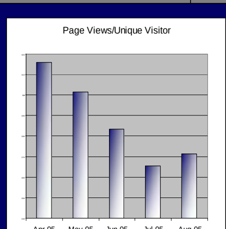
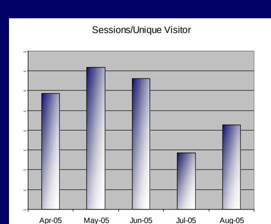


Performance Ratio Analysis

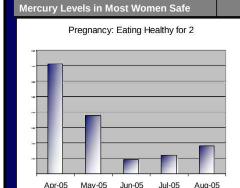
Ratio Analysis	Totals	Apr-05	May-05	Jun-05	Jul-05	Aug-05
Page Views/Unique Visitor	2.90	3.16	3.01	2.83	2.66	2.71
Sessions/Unique Visitor	1.04	1.05	1.05	1.03	1.04	1.04

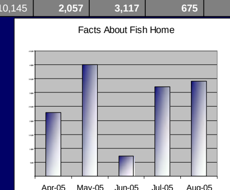




Page View Analysis – Promotional Effects

Page Views	Totals	Apr-05	May-05	Jun-05	Jul-05	Aug-05
Pregnancy: Eating Healthy for 2	147,772	71,052	37,520	9,155	12,043	18,002
Facts About Fish Home	136,279	22,735	39,971	7,280	32,126	34,167
What You Need to Know About Mercury in Fish	94,071	18,117	25,417	4,971	23,198	22,368
Avoiding Mercury in Fish -- Topic Overview	62,341	11,484	20,003	3,670	13,795	13,389
Mercury Levels in Most Women Safe	10,145	2,057	3,117	675	2,103	2,193





Promoting Fish Advisories on the Web: WebMD Case Study

Michael Hatcher for Susan Robinson, Centers for Disease Control and Prevention

Promotional Effects (cont.)

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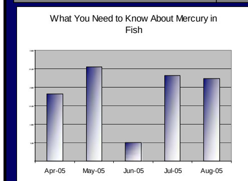
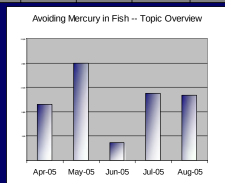




Click Through to U.S. EPA, FDA Sites

Clicks to EPA/FDA Web sites	Totals	Apr-05	May-05	Jun-05	Jul-05	Aug-05
http://epa.gov/waterscience/fish/states.htm	2,109	398	643	41	527	500
http://www.cfsan.fda.gov	381	79	106	8	90	98
http://www.epa.gov/waterscience/fish/	1,349	267	428	30	311	313
http://www.epa.gov/waterscience/fishadvice/advice.html	7,881	1,543	2,479	166	1,780	1,913

Summary

- Think beyond your destination site (.gov) to achieve reach into desired audiences
- Good content is key, but promotion is crucial
- Match your needs with needs held by potential Web outlet partners
- Understand your partners' constraints (e.g., editorial, policy, etc.)
- Next enhancement: Cross-promotion beyond the Web (earned media, point-of-use, mail, radio, etc.).

Seafood Safe Case Study: Voluntary Seafood Contaminant Testing and Labeling Program

Henry W. Lovejoy, Seafood Safe,
Barbara A. Knuth, Department of Natural Resources, Cornell University

Seafood Safe

Case Study:

Voluntary Seafood Contaminant Testing and Labeling Program

EcoFish as First Adopter

Nationwide Sustainable Seafood Distributor

- 1,500 grocery stores
- 125 restaurants

Evolution

- Media attention
- Consumer demographics
- Project research

Conflicting and Confusing Messages

"Sound's Salmon Carry High PCB Levels: But State Says Health Benefits of Eating the Fish Outweigh Risks"

"Mercury Debate Gets Murkier – No Clear Choices on Which Fish are Best"

"Rich Folks Eating Fish Feed on Mercury too – 'Healthy Diet' Clearly Isn't"

"Study Finds Mercury Levels in Fish Exceed U.S. Standards"

"EPA Says Mercury Taints Fish Across U.S."

"EPA Raises Estimate of Babies Affected by Mercury Exposure"

Consumers Are Confused

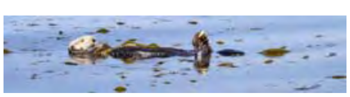
Something Fishy: The Salmon Debate

The Miami Herald
November 4, 2004

"Eat salmon, we're urged. It is rich in omega-3 fatty acids, which help our hearts, cholesterol and blood pressure, fights rheumatoid arthritis, and might even ease depression.

Eat salmon only sparingly, we're warned. The fish, especially when farm-raised -- as is 65 percent of the salmon sold in U.S. supermarkets -- contains PCBs and other toxins that may cause cancer.

What's a health-conscious consumer to do? Studies and counter-studies, alarms and assurances, leave the public unsure, anxious."



Business Model

- Autonomous independent structure
  - Advisory panel
  - Sampling
  - Labs (Axys Analytical, Brooks Rand)
  - Consumer advocacy organization (Environmental Defense)
- Precautionary principle
- EcoFish first adopter.

Seafood Safe Case Study: Voluntary Seafood Contaminant Testing and Labeling Program

Henry W. Lovejoy, Seafood Safe,
Barbara A. Knuth, Department of Natural Resources, Cornell University

Marketing Strategy

- Positive industry message
- Consumer driven
- State agency driven (CA A.G.)
- Media follow through.

Future Financial Model

- Industry pays
- Consultation with client
- Customized programs
  - Species life history, regionality, size range, seasonality, historical data, etc.
- Testing
- Licensing.

Future Participation

- Seafood industry (fisheries, processors, distributors, packers)
- Grocery store chains
- Restaurant chains.

EcoFish Species Tested

- Wild Alaskan salmon – *Oncorhynchus keta*
- Wild Alaskan halibut – *Hippoglossus stenolepsis*
- Wild Peruvian mahi mahi – *Coryphaena hippurus*
- Wild Oregon/Washington albacore tuna – *Thunnus alalunga*
- Wild California squid – *Loligo opalescens*
- Farmed Chinese bay scallops – *Argopecten irradians*
- Farmed Florida white shrimp – *Penaeus vannamei*

Contaminants Tested

- Mercury
- PCBs
- Additional future contaminants?

Labeling

- How to read?
- Guidance derivation
  - U.S. EPA's *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories*
  - U.S. EPA's risk-based consumption tables

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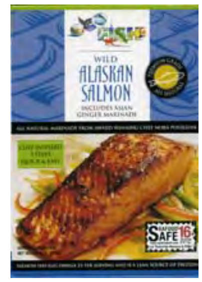
Recommendations

Assumptions

Sub-population	Age	Weight in kg	Weight in lbs
Women of childbearing age	15-45	64	141
Men	18-75	78.1	172
Average adult	18-75	70	154
Young children	0-6	14.5	32
Older children	6-12	30.6	67

Tested Species	Avg. ppm Hg	Hg Servings Woman/Month	Avg. ppm PCB/HR	PCB Servings Woman/Month	4 oz. Meals Per Month	8 oz. Meals Per Month
Calamari	0.022	77.9	0.002	57.1	16+	16+
Albacore Tuna	0.249	6.5	0.007	13.6	6	3
White Shrimp	0.007	255.9	0.001	71.4	16+	16+
Mahimahi	0.223	7.7	0.000	857.2	7	3.5
Bay Scallops	0.006	194.8	0.000	428.6	16+	16+
Halibut	0.166	10.1	0.001	94.2	10	5
Keta Salmon	0.028	60.4	0.001	57.6	16+	16+

Label in Use



Risk Perception Constructs

- Volition, choice
- Control
- Seriousness
- Dread
- Certainty
- Causality – natural or not
- Distribution of risks and benefits
- Responsiveness
- Trust, credibility.

Risk Communication Strategy

- Focus on behavior
  - Addresses choice, volition
    - For consumer
    - For industry/markets
  - Provides "control."

Risk Communication Strategy

- Focus on message to women of childbearing age
  - Addresses concerns about distribution of benefits and risks
  - Addresses seriousness, dread.

Risk Communication Strategy

- Supporting information addresses
  - Dread
  - Seriousness
  - Causality
- Consistent message
  - Reduces uncertainty
  - Personalized calculations
  - Cumulative consumption charts (under development).

Risk Communication Strategy

- Provide testing details (independent labs, advisory panel)
  - Credibility
  - Confidence
  - Trust.

Future Considerations

- Risks vs. benefits
  - Contaminants vs. omega-3s?
- Evaluation
  - Consumer response
    - Purchasing
    - Consumption
    - Environmental advocacy
    - Food safety advocacy
  - Industry participation.

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Share your comments!

Appendix A

Biosketches of Speakers and Moderators

2005 National Forum on Contaminants in Fish
Biosketches of Speakers and Moderators

David Acheson, M.D., F.R.C.P.

David Acheson graduated from the University of London Medical School in 1980, and following training in internal medicine and infectious diseases in the United Kingdom, moved to the New England Medical Center and Tufts University in Boston in 1987. As an associate professor at Tufts University, Dr. Acheson undertook basic molecular pathogenesis research on food-borne pathogens, especially Shiga toxin-producing *E. coli*. In 2001, Dr. Acheson moved his laboratory to the University of Maryland Medical School in Baltimore to continue research on food-borne pathogens. In September 2002, he accepted a position as the Chief Medical Officer at the Food and Drug Administration's (FDA's) Center for Food Safety and Applied Nutrition (CFSAN). In January 2004, Dr. Acheson became CFSAN's Director of Food Safety and Security, and in January 2005, he became the Director of CFSAN's Office of Food Safety, Defense, and Outreach.

Dr. Acheson has published extensively and is internationally recognized both for his public health expertise in food safety and his research in infectious diseases. Additionally, he is a Fellow of both the Royal College of Physicians (London) and the Infectious Disease Society of America.

Linda L. Andreasen, M.S.

Linda Andreasen is a fisheries biologist with the U.S. Fish and Wildlife Service's (FWS's) national office in Arlington, VA. Ms. Andreasen is currently working on policy and budget in the Division of the National Fish Hatchery System, including developing national policy for contaminant issues at federal hatcheries. Previous work with the FWS includes projects to restore sturgeon and striped bass in the mid-Atlantic and to investigate environmental contaminant investigations. Ms. Andreasen received her M.S. in Fisheries Science from the University of Maryland in 1994.

Scott M. Arnold, Ph.D.

Scott Arnold is an environmental toxicologist for the Environmental Public Health Program, Alaska Division of Public Health. Dr. Arnold interprets the public health significance of environmental contaminant exposures. Previously, he worked for Ecology and Environment, Inc., in Anchorage, AK (1996 to 2000), where he developed risk assessments to support hazardous waste site investigations and prepared scientific background documents for private-industry clients. Dr. Arnold received his Ph.D. degree in Environmental Toxicology from the University of Wisconsin–Madison in 1995.

Melanie Barbier, M.S.

Melanie Barbier is a Ph.D. candidate at Michigan State University in the Department of Fisheries and Wildlife. She received a B.S. degree in Social Sciences and an M.S. degree in Environmental Policy from Michigan Technological University. Currently, Ms. Barbier is working on a project to improve fish consumption advisory risk communication in Michigan's Upper Peninsula using community-based research methodologies and local collaboration. Her research interest is the interaction of science, policy, and culture in natural resource management.

Joseph Beaman, M.S.

Joseph Beaman is head of the Ecotoxicology and Standards Section for the Technical and Regulatory Services Administration of the Maryland Department of the Environment. He received his B.S. degree in Forest Biology from the College of Environmental Science and Forestry at Syracuse University and his M.S. degree in Environmental Science from Hood College. Mr. Beaman worked as a military scientist for the U.S. Army, performing research on arboviruses for seven years at the U.S. Army Research Institute for Infectious Diseases at Fort Detrick. He then transitioned to work for the Army as a civilian contractor, performing aquatic toxicology research for eight years at the U.S. Army Center for Environmental Health Research at Fort Detrick. For the past three years, Mr. Beaman has been a toxicologist at the Maryland Department of the Environment, where his main duties include serving as technical lead for the state's water quality standards program and as programmatic lead for monitoring, risk assessment, and risk communication related to fish consumption advisories.

Jerry BigEagle

Jerry BigEagle is the fishery biologist of the Cheyenne River Sioux Tribe, which is located in the north-central portion of South Dakota. The reservation encompasses about 2.6 million acres; 370 linear miles of aquatic-riverine habitat; and nearly 280 lakes, ponds, reservoirs, and impoundments of cold- and warm-water fish communities. Mr. BigEagle received his B.S. degree in Fish and Wildlife Management from Montana State University–Bozeman, with an emphasis in Coldwater Ecology and a minor in Native American Policy and Law. He completed four years as a technician in Montana, providing management assistance to 13 Tribes doing recovery work regarding various fish, including bull trout and Yellowstone cutthroat trout. He served as a Student Career Experience Program (SCEP) student with the FWS and worked as a fishery biologist for ecological services, completing two-dimensional modeling and instream-flow incremental methodology (IFIM) on the Sacramento River in northern California. For the past five years, Mr. BigEagle has served as a fishery biologist for the Cheyenne River Sioux Tribe for its Game, Fish & Parks department. His duties have included serving as a technical adviser for the Sioux Tribe's consumption advisory, stocking largemouth bass for an ongoing bioaccumulation study, and undertaking risk communication related to Native American groups among small communities, where people fish as a priority of subsistence.

Other personal achievements include being a member of the Native American Fish and Wildlife Society, a member of the National Nature Conservancy, a certified diver with the Professional Association of Diving Instructors (PADI), a certified electrofishing team leader with the FWS, and a member of the American Fisheries Society.

Jeffrey D. Bigler

Jeff Bigler serves as National Program Manager and National Technical Expert for EPA's National Fish and Wildlife Contamination Program. He has managed the development of national guidance on advisory development and management, as well as national databases such as the Web-based National Listing of Advisories. In cooperation with the FDA, Mr. Bigler was the co-lead for the development and implementation of the 2001 and 2004 Joint EPA/FDA National Mercury Advisories. He also serves as chair for the Annual National Forum on Contaminants in Fish.

Linda S. Birnbaum, Ph.D.

Linda S. Birnbaum is a division director at the U.S. Environmental Protection Agency (EPA), Office of Research and Development, National Health and Environmental Effects Laboratory. Her professional experience includes teaching at the University of Illinois in Urbana, IL, where she received her Ph.D. degree in Microbiology. Dr. Birnbaum is the recipient of several awards and honors for the leadership she has provided to the scientific community and to EPA. She is also the current president of the Society of Toxicology.

Michael Bolger, Ph.D., D.A.B.T.

Michael Bolger received his B.S. degree in Biology in 1971 from Villanova University and his Ph.D. degree in Physiology and Biophysics in 1976 from Georgetown University. After a two-year postdoctoral position at Georgetown University Medical Center, Dr. Bolger became a staff fellow in toxicology with the Bureau of Foods in the FDA. Upon completion of his staff fellowship, Dr. Bolger accepted a position as a toxicologist with the FDA's Contaminants Branch. Since 1980, Dr. Bolger has been involved in the hazard/safety/risk assessment of anthropogenically and naturally derived contaminants in food. A board-certified toxicologist by the American Board of Toxicology, Dr. Bolger is currently Director of the of Risk Assessment Staff in the Office of Plant and Dairy Foods, which is responsible for the hazard/safety/risk assessment of food-borne contaminants and for reporting FDA monitoring efforts on food-borne environmental contaminants. Dr. Bolger is also currently serving as a member of the Expert Advisory Panel on Food Safety of the World Health Organization.

Robert K. Brodberg, Ph.D.

Robert Brodberg 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. degree in Biology from Heidelberg College and his M.S. and Ph.D. degrees in Biology from Bowling Green State University. He has worked as a risk assessor for the state of California since 1989, including work on human health assessments for pesticides, sediment quality objectives, and water quality issues. He is currently Chief of the Fish and Water Quality Evaluation Unit, which is responsible for assessing the potential human health risks of eating chemically contaminated sport fish and seafood, as well as issuing sport fish consumption advisories for California.

Gary A. Buchanan, Ph.D.

Gary Buchanan is Bureau Chief of the Bureau of Natural Resources Science within the Division of Science, Research and Technology of the New Jersey Department of Environmental Protection (NJDEP). He received his B.S. and M.A. degrees in Biology from Montclair State University and a Ph.D. degree in Environmental Science from Rutgers University. Dr. Buchanan was an environmental consultant for 17 years, conducting numerous environmental, ecological, and ecotoxicological investigations at sites across the United States. He also managed several technical groups under EPA and U.S. Army Corps of Engineer (USACE) contracts. For the past six years, Dr. Buchanan has been with the NJDEP, initially as a research scientist and ecotoxicologist, conducting studies on fish biomarkers and contaminant bioaccumulation. He was the Chair of the Ecological Quality Work Group for the New Jersey Comparative Risk Project, which broadly examined the risk of stressors to New Jersey's ecosystems. He is also the Chair of the Interagency Toxics in Biota Committee, which develops and recommends New Jersey's fish consumption advisories, as well as the Co-Project Manager for the Toxics in Fish Monitoring Program. Most recently, his duties as Bureau Chief have involved leading a team of scientists in providing technical and research support to apply the most up-to-date science in meeting the natural resource protection goals of the NJDEP.

Joanna Burger, Ph.D.

Joanna Burger is a Distinguished Professor of Biology at Rutgers University. Her interests are in the intersection of toxicology and human health, fish consumption and risk from chemicals, the effects of heavy metals on neurobehavioral development, human health risk assessment, and bioindicators of human health and well-being. She has published numerous articles on fishing, fish consumption, risk from consuming contaminated fish, fish availability, human health risk assessments with fish and game consumption, risk perception, and risk communication. She has been principal investigator on many studies that have spanned the pure laboratory aspects to human health risk assessments and risk communication. She has been involved with several state and federal governmental agencies, collecting fish, analyzing mercury and other heavy metals, assessing fish consumption rates and cooking methods, and combining the laboratory results with consumption patterns to examine human health risks from consuming fish. Her laboratory studies have dealt with using avian models to examine the effect of heavy metals (e.g., lead, chromium, manganese, mercury) on behavioral development, and developing bioindicators for environmental conditions and human health. Her interest in understanding food-chain effects of contaminants has resulted in studying fish, fishing behavior, consumption patterns, and the contaminants in fish. This research involves risk assessment, risk management, and risk communication.

Dr. Burger is an adviser to several companies, state and federal governmental agencies, and the National Research Council (NRC). She has served on several NRC committees and panels and on international panels on environmental health issues, including endocrine disruptors and heavy metals. In addition, she serves on several international committees for SCOPE (Scientific Committee on Problems of the Environment) and currently co-chairs the SCOPE International Committee of Endocrine Disruptors.

Janet F. Cakir, Ph.D., M.S.

Janet Cakir is an environmental protection specialist in the Innovative Strategies and Economics Group in the Office of Air Quality and Planning Standards at the EPA. She received her B.S. degree in Geography from Radford University and her M.S. degree in Geography from Virginia Polytechnic Institute and State University (Virginia Tech), and her Ph.D. work at North Carolina State University focused on developing and automating models of hiking-trail degradation. She has worked at EPA for two years, performing geographic and statistical analyses in support of regulatory impact analyses. Her main duties include mapping, visualization, and the geographic analysis of air quality data, population, and other landscape characteristics.

Susan E. Carlson, Ph.D.

Susan Carlson is the Midwest Dairy Council Professor of Nutrition at the University of Kansas Medical Center, where she is appointed in the Departments of Dietetics and Nutrition and Pediatrics. She also holds an honorary faculty appointment in Obstetrics and Gynecology at the University of Missouri–Kansas City. Dr. Carlson received her B.S. degree in Home Economics from Washington State University and her Ph.D. degree in Nutrition from Iowa State University. Her postdoctoral work at the Universities of Wisconsin and South Florida was funded by the National Heart, Lung, and Blood Institute. Most of Dr. Carlson's career has been spent serving on faculties in Pediatrics at the University of South Florida, University of Mississippi Medical Center, and University of

Tennessee, Memphis. She has been at the University of Kansas Medical Center since 1999. Dr. Carlson's major research interest during the past 20 years has been the role of the long-chain omega-3 fatty acid, docosahexaenoic acid (DHA), in infant development. Recently, that interest has extended to the role that intrauterine exposure to DHA has on the developing fetus.

Paul Cocca, M.S.

Paul Cocca is an environmental engineer with EPA's Office of Water. Mr. Cocca received his B.S. degree in Civil Engineering from the State University of New York (SUNY) at Buffalo and his M.S. degree n Environmental Engineering from Carnegie Mellon University. He has worked as a consultant, conducting human health risk assessments for coal-tar contaminated hazardous waste sites, and was a Peace Corps volunteer in Guatemala. Mr. Cocca has worked in EPA's Office of Water, Office of Science and Technology for nine years. As a member of the Modeling and Information Technology team he has helped develop software products for modeling the fate and transport of pollutants in watersheds. He also developed the Mercury Maps (MMaps) project—an approach to linking mercury air deposition and fish tissue contamination on national, regional, or local scales.

Lisa Conner, M.E.

Lisa Conner is an economist in EPA's Office of Air and Radiation. She received her Master of Economics degree from North Carolina State University, and for nearly 15 years, she has conducted benefit-cost analyses of air pollution regulations for EPA. Ms. Conner was the Project Lead for the Regulatory Impact Analysis of the recently promulgated Clean Air Mercury Rule (CAMR) and worked with experts throughout EPA to characterize and assess the risks of mercury exposure and the benefits of the mercury reductions from the CAMR.

John R. Cosgrove, Ph.D., M.Sc.

John Cosgrove began his career in the fields of physiology/endocrinology (Ph.D. degree and research at the University of Nottingham and University of Alberta) and population genetics (M.Sc. degree and research at the University of Edinburgh). During the past decade, however, he has been a Senior Manager in the Canadian meat genetics industry. In 2003, Dr. Cosgrove joined AXYS Analytical Services, Ltd., as President. That year, AXYS coauthored publications in *Science* and other journals reporting comparisons of PCBs and polybrominated diphenyl ethers (PBDEs) in wild and farmed salmon. AXYS also completed analytical work in support of EPA's National Study of Chemical Residues in Lake Fish Tissue in 2005.

For more than 20 years, AXYS has prided itself on the refinement of organo-halogen contaminant analysis in a wide variety of matrices, including many fish tissues, via high-resolution mass spectrometry for PCBs, dioxin/furans, and brominated diphenyl ethers. AXYS has founded its reputation on supporting its clients via the provision of not only the highest quality analytical data but also interpretive support of the underlying chemistry and its environmental context. AXYS works closely with many federal, state, and municipal agencies and private-sector companies to enhance their research, regulatory, and quality assurance processes.

Lyle Cowles

Lyle Cowles is an environmental scientist within EPA's Region 7 Environmental Services Division in Kansas City, KS. Mr. Cowles currently coordinates all the regional R-EMAP projects for EPA Region 7 and is the Region's Water Monitoring Coordinator, working with states on drafting and implementing their state water monitoring strategies. He drafts and coordinates the water monitoring strategy for Region 7, including the strategy for fish tissue. Mr. Cowles has more than 20 years experience planning, conducting, and analyzing data from a wide variety of water quality studies. He recently led a regional multiagency (federal and state) collaboration effort to overhaul and redesign Region 7's fish tissue monitoring program. Mr. Cowles received his B.S. degree from Drake University in Des Moines, IA.

Julie L. Daniels, Ph.D., M.P.H.

Julie Daniels is an assistant professor in the Departments of Epidemiology and Maternal and Child Health at the University of North Carolina at Chapel Hill. Her research focuses on perinatal environmental exposures that may be associated with pediatric health. Dr. Daniels is specifically interested in exposure to chemical pollutants and nutrients during gestation that may affect children's neurodevelopment. She is the Principal Investigator of the North Carolina Center for Autism and Developmental Disabilities Epidemiology.

Anthony Mark "Teharatats" David, M.P.S.

Anthony Mark David is member of the St. Regis Mohawk Tribe and its Canadian counterpart, the Mohawk Council of Akwesasne. He has been with the Environment Division for approximately three years as a student intern and technician, and in June 2004, returned from educational leave to become the Program Manager of Water Quality. He received a Master of Professional Studies degree from the Department of Natural Resources at Cornell University in August 2005 and his B.A. degree in Environmental Studies from SUNY–Buffalo in 2001. His academic and professional interests are in the importance of revising human health risk assessment policies to better characterize indigenous peoples.

Colin Davies, M.B.A

Colin Davies is president and owner of Brooks Rand LLC, a specialized trace metals and metals speciation analytical laboratory. Mr. Davies currently focuses on business development and oversight of laboratory operations management. Prior to his current position, Mr. Davies was Lab Director of Brooks Rand, where he managed all operations and projects for the laboratory and developed new analytical methodology. In 1992, Mr. Davies became the first quality assurance (QA) manager at Brooks Rand, where he developed and implemented the laboratory's first comprehensive QA program. He began his career as a scientist with a medical diagnostics division of Baxter, where he learned the rigors of quality assurance in the medical products industry. Mr. Davies received his B.S. degree in Biology from Whitman College and his M.B.A. degree from the University of Washington.

David De Vault, M.S.

David De Vault is a contaminant biologist with FWS Ecological Services, Region 3, in Fort Snelling, MN. He received a B.S. degree in Biology and a M.S. degree in Aquatic Biology from SUNY. Prior to coming to FWS, he was employed by EPA's Great Lakes National Program Office for 17 years, where he managed the Fish Contaminant Monitoring Program, the Green Bay Mass Balance Study, and other contaminant programs and studies. While at EPA, he also had extensive experience working with the Great Lakes states on development of common criteria for sport fish consumption advisories. His research interests focus on contaminant bioaccumulation and modeling, as well as impacts of contaminants on fish and wildlife populations. He has published more than 20 articles in peer-reviewed literature and numerous reports and book chapters on subjects ranging from contaminant bioaccumulation to ecological risk assessment in complex systems. He is currently working on several complex natural resource damage cases and serves on the faculty of the Department of Fisheries, Wildlife, and Conservation at the University of Minnesota in St. Paul, MN.

Katie Egan, R.D.

Katie Egan is a dietary exposure analyst in the Office of Plant and Dairy Foods in the FDA's Center for Food Safety and Applied Nutrition (CFSAN). Since joining CFSAN in 1999, she has provided technical guidance to FDA's Total Diet Study and other food safety monitoring programs. As a member of the Risk Assessment Staff, Ms. Egan also compiles analytical data from CFSAN's monitoring programs and provides estimates of dietary exposure for food safety assessments. She has participated in international meetings related to food safety monitoring and dietary exposure, including the Joint FAO/WHO Expert Committee on Food Additives and Contaminants and WHO--sponsored Total Diet Study workshops. Prior to joining FDA, Ms. Egan gained experience in dietary exposure assessment and food regulations while working for private consulting firms (TAS, Inc., and Novigen Sciences) in Washington, D.C. She received her B.S. degree in Nutrition from Georgia State University in Atlanta, GA. She is a Registered Dietitian and is a member of the American Dietetics Association and the Institute of Food Technologists.

Eric J. Frohmberg, Ph.D.

Eric Frohmberg is a toxicologist with the Maine Environmental and Occupational Health Program. He has been involved in the development of fish consumption advisories and the Bureau's fish advisory communication program. This work has included development of the new brochures, testing efforts with low literacy focus groups, and surveys to evaluate effectiveness of the risk communication program.

Benjamin H. Grumbles, L.L.M., J.D.

Benjamin Grumbles was confirmed by the U.S. Senate on November 20, 2004, as Assistant Administrator for the EPA's Office of Water. Prior to being appointed Acting Assistant Administrator in December 2003, Mr. Grumbles served as Deputy Assistant Administrator for Water and Acting Associate Administrator for Congressional and Intergovernmental Relations. Before coming to EPA in 2002, Mr. Grumbles was Deputy Chief of Staff and Environmental Counsel for the Science Committee in the U.S. House of Representatives. For more than 15 years, he served in various capacities on the House Transportation and Infrastructure Committee staff, including Senior Counsel for the Water Resources and Environment Subcommittee, where he focused on programs and activities of the EPA and USACE. From 1993 to 2004, he was an adjunct professor of law at the George Washington University Law School, teaching a course on the Clean Water Act, Safe Drinking Water Act, Ocean Dumping Act, and Oil Pollution Act. His degrees include a B.A. from Wake Forest University, J.D. from Emory University, and LL.M. in Environmental Law from George Washington University Law School.

Geoffrey B. Habron, Ph.D., M.S.

Geoffrey Habron arrived at Michigan State University in 1999 and currently serves as an associate professor, with a joint appointment in the Department of Fisheries and Wildlife and the Department of Sociology and with the Michigan State University Extension. He participates in the Liberty Hyde Bailey Scholars Program within the College of Agriculture and Natural Resources. Dr. Habron's scholarship across learning, discovery, and engagement focuses on democratic approaches to natural resource inquiry. Originally from Pleasantville, NJ, he obtained his B.A. degree from the University of Miami in Florida, his M.S. degree from Mississippi State University, and his Ph.D. degree from Oregon State University. Dr. Habron also served as a Peace Corps volunteer in St. Lucia, Eastern Caribbean.

William S. Harris, Ph.D.

William Harris obtained an undergraduate degree in Chemistry from Hanover College in Hanover, IN, and a Ph.D. degree in Nutritional Biochemistry from the University of Minnesota. He did postdoctoral fellowships in Clinical Nutrition and Lipid Metabolism at the Oregon Health Sciences University between 1978 and 1983 and then moved to Kansas University Medical Center (UKMC), where he became the Director of the Lipid Research Laboratory in 1985. In 1996, Dr. Harris became the first recipient of the Daniel J. Lauer/Missouri Chair in Metabolism and Vascular Research at the University of Missouri–Kansas City and the Mid-America Heart Institute of Saint Luke's Hospital. He currently is Co-Director of the Lipid and Diabetes Research Center at Saint Luke's and is a Professor of Medicine at UKMC School of Medicine.

Dr. Harris' research has generally focused on the effects of drugs and nutrients on lipid metabolism in humans; however, his specialty is in fish oils (omega-3 fatty acids) and cardiovascular disease. Dr. Harris has been the Principal Investigator on two previous National Institutes of Health (NIH)-funded grants and is currently examining the effects of niacin and fish oils on lipid metabolism in patients with the "metabolic syndrome." This project is also funded through NIH. Dr. Harris has 90 peer-reviewed research publications to his credit in the scientific literature, and he was also the developer of the Omega-3 Index, a new blood test to assess risk for cardiovascular disease.

Karen S. Hockett, M.S.

Karen Hockett is a Human Dimensions Division Project Associate at the Conservation Management Institute in the College of Natural Resources at Virginia Tech. She received a B.S. degree in Biology from Ohio Northern University, an M.S. degree in Zoology from the University of Maine, and an M.S. degree in Outdoor Recreation from Virginia Tech. Ms. Hockett is currently working toward a Ph.D. degree in Outdoor Recreation in the Department of Forestry at Virginia Tech. She has worked on fisheries research projects at both the University of Maine and Virginia Tech, focusing on Atlantic salmon and brown and rainbow trout. For her outdoor recreation degrees, Ms. Hockett has specialized in conducting research on visitors, mostly for the National Park Service. These studies have focused on developing communication messages to reduce risky behavior (e.g., feeding wildlife) or depreciative behaviors (e.g., fossil theft) among park visitors. She has also evaluated the effectiveness of different communication techniques in gaining the attention of and communicating information to park visitors. During her two years at the Conservation Management Institute, Ms. Hockett has been involved with projects assessing the stewardship attitudes and behaviors of the public, boaters, and anglers and has interviewed anglers to assess their knowledge of and adherence to consumption advisories.

Lynda M. Knobeloch, Ph.D.

Lynda Knobeloch received her Ph.D. degree in Environmental Toxicology from the University of Wisconsin–Madison in 1988. Since 1990, she has worked for the Wisconsin Department of Health and Family Services, where she manages the Research and Toxicology Unit. Dr. Knobeloch also provides regulatory support to Wisconsin's air quality, drinking water safety, groundwater protection, and pesticide regulation programs. She was a member of the NRC Committee on the Toxicological Effects of Mercury and served as an external reviewer of the Institute of Medicine's Immunization Safety Review and EPA's Mercury Report to Congress. Dr. Knobeloch is a current member of EPA's National Pollution Prevention and Toxics Advisory Committee and the newly formed Homeland Security Advisory Committee. She recently published her findings from a large, population-based arsenic exposure and health study and has just completed a two-year study that assessed methylmercury exposure and fish consumption rates among more than 2,000 Wisconsin residents. As an Adjunct Associate Professor in the Molecular and Environmental Toxicology Center at the University of Wisconsin–Madison, Dr. Knobeloch is a frequent lecturer and guest speaker. She has authored numerous scientific articles on a broad range of environmental health issues, including the health effects of contaminated drinking water, methylmercury exposure, and chronic exposure to carbon monoxide.

Barbara A. Knuth, Ph.D.

Barbara Knuth is a professor in and the chair of the Department of Natural Resources at Cornell University and is a Co-Leader of the Human Dimensions Research Unit. She received two bachelor's degrees (in Zoology and Interdisciplinary Studies) and a Master of Environmental Science degree from Miami University in Ohio. Dr. Knuth received her Ph.D. degree in Fisheries and Wildlife Sciences from Virginia Tech. Her research interests focus on the risk perception, communication, and management associated with chemical contaminants in fish and with other wildlife and natural resources issues. She has served on National Academy of Sciences and Institute of Medicine committees, most recently focusing on the implications of reducing dioxins in the food supply, and on numerous scientific panels and advisory boards, including the Board of Technical Experts of the Great Lakes Fishery Commission and the Great Lakes Science Advisory Board of the International Joint Commission.

While on sabbatical leave from Cornell University, Dr. Knuth authored the first risk communication guidance document used by EPA in its support to states and tribes on issues related to contaminants in fish. She is the immediate Past President of the American Fisheries Society (AFS) and received the AFS Distinguished Service Award in 1999. She has served as Associate Editor for *Society and Natural Resources* and for the *North American Journal of Fisheries Management*.

David Krabbenhoft, Ph.D.

David Krabbenhoft began his career with the U.S. Geological Survey (USGS) after completing his Ph.D. degree at the University of Wisconsin–Madison in 1988. Immediately after joining the USGS, he began working on environmental mercury cycling, transformations, and fluxes in aquatic ecosystems with the Mercury in Temperate Lakes project; since then, the topic has consumed his professional life. In 1994, Dr. Krabbenhoft established the USGS's Mercury Research Laboratory, which includes a team of multidisciplinary mercury investigators. The laboratory is a state-of-the-art, analytical facility strictly dedicated to the analysis of mercury, with low-level speciation. In 1995, he initiated the multiagency Aquatic Cycling of Mercury in the Everglades project. More recently, Dr. Krabbenhoft has been a Primary Investigator on the internationally conducted Mercury Experiment to Assess Atmospheric Loadings in Canada and the U.S. (METAALICUS) project, which is a novel effort to examine the ecosystem-level response to loading an entire watershed with mercury. The Wisconsin Mercury Research Team is currently active on projects from Alaska to Florida and from California to New England. Since 1990, Dr. Krabbenhoft has authored or co-authored more than 50 papers on mercury in the environment. In 2006, he will serve as the cohost for the 8th International Conference on Mercury as a Global Pollutant in Madison, WI.

Amy D. Kyle, Ph.D., M.P.H.

Amy Kyle holds appointments as associate researcher and lecturer in the Environmental Health Sciences Division in the School of Public Health at the University of California, Berkeley, and is a Co-Investigator at the Center for Excellence in Environmental Public Health Tracking. She received her M.P.H. degree and her Ph.D. degree in Environmental Health Sciences and Policy from the University of California at Berkeley and her B.A. degree from Harvard College. Early in her career, Dr. Kyle spent 13 years in public service in a variety of positions in environmental protection, natural resources management, and public health and retains a keen interest in improving public health practice. Her research currently focuses on the translation of scientific results for policy and stakeholder audiences, policy approaches relevant to persistent pollutants, and children's environmental health. Dr. Kyle teaches graduate students in the environmental health science disciplines about the role of science, as well as other factors, in policy. She works with a variety of nongovernmental and public interest organizations; serves on the California Breast Cancer Research Council and the Committee on Emerging Contaminants of the National Academy of Sciences; and has recently served as an adviser to the Environmental Council of the States, National Drinking Water Advisory Committee, California Environmental Protection Agency, Division of School and Adolescent Health in the Centers for Disease Control, National Oceanographic and Atmospheric Administration, and California Energy Commission.

Christopher Lau, Ph.D.

Christopher Lau is a pharmacologist in the Developmental Biology Branch of the Reproductive Toxicology Division within EPA's National Health and Environmental Effects Research Laboratory, Office of Research and Development. He received both his A.B. degree in Chemistry and Zoology and Ph.D. degree in Pharmacology from Duke University. Dr. Lau has worked for EPA at Research Triangle Park, NC, since 1984. His research interests include developmental toxicology, teratology, and risk assessment modeling.

Henry W. Lovejoy

Henry Lovejoy is the president and founder of EcoFish, Inc., and Seafood Safe, LLC. Established in 1999 and based in Dover, NH, EcoFish was founded as the world's first distributor of seafood exclusively from environmentally sustainable fisheries. Today, EcoFish can be purchased in more than 1,500 grocery stores and 125 top restaurants nationwide. In 2005, Mr. Lovejoy established Seafood Safe, LLC— a testing and labeling program for contaminants in seafood that provides consumers with an easy-to-use system to derive the maximum health benefits from seafood without exposing themselves to dangerous levels of contaminants.

A native of northern New England, Mr. Lovejoy gained a deep respect for the oceans early in his life, inspired by Jacques Cousteau's conservation ethic. Having spent his entire career in the global seafood industry, from pulling lobster traps in Maine to exporting seafood and traveling throughout Europe, Asia, and North America, it became evident to Mr. Lovejoy that man's increasing ability to remove sea life from the ocean far outstripped the ocean's ability to replenish itself. Seeking a sustainable and safe solution for the oceans and consumers, he has been a pioneer in the seafood industry, believing that ultimately the consumer is the force for change in marine conservation.

Mr. Lovejoy received a liberal arts education at Boston University and later attended the Program for Global Leadership at the Harvard Business School. He is considered an innovative entrepreneur and industry expert on sustainability issues. He has been a guest on numerous national radio and television shows, has been quoted in dozens of national newspapers and magazines, and has made presentations to numerous national audiences.

Kathryn R. Mahaffey, Ph.D.

Kathryn Mahaffey's professional career is in exposure assessment and toxicology of metals, and she has worked extensively in the area of food safety. Following graduate training in Nutritional Biochemistry and Physiology at Rutgers University, she completed postdoctoral training in Neuro-endocrinology at the University of North Carolina School of Medicine. Her research has been on susceptibility to lead toxicity, with greatest focus on age and nutritional factors, resulting in more than 100 publications in this area. During her long career with the U.S. government, she has been influential in lowering lead exposures for the U.S. population through actions to remove lead from foods and beverages and from gasoline additives during the 1970s and 1980s. In the past decade, Dr. Mahaffey has been actively involved in risk assessments for mercury and assessments of human exposure to methylmercury. She was the author of the NIH Report to Congress on Mercury and a primary author of EPA's Mercury Study Report to Congress. Dr. Mahaffey was one of the primary developers of EPA's Mercury Research Strategy, which was released in late 2000. Along with other team members, she was responsible for the 2001 EPA/FDA national advisory on fish consumption. Dr. Mahaffey was one of a group of three EPA health scientists who revised the basis for the Agency's reference dose for methylmercury, which was used in developing the Methylmercury Water Quality Human Health Criterion. In 2002, she received EPA's Science Achievement Award in Health Sciences for this work. This is EPA's highest health sciences award and is presented in conjunction with the Society of Toxicology. Most recently, she has been evaluating and publishing national estimates of exposures to methylmercury in the U.S. population as shown in the 1999–2000 National Health and Nutrition Examination Survey.

Dr. Mahaffey is the director of the Division of Exposure Assessment Coordination and Policy within the Office of Science Coordination and Policy of EPA's Office of Prevention, Pesticides, and Toxic Substances. This division runs EPA's Endocrine Disruptor Screening and Validation Program. Dr. Mahaffey remains active in research and developing EPA's policies on methylmercury.

Randall O. Manning, Ph.D., D.A.B.T.

Randall Manning is the coordinator of the Environmental Toxicology Program in the Georgia Department of Natural Resources, Environmental Protection Division. Dr. Manning received his Ph.D. degree from the University of Georgia and was 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. 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, a diplomate of the American Board of Toxicology, and an Adjunct Assistant Professor in the Departments of Pharmaceutical and Biomedical Sciences, College of Pharmacy, University of Georgia, and in the Department of Environmental and Occupational Health, Rollins School of Public Health, Emory University.

David McBride

David McBride is a toxicologist with the Washington State Department of Health. He received his B.S. degree in Biology and Chemistry from the California State University at Chico and his M.S. degree in Environmental Toxicology from the University of Washington, Seattle. Mr. McBride was a Peace Corps Volunteer in Thailand, where he directed a rural hospital laboratory. After his service, he directed a medical research laboratory at Tufts University's New England Medical Center in Boston, MA. Since 1991, Mr. McBride has been a toxicologist at the Washington State Department of Health, where his main duties include serving as technical lead for the state's human health sediment quality standards and fish advisory program.

Pat McCann, M.S.

Pat McCann is a scientist with the Minnesota Department of Health. She received a B.S. degree in Chemical Engineering from the University of Minnesota Institute of Technology in 1984 and an M.S. degree in Environmental Health from the University of Minnesota School of Public Health in 1995. Ms. McCann coordinates the Fish Consumption Advisory Program at the Minnesota Department of Health. She is involved with site selection for sampling fish for contaminants, performing data analysis, researching the health effects of fish contaminants, developing consumption advice, and communicating this advice to the public.

George Noguchi, Ph.D.

George Noguchi is an environmental toxicologist with the FWS Division of Environmental Quality (DEQ) in Washington D.C. He received his B.S. degree in Environmental Sciences from the University of Wisconsin–Green Bay, his M.S. degree in Natural Resources from the University of Michigan, and his Ph.D. degree in Fisheries and Wildlife/Environmental Toxicology from Michigan State University. Prior to joining the DEQ, Dr. Noguchi worked for 19 years in research, first with the University of Michigan (Great Lakes Research Division) and later with FWS (Great Lakes Fisheries Laboratory). His research interests included contaminant bioaccumulation and the effects of contaminants on fish reproductive and immune systems. He is currently working on national water quality issues for FWS and is coordinating with the National Fish Hatchery Program on the evaluation of contaminants in hatchery fish.

Emily Oken, M.D., M.P.H.

Emily Oken is an instructor in the Department of Ambulatory Care and Prevention (DACP) at Harvard Medical School. She is a graduate of Harvard Medical School and the Harvard School of Public Health. She has completed clinical training in both internal medicine and pediatrics and currently practices as a primary care physician at the Women's Health Center of Brigham and Women's Hospital. Her research interests include childhood anemia, international nutrition, women's health, and the impact of nutrition during pregnancy and early life on outcomes of pregnancy and later maternal and child health. At the DACP, Dr. Oken has led funded studies of maternal fish consumption, fatty acid intake, and mercury exposure during pregnancy.

Dr. Oken has authored a recent review of the fetal origins of obesity. She recently received an award from the American Scandinavian Foundation to study associations of maternal diet during pregnancy and infant diet with child development.

John R. Olson

John Olson has worked in the Water Quality Bureau, Iowa Department of Natural Resources (DNR), for 20 years and has coordinated Iowa's annual fish contaminant monitoring program during that time. Since 1994, he has prepared the state's biennial water quality reports, as required by Section 305(b) of the Clean Water Act (CWA). Mr. Olson has also been involved with the preparation of Iowa's lists of "impaired waters," as required by Section 303(d) of the CWA. He represents the Iowa DNR on the Upper Mississippi River Conservation Committee, the Upper Mississippi River Basin Association's Water Quality Task Force, and EPA's Region 7 technical workgroup on nutrient criteria development. Mr. Olson earned a B.S. degree in Animal Ecology from Iowa State University, with an emphasis in Fisheries Biology.

James F. Pendergast, M.S.E.

James Pendergast is the chief of the Fish, Shellfish, Beach and Outreach Branch in the EPA Office of Water, where he manages the fish and beach advisory programs and provides technical support for shellfish and sediment contamination assessments. He has 29 years of professional experience in environmental engineering, water quality modeling, and regulatory controls. Since moving to EPA headquarters in 1990, he has worked on the 2000 revision to the TMDL rule and the reauthorization of the CWA and as a Section and Branch Chief and Acting Director of the NPDES Permits Division. He was a principal in leading the Water Protection Task Force, where he helped manage EPA's work to support efforts by drinking water and wastewater treatment utilities to understand vulnerable points and to mitigate the threat from terrorist attacks as quickly as possible. He worked for six years in EPA Region 6 in the NPDES permits and Superfund programs. Prior to joining EPA in 1984, he was a project manager at Limno-Tech, Inc., where he developed models of water quality impacts from nonpoint and point sources on rivers, lakes, and estuaries.

Mr. Pendergast received a B.S. degree in Environmental Engineering in 1976 and an M.S. degree in Water Resources Engineering in 1978, both from the University of Michigan. He is a registered professional engineer and a member of the Water Environment Federation, American Society of Civil Engineers, and Society of Environmental Toxicology and Chemistry. Mr. Pendergast has published several papers on water quality modeling in engineering journals and conference proceedings.

Kendl (Ken) P. Philbrick, M.B.A.

Kendl Philbrick was appointed Secretary of the Maryland Department of the Environment (MDE) by Governor Robert L. Ehrlich, Jr., on March 5, 2004. Secretary Philbrick also served as the Acting Secretary and Deputy Secretary of the MDE prior to becoming Secretary. As Secretary, Mr. Philbrick oversees pollution prevention, environmental regulation, and environmental enforcement in Maryland, including the administration of a combined operating and capital budget of approximately $199 million. MDE's programs include air quality control of stationary and mobile sources, the management of hazardous and solid waste, oil control, the regulation of wastewater discharges and public drinking water, wetlands protection, environmental risk assessment, and financial assistance for environmental restoration.

Prior to his appointment, Mr. Philbrick served as the executive vice president of LMC Properties, Inc., a wholly owned subsidiary of Lockheed Martin Corporation. For 10 years, he was responsible for a broad range of matters, including the coordination of environmental assessments and investigations and the development, approval, and implementation of remediation activities for environmentally affected properties. Prior to his position with LMC, Mr. Philbrick managed real estate operations for Colgate-Palmolive Company, American Can Company and PepsiCo during the 1980s and early 1990s. He received his bachelor's degree from the University of Richmond and his M.B.A. degree from the University of Chicago.

Nicholas V. Ralston, Ph.D.

Nicholas Ralston, a research scientist at the University of North Dakota Energy and Environmental Research Center, is the lead investigator in several multidisciplinary studies of heavy metal toxicity. Dr. Ralston received his B.S. degree in Biology from Mayville State University and his Ph.D. degree in Biomedical Research Biochemistry from the Mayo Graduate School at Mayo Medical Center. He worked in trace mineral nutrition for 10 years at the Grand Forks Human Nutrition Research Center; on the molecular basis of inflammatory disease for six years at the Mayo Clinic; on stereospecific phospholipase-resistant phospholipid metabolism for three years at Bowman Gray Medical School of Wake Forest University; and on boron and selenium biochemistry for three years at the Grand Forks Human Nutrition Research Center. For the past four years, he has studied the toxicity and pathophysiology of mercury and methylmercury interactions with selenium at the Energy and Environmental Research Center. Dr. Ralston is the Health Effects Program Area Manager of the EPA-sponsored Center for Air Toxic Metals at the Energy and Environmental Research Center, where he leads several studies that focus on selenium interactions with mercury. His current projects include studies of how selenium-dependent mercury retirement decreases mercury bioaccumulation in fish; the effects of mercury exposure on selenium-dependent enzyme physiology; and selenium's protective effect against mercury toxicity.

Eric Rimm, Ph.D.

Eric Rimm is an associate professor at the Harvard School of Public Health and the Channing Laboratory at the Harvard Medical School and is the associate director of the Health Professional Follow-up Study. His main interests include the study of associations between diet in relation to risk of obesity, diabetes, heart disease, and stroke, and he has specifically examined the associations between intake of dietary fiber, flavonoids, alcohol, B vitamins, and antioxidants from diet or supplements that may aid in the prevention of coronary heart disease and cancer. In addition, he has examined biological predictors of chronic disease as measured in blood, toenails, and DNA, as well as how these predictors may modify the underlying risk of disease associated with diet. This includes the assessment of trace metals in toenails, gene-diet interactions, and interactions of diet with lipids, inflammatory markers, adipocyte-related cytokines, clotting factors, and other metabolic parameters.

Dr. Rimm has published more than 280 peer-reviewed manuscripts in such journals as the *New England Journal of Medicine*, *Journal of the American Medical Association*, *Lancet*, *Circulation, British Medical Journal*, and *Journal of the National Cancer Institute*. Dr. Rimm served on the Institute of Medicine's Dietary Reference Intakes for Macronutrients Committee and is an Associate Editor of the *American Journal of Epidemiology*.

Susan J. Robinson, M.S.

Susan Robinson currently serves as the deputy director for the Office of Communication for the CDC National Center for Environmental Health (NCEH) and the Agency for Toxic Substances and Disease Registry (ATSDR). In this capacity, she consults to programs regarding communication research and strategies for engaging NCEH and ATSDR audiences. She is an expert in communication planning and development, with a specialty in Web-based outreach, bridging the disciplines of social marketing, health communication, and human-computer interaction (HCI). Ms. Robinson has a B.A. degree in Economics from the University of North Carolina and an M.S. degree in Human-Computer Interaction from the Georgia Institute of Technology. She is currently pursuing a Ph.D. degree in Digital Media at Georgia Institute of Technology.

Charles R. Santerre, Ph.D.

Charles Santerre is an associate professor of Food Toxicology in the Department of Foods and Nutrition and is the director of the Purdue University Toxicology (PUT) Program. Prior to these positions, he served as an operations manager of chemistry at Silliker Laboratories, Inc.; as an associate professor in the Environmental Sciences Program at Ohio State University; and as an assistant professor in the Environmental Health Science Program and the Institute of Ecology at the University of Georgia. Dr. Santerre's research involves food toxicology and nutrition. He has conducted studies to examine the effects of cooking on xenobiotics and has developed rapid methods for measuring chemical contaminants. Dr. Santerre was the National Spokesperson for the Institute of Food Technologists and has served as the Chairperson for the Toxicology and Safety Evaluation Division and as the Director of the Food Toxicology Center of the National Alliance for Food Safety. He 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.

Dr. Santerre received a B.S. degree in Human Nutrition and a Ph.D. degree in Environmental Toxicology and Food Science, both from Michigan State University.

John D. Schell, Ph.D.

John Schell is a vice president and principal toxicologist with BBL Sciences. He has more than 15 years of environmental assessment experience, focusing on human health and the ecological impacts of PCBs, dioxins, volatile organics, chlorinated pesticides, and metals. He received a Ph.D. degree from the Joint Graduate Program in Toxicology, Rutgers University, and has held adjunct teaching positions at the University of South Florida and University of Florida. Dr. Schell has experience performing human health and ecological risk assessments under state and federal programs, such as Superfund, the Resource Conservation and Recovery Act (RCRA), and state risk-based corrective action programs. His experience includes assessing the toxicity of PCBs, dioxins, volatile organic compounds (VOCs), pesticides, aromatic hydrocarbons, and metals (particularly as they are found in aquatic systems) and their impact on human health and the environment. Prior to joining BBL in his current position, Dr. Schell was a staff toxicologist at the St. Johns River Water Management District in Florida, where he developed a sediment assessment program for the St. Johns River. While at the District, he worked with scientists from the Florida Department of Health in developing fish advisory levels and a monitoring program to evaluate the need for them in the St. John River. In addition, Dr. Schell continues to serve as a consultant to the District for its Lake Apopka and Everglades restoration programs. He is a member of EPA's Pesticide Program Dialogue Committee, has served on advisory bodies on chemical risk assessment issues in Florida and Michigan, and has provided congressional briefings in Washington, D.C., concerning the use of risk assessment in developing clean-up strategies.

Rita Schoeny, Ph.D.

Rita Schoeny is senior science advisor for the EPA Office of Water. She received her B.S. degree in Biology at the University of Dayton and a Ph.D. degree in Microbiology from the School of Medicine of the University of Cincinnati. (U.C.) After completing a postdoctoral fellowship at the Kettering Laboratory, Department of Environmental Health, she was appointed assistant professor in that department of the U.C. Medical School. Dr. Schoeny has held several adjunct appointments and regularly lectures at colleges and universities on risk assessment.

Dr. Schoeny joined EPA in 1986. Prior to her current position, she was associate director of the Health and Ecological Criteria Division of the Office of Science and Technology. In that position, she was responsible manager 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 the Office of Research and Development, including chief of the Methods Evaluation and Development staff, Environmental Criteria and Assessment Office; associate director of the National Center for Environmental Assessment–Cincinnati Division; and chair of the Agency-wide workgroup on cancer risk assessment.

Dr. Schoeny has published in the areas of metabolism and mutagenicity of PCBS and polycyclic aromatic hydrocarbons; assessment of complex environmental mixtures; health and ecological effects of mercury; principles of human health risk assessment; and drinking water contaminants. She was a lead and coauthor of the Mercury Study Report to Congress and was a principal scientist and manager for Ambient Water Quality criterion for methylmercury. Recently, she has been heading an EPA workgroup on characterization of benchmark doses and other points of departure for quantitative assessment of human health risks. She participates in many EPA scientific councils, as well as national scientific advisory and review groups.

Dr. Schoeny is the recipient of several awards, including 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; Staff Choice Award for Management Excellence; and most recently, the FDA Teamwork Award for publication of national advice on mercury-contaminated fish.

H. Joseph Sekerke, Jr., Ph.D.

Joseph Sekerke is an environmental consultant with the Florida Department of Health, Division of Environmental Health. His primary technical responsibility is for evaluating risk and providing information about fish consumption advisories in Florida. (Health advisories can only be issued by the State Health Officer.) He evaluates criteria used to assess risk from consuming contaminated fish by reviewing toxicity data and exposure assessments for one primary contaminant per year. In addition, he monitors laboratory reports of biomarkers for mercury, arsenic, and cadmium exposure in Florida as part of the Florida Reportable Disease Program. Dr. Sekerke also provides assistance to the Childhood Lead Poisoning Prevention Program and the Pesticide Surveillance Program.

Judy Sheeshka

Judy Sheeshka is an Associate Professor at the University of Guelph in Ontario, Canada, and a registered dietitian. Her research has focused on the nutritional and health benefits of eating fish compared with the potential contaminant risks. She is particularly interested in how people's perceptions of risk influence their food choices and nutrition behaviors.

Andreas Sjödin, Ph.D.

Andreas Sjödin earned his Ph.D. in Environmental Chemistry at Stockholm University, Sweden, in 2000. His area of research was mainly directed toward assessing work-related exposure to brominated flame retardants, in particular PBDEs, in occupational settings at special risk, as well as assessing background levels in the general Swedish population. Dr. Sjödin has published journal articles in such publications as *Talanta*, *Analytical Chemistry*, *Health Perspectives*, and *Chemosphere*.

Dr. Sjödin was employed from September 2000 to December 2002 under the research participation program at the Centers for Disease Control and Prevention (CDC), as arranged by the Oak Ridge Institute for Science and Education. In January 2003, he was employed as a senior service fellow at CDC. Dr. Sjödin's area of research at CDC has been dedicated to the development and improvement of methods for analyzing halogenated organic pollutants and PAHs in biological matrices, as well as searching for unknown environmental pollutants. At CDC, he has supervised the development of an automated analytical method for the extraction, cleanup, and fractionation of human serum and human milk. This method is at present certified for PBDEs, polybrominated biphenyls, polychlorinated biphenyls, and persistent pesticides. Polybrominated and polychlorinated dibenzo-p-dioxins and furans (PXDD/F) are to be included in the near future. The method has good reproducibility and accuracy, as has been shown by analyzing quality control samples. Since May 2004, Dr. Sjödin has assumed supervisory responsibility for the combustion and biomarkers laboratory at CDC. He has supervised the development of a new extraction method for hydroxylated polycyclic aromatic hydrocarbon metabolites (OH-PAHs) in human urine. The developed methodology will be applied to epidemiological studies during spring 2005. The developed methodology is currently applied to biomonitoring studies aimed at identifying and quantifying exposures to environmental contaminants in the general population, as well as in certain populations at special risk.

Heather Stapleton, Ph.D.

Heather Stapleton is an assistant professor of Environmental Chemistry at Duke University's Nicholas School of the Environment and Earth Sciences. Dr. Stapleton received her B.S. degree in Marine Biology and Marine Chemistry from Long Island University's Southampton College. She received her M.S. degree and Ph.D. degree in Environmental Chemistry from the University of Maryland and then spent two years as a National Research Council postdoctoral fellow at the National Institute of Standards and Technology (NIST) in Gaithersburg, MD. During her graduate school training and postdoctoral experience at NIST, Dr. Stapleton focused her research on the environmental fate and transport of persistent organic pollutants, specifically on PBDEs. She has particular interest in examining the accumulation and biotransformation of PBDEs in fish, with emphasis on potential toxicity resulting from biotransformation processes. Her current research at Duke is focusing on biotransformation of PBDEs in *in vitro* systems to assess the fate and toxicity of PBDEs across species, and specifically, people.

Alan H. Stern, Dr.P.H.

Alan Stern is the section chief for Risk Assessment in the Division of Science, Research, and Technology of the New Jersey Department of Environmental Protection; an adjunct associate professor in the Department of Environmental and Occupational Health at the University of Medicine and Dentistry of New Jersey–School of Public Health; and an adjunct associate professor in the Department of Environmental and Occupational Medicine at the University of Medicine and Dentistry of New Jersey–Robert Wood Johnson Medical School. He received a bachelor's degree in Biology from SUNY–Stony Brook; a master's degree in Cellular and Molecular Biology from Brandeis University; and a doctorate degree in Public Health from the Columbia University School of Public Health

(1987). Dr. Stern is board-certified in toxicology by the American Board of Toxicology (Diplomate of the American Board of Toxicology). He was 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 and is also involved with the consumption advisory process in the State of New Jersey.

Jim VanDerslice, Ph.D.

Dr. VanDerslice is the senior epidemiologist in the Office of Environmental Health Assessments for the Washington State Department of Health. He has an M.S. degree and a Ph.D. degree in Environmental Engineering from the University of North Carolina at Chapel Hill. Dr. VanDerslice has worked for the past four years as an environmental epidemiologist with the Department of Health on issues, including fish consumption, infants' exposure to nitrate in drinking water, use of geographic information systems, and pesticide illness surveillance. Prior to that, he taught at the University of Texas, School of Public Health, focusing on water quality and ambient air quality epidemiology studies.

Nigel J. Walker, Ph.D.

Nigel Walker is a staff scientist in the Toxicology Operations Branch of the Environmental Toxicology Program at the National Institute of Environmental Health Sciences (NIEHS), NIH. Dr. Walker received his B.Sc. degree in Biochemistry from the University of Bath in 1987 and his Ph.D. degree in Biochemistry from the University of Liverpool in England in 1993. Following postdoctoral training in environmental toxicology at the Johns Hopkins School of Hygiene and Public Health in Baltimore, MD, he moved to NIEHS, where he has been since 1995.

Dr. Walker is currently the lead scientist for several initiatives of the National Toxicology Program (NTP), including the NTP's evaluation of the Toxic Equivalency Factor approach for assessing risks to persistent organic pollutants, including dioxins and PCBs. Other research interests include the use of toxicogenomics in hazard characterization and the health risk posed by exposure to materials produced through nanotechnology. He is an adjunct assistant professor in the Curriculum in Toxicology at the University of North Carolina at Chapel Hill and is currently the president of the North Carolina Society of Toxicology.

Ann L. Yaktine, Ph.D.

Ann Yaktine is a senior program officer at the Food and Nutrition Board (FNB) (F113), Institute of Medicine (IOM). She has previously been an instructor at the University of Nebraska–Lincoln and Virginia Tech. Since joining IOM in 2001, Dr. Yaktine has directed studies on dioxins and dioxin-like compounds in the food supply and the safety of genetically engineered foods and has coordinated a workshop on Nutrition and the Human Genome, which was presented at the Federation of Experimental Biology annual meeting in 2003. She is currently serving as the director for two studies—Assessing Worksite Preventive Health Programs for NASA Employees and Nutrient Relationships in Seafood: Selections to Balance Benefits and Risks.

Dr. Yaktine received her Ph.D. degree in Biochemistry and Molecular Biology from the Eppley Cancer Research Center at the University of Nebraska Medical Center. While at the University of Nebraska, she co-authored a chapter on Chemoprevention of Cancer for the nutrition text, *Modem Nutrition in Health and Disease*. Prior to joining the FNB, she was a postdoctoral research fellow at the Massachusetts General Hospital.

Proceedings of the 2005 National Forum on Contaminants in Fish

Appendix B

Final Participant List

U.S. Environmental Protection Agency
Office of Water

2005 National Forum on Contaminants in Fish

Marriott Baltimore Inner Harbor at Camden Yards
Baltimore, Maryland
September 17-22, 2005

Final Participant List

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Proceedings of the 2005 National Forum on Contaminants in Fish

Appendix C

Poster Abstracts

2005 National Forum on Contaminants in Fish
Poster Abstracts
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Contaminant Loads in Salmonid Fish in the National Fish Hatchery System, Northeast Region

Mike Millard and Bill Fletcher, USFWS, Northeast Fisheries Center, Lamar PA; Jaime Geiger, USFWS, Regional Office, Hadley, MA; and Linda Andreasen, USFWS, Arlington, VA.

Following published reports of elevated levels of polychlorinated biphenyls (PCBs) in farm-raised salmon, the U.S. Fish & Wildlife Service tested contaminant levels in salmonids from select national fish hatcheries in the northeast. Skin-on fillets from discrete age groups of Atlantic salmon, lake trout, rainbow trout, and cutthroat trout were analyzed via standard methodology for PCBs, dioxins, and mercury concentrations. Mean PCB levels in Atlantic salmon were consistent with levels previously reported for farmed salmon. Highest PCB levels were seen in sea-run Atlantic salmon in the Merrimack River. As a species, lake trout brood stock exhibited the highest mean PCB concentrations, with some triggering a 0.5 meal/month EPA consumption advisory. With respect to EPA consumption advisories, dioxin levels were at least as restrictive as PCB levels. Dioxin caused 14 of 22 composited fish samples to fall within the 0.5 or 0 meals per month EPA categories. Mercury, dieldrin, and endrin levels were far less restrictive than either dioxins or PCBs. Natural prey, environmental inputs, and/or commercial feed may be significant sources of PCBs in Atlantic salmon in the North Atlantic. Dioxins were viewed as the limiting factor when considering the fate of these fish.

Fair Warning: Why Grocery Stores Should Tell Parents About Mercury in Fish

Michael Bender, Mercury Policy Project, Montpelier, VT.

Recent testing conducted for the Mercury Policy Project indicates that the mercury concentrations found today in swordfish and tuna sold across the United States places consumers at risk. The average mercury concentrations in swordfish samples were 1.11 parts per million, with half of the samples above 1 ppm, and the average levels in tuna were 0.33 ppm. Food and Drug Administration (FDA) data from the 1990s show similar results, indicating that 36% of the swordfish and nearly 4% of the tuna sampled exceeded the agency’s 1 part per million “action level” for mercury. A joint Environmental Protection Agency–FDA advisory issued in 2004 warns pregnant women, women of childbearing age, and young children to avoid certain fish, including swordfish, and limit consumption of other fish, particularly tuna. Yet FDA scientists have estimated that between 30% and 50% of women of childbearing age are not aware of the exposure risks of mercury. To increase consumer awareness, the State of California requires grocery stores to post warnings where fish are sold. In addition, the American Medical Association passed a resolution in 2004 encouraging the FDA to require the posting of point-of-purchase warnings wherever fish is sold: “Given the limitations of national consumer fish consumption advisories, the Food and Drug Administration should consider the advisability of requiring that fish consumption advisories and results related to mercury testing be posted where fish, including canned tuna, are sold.”

Does Living Near a Superfund Site Lead to Higher Polychlorinated Biphenyl (PCB) Exposure?

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We assessed the determinants of cord serum polychlorinated biphenyl (PCB) levels among infants of mothers living near a PCB-contaminated Superfund site in southeastern Massachusetts. Mother-infant pairs were recruited at birth between March 1993 and December 1998. We measured 51 PCB congeners (∑PCB) in the 718 cord serum samples. Each family's address, diet, PCB exposure risk factors, occupation, and demographics were obtained from maternal interviews and medical record reviews. Addresses were geocoded to obtain distance to the Superfund site and data on neighborhood characteristics. We modeled log10∑PCB as a function of individual exposure pathways and potential individual and neighborhood risk factors, mapping model residuals to provide information on any unmeasured spatial correlates of PCB exposure. Similar analyses were performed for the light (mono- to tetra-CBs) and heavy (penta- to deca-CBs) PCBs and congener 118 to assess potential differences in exposure pathways as a function of relative volatility. Cord serum ∑PCB levels had a geometric mean of 0.40 ng/g serum (maximum 18.1 ng/g serum). Maternal age and birthplace were the strongest predictors of ∑PCB, with a significant association with organ meat and local dairy consumption. Infants born later in the study had lower levels of ∑PCB, possibly due to secular declines in exposure and site remediation. No association was found between ∑PCB levels and distance of residence from the Superfund hot spot. Similar results were found with light and heavy PCBs, and congener 118. We conclude that maternal age, early exposures to PCBs, smoking, lactation, and diet, including consumption of some locally produced foods, were important determinants of cord serum PCB levels. Infant birth year and local factors related to Superfund site dredging, but not residential proximity to the site, were additional determinants of cord serum PCBs in the study community.
(This study was funded by NIEHS grant number 5 P42 ES05947.)

Fish Advisories and Tissue Data: National Picture Compared to Tribal Lands

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Using tribal polygon GIS coverages obtained from the American Indian Environmental Office and GIS coverages of fish consumption advisories and associated fish tissue residue data from the National Listing of Fish Advisories (NLFA) database, the authors evaluated differences between the national perspective and tribal lands. Several differences were apparent. First, the fish advisories issued for tribal lands were overwhelmingly issued for mercury and secondarily for several organochorine pesticides, whereas advisories even within 10 and 50 miles of tribal lands have been issued for a much larger number of chemical contaminants including organophosphates, other heavy metals, PCBs, PBDs, and dioxins. In addition, the amount of tissue data supporting advisories issued for nationally was almost three times greater than for advisories issued for tribal lands. These differences may have several causes including geographic differences (e.g., tribal areas in the West may have small numbers of perennial rivers compared to the United States as a whole), differences in sampling intensity (e.g., primarily associated with resource constraints of tribal monitoring programs), and/or differences in the rates of tribal reporting of the results obtained in their fish tissue monitoring programs to the NLFA. Any or all of these factors maybe responsible for differences in the magnitude and patterns observed in fish advisories and tissue data collected by the Nation as a whole vs. data collected on tribal lands.

Idaho's Fish Consumption Advisory Program: How to Maintain a Program through Cooperative Agreements.

Chris Corwin, Environmental Health Education and Assessment Program, Boise, ID.

The Idaho Fish Consumption Advisory Program (IFCAP) was started 5 years ago to help protect the public from adverse health risks associated with consuming contaminated fish from Idaho and tribal waters. The program is run collectively by a committee of representatives from at least six state and federal agencies. The program has no money earmarked for its activities and thus relies on the "volunteering" of the agencies participating in the program. Using the resources at each agency (for example, Idaho Department of Fish and Game collect fish for their counts and keep and bottle samples for IFCAP), we are able to collect fish from select bodies of water and have them tested for contaminants such as mercury and PCB's. Through this cooperative agreement, IFCAP has issued fish advisories for seven water bodies in Idaho and has others in the works.

The Quincy Bay Study Revisited 20 Years Later

Mary E. Davis and William Robinson, University of Massachusetts Boston.

In April 1988, an EPA-funded study was released that identified concentration levels of certain heavy metals, pesticides, PCBs, and PAHs in sediment and marine life in the Quincy Bay area of Massachusetts. In particular, the histopathological conditions of Quincy Bay flounder, lobsters, and soft-shelled clams and of transplanted, caged oysters were examined for the purposes of performing a detailed risk assessment of seafood in that area. The lifetime cancer risk associated with consuming Quincy Bay's seafood was then determined, and the risk of noncarcinogenic adverse health effects were calculated.

This study was performed when this coastal region was notoriously contaminated with pollutants, with the goal of better understanding the public health impacts of contaminated seafood for residents and consumers. Since 1988, many changes have occurred in Quincy Bay and the larger Boston Harbor area. These changes directly affect the levels of contamination and, therefore, likely impact associated health risks from eating contaminated shellfish. However, there are still Massachusetts Department of Public Health advisories against eating fish and shellfish from Boston Harbor based on that Quincy Bay study nearly 20 years later.

A reanalysis of Quincy Bay seafood is currently under way at the University of Massachusetts Boston, and preliminary data from lobster tissue and hepatopancreas suggest some interesting trends. Although these results are still being analyzed, and certain contaminants have not yet been reported, lobster tissue concentrations from all of the reported chemicals were down from their 1988 levels. However, hepatopancreas levels were elevated for some of the contaminants, including certain PAHs and PCB congeners, while pesticides and total PCBs were down. Once the pilot data have been thoroughly reviewed, we plan to resample a larger population of lobster and other shellfish, to perform a detailed comparative risk assessment of Quincy Bay seafood.

Development of Hatchery Feed Criteria

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PCB concentrations in lake trout brood stock maintained in U.S. Fish and Wildlife (FWS) Region 3 National Fish Hatcheries occasionally exceed the fish consumption advisory trigger for PCBs used by Great Lakes States. The available data indicate that a primary source of PCBs to hatchery fish is contaminated food. We used a simple bioaccumulation model to calculate a PCB criteria for hatchery food that will result in PCB concentrations in brood stock below thresholds posing risk to

1. Human consumers.
2. Wildlife that consume stocked brood stock.
3. Fry produced in hatcheries.

Modeling results indicate that, for hatchery lake trout, a PCB concentration of 0.057 µg/g, or less, in food will result in concentrations in lake trout that are below the Great Lakes fish consumption advisory trigger of 0.05 µg/g and pose minimal risk to mink and lake trout fry. FWS Region 3 contracts now specify that PCB concentrations in fish oils not exceed 0.02 µg/g, and the finished feed not exceed 0.057 µg/g. FWS will conduct random testing to ensure compliance.

Engaging New Audiences: NGOs as Sources of Information on Contaminants in Seafood

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The risks of consuming contaminated fish have traditionally been conveyed to the public in two ways: (1) through the federal methylmercury advisory for commercial seafood and (2) via state health or natural resources agencies for recreational and subsistence catches. Sources of information are increasing, however, as a number of nongovernmental organizations (NGOs) now issue consumption advice through tools such as mercury calculators and healthy fish guides. Few NGOs conduct their own contaminants testing, but rather rely on state advisory information and fish tissue data from such programs as the Environmental Protection Agency’s National Listing of Fish Advisories and the Food and Drug Administration’s Mercury Monitoring Program. The resulting consumption advice varies depending on data sources evaluated, study areas surveyed, subpopulations targeted, and contaminants considered.

Environmental Defense, an environmental NGO that links science, economics, law, and private-sector partnerships, provides species-specific ecological advice and consumption recommendations to consumers through seafood wallet cards and an online seafood database (http://www.oceansalive.org/go/seafood). Mean contaminant levels for each species are based on mercury, PCB, dioxin, and pesticide data collected from more than 60 government databases and scientific studies. The data are filtered through a series of decision rules governing data credibility and quality, and advisories are then generated according to the EPA’s “National Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories.” This method provides consumers with reliable and accurate consumption advice for many of the most popular seafood items in the United States. Environmental Defense presents this information on contaminants alongside information on ecologically responsible seafood choices. Our findings show that fish high in contaminants are often produced using environmentally harmful fishing and aquaculture practices. Thus, our food safety and ecological advice to consumers tend to reinforce each other.

Polychlorinated Biphenyls in the Upper Rio Grande Watershed, 2000-2003 Surface Water, Soils, and Sediment Sampling: A Cooperative Study

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From 2000 to 2003 researchers from Los Alamos National Laboratory, New Mexico Environment Department, San Ildefonso Pueblo, and Los Alamos County determined levels of polychlorinated biphenyls (PCBs) in ambient water, storm water, background soils, and sediments in the upper Rio Grande watershed. All samples were analyzed using EPA method 1668A, a high-resolution method, for the determination of PCB congener concentrations. PCB concentrations in stream channel sediments ranged from 0.03 pg/g to 2,500 pg/g. We found levels of PCBs in the upper Rio Grande watershed soils ranging from 5 pg/g to 253 pg/g with a mean concentration of 45.4 pg/g. This likely represents background concentrations in soils from atmospheric deposition. The New Mexico Water Quality Control Commission (NMWQCC) has established the Wildlife Habitat Standard to protect aquatic organisms and wildlife that consume fish. Total PCBs in storm runoff in tributaries to the Rio Grande ranged from 1.4 ng/L to 925 ng/L (mean 226 ng/L) and often exceeded the Wildlife Habitat Standard of 14 ng/L. Total PCBs in the Rio Grande ranged from 0.03 ng/L to 12.8 ng/L (mean 2.57 ng/L) and often exceed the NMWQCC Human Health Standard of 0.64 ng/L. The Human Health Standard represents a level in water where PCBs may accumulate in fish and pose an unacceptable health risk for people who eat the fish. This finding is consistent with previous studies of fish in the Rio Grande that show concentrations of PCBs in tissues of some fish species exceed EPA recommendations for fish consumption and may warrant fish consumption advisories. Levels of PCBs in the Rio Grande did not at any time exceed the EPA drinking water standard for PCBs (500 ng/L). Semipermeable membrane devices (SPMDs) were also deployed at four locations along the Rio Grande from Embudo through Albuquerque to provide a measure of dissolved PCB concentrations. The levels of dissolved PCBs in the Rio Grande, based on SPMD data, increase below Cochiti Reservoir and remain elevated through Albuquerque. This may indicate conversion to lesser chlorinated and more soluble PCB congeners due to anaerobic dechlorination in bottom sediments of Cochiti Reservoir. The level of dioxin-like congeners increases from the Cochiti Reservoir outlet to our most downstream sample below Albuquerque. This may indicate additional industrial sources of PCBs below Cochiti Reservoir and through Albuquerque.

Pilot Study to Assess Fish Consumption Patterns and Knowledge of Fish Advisories

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Background: In March of 2004, a joint FDA/EPA advisory was issued warning certain at-risk populations to limit their fish intake based on potentially unsafe levels of mercury. Pregnant women, women who may become pregnant, and young children are warned to limit their total intake of fish to 12 ounces per week. They should eat no more than a single six-ounce can of Albacore tuna each week and should avoid certain species of fish (shark, tile fish, king mackerel and swordfish) altogether. People are also encouraged to eat a variety of different fish and observe local advisories when applicable.

Objectives: This project was a pilot study to determine if local sport fishermen were aware of any advisories concerning fish consumption and if so, where they found out about them. An additional goal was to assess if fish consumption patterns for at-risk populations were consistent with those outlined in the federal mercury advisory. Sport fishermen were chosen since they would know more about fish advisories and possibly eat more fish than the general population.

Methods: A survey tool was developed and administered to sport fishermen at a local fishing pier and fishing club meeting in Charleston, South Carolina, from December, 2004 to February, 2005. In addition to the fishermen, data were collected on other household members to determine their fish consumption patterns.

Results: A total of 34 surveys were completed with the following results:
72% (23) of respondents were aware of fish consumption advisories and 83% (19) of them could name a specific contaminant. 95% (18)* of respondents that identified a specific contaminant named mercury, while PCB's, parasites, and heavy metals were also mentioned. 68% (13)* named a specific fish, with king mackerel (9), swordfish (4), and tuna (3) noted most. Barracuda, blackfin tuna, and wahoo were other species respondents listed as having consumption advisories. Newspaper or magazine (53% (18)*) was the most common source of information for those who knew about advisories. Respondents picked newspaper or magazine (50% (17)*) as the most reliable source of information, whereas only one person named government material as the most reliable source of information. 77% (26) of the respondents were interested in learning more about fish consumption advisories.
*More than one response was accepted for these questions.

Conclusions: The results of this pilot study show that respondents and their household members consistently consume fish at levels lower than the safe threshold outlined in the FDA/EPA mercury advisory. These fishermen were aware of fish consumption advisories, were able to name mercury as a contaminant, and were aware of some specific fish identified in the federal advisory. Conducting this survey was a valuable learning experience, and the lessons learned will be applied to future research in this area. A new survey tool is currently being developed that will be administered specifically to women. Future work could also include education aimed at health care workers or the general public.

<u>To Post or Not To Post? Results from OEHHA's 2004 Survey of Posting in Fish Advisory Programs</u>

Robert K. Brodberg, Ph.D., <u>Margy Gassel</u>, Ph.D., and Sue Roberts, M.S., Office of Environmental Health Hazard Assessment, California Environmental Protection Agency

The California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) circulated a survey, during the 2004 Fish Forum, among fish advisory program staff from states and tribes on the issue of posting advisories as part of state communication efforts. Twenty-seven staff representing 26 states and the District of Columbia submitted responses. One state responded that they have no advisories. Therefore, because the questions in the survey were not applicable to this state, the total number of respondents used to report findings was 26. Although 20 states reported posting at least some advisories, only 7 indicated that they have a requirement, mandate, or policy to do so. One state that no longer posts signs reported that signs posted in the past were destroyed. About half of the states post signs in English only, while the other half post signage in at least two (English and Spanish) and up to six different languages. Sixty-five percent of the states that conduct posting considered signs a useful communication tool. One state that does not post suggested that other communication methods could be better for reaching target audiences of women and children (for mercury advisories). Of all the states that post some advisories, only three states indicated that they have a program for evaluating the effectiveness of signage. The expense of posting and maintaining signs, and vandalism were common concerns expressed in respondents' comments.

Fish Tissue Sampling Program in Alaska: Update

Robert Gerlach and Howard Teas, State of Alaska, Anchorage, AK.

The presence of environmental contaminants in fish has been of major concern for the general public and has raised some questions regarding the benefit of consuming fish as part of a healthy diet. Recent articles focusing on mercury, PCB, and dioxin content of salmon have been of particular interest to Alaskans who eat salmon at a much higher consumption rate than the general population of the United States.

To answer some of these concerns, the Alaska Department of Environmental Conservation (ADEC) is working in collaboration with the Alaska Department of Public Health (ADPH). ADEC is collecting fish from Alaskan waters to analyze for heavy metals (methylmercury, total mercury, total arsenic, inorganic arsenic, cadmium, lead, chromium, nickel, selenium) and inorganic contaminants (PCBs, dioxins, furans, organocholorine pesticides, PBDEs). The ADPH initiated a statewide mercury biomonitoring program, which involves analyzing hair from women of childbearing years. The results of the biomonitoring study will be used with mercury data from the fish collected to develop public health advice for fish consumption in Alaska.

This poster presents the mercury data from the 1776 fish samples collected from 2001 to 2004. Sample numbers of each species of fish from each corresponding year are listed, and comparisons among species of fish and geographic locations are highlighted. PBDE congener (47, 99, 100, 153, 154) data from 89 fish (salmon: Chinook, chum, sockeye; sheefish; halibut; and sablefish) are also illustrated.

Fish Consumption Patterns and Advisory Awareness Among Anglers in Three Regions of Concern in the Chesapeake Bay Watershed.

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Full report (CMI-HDD-05-01) is available online: http://www.cmiweb.org/hdd.htm.

The Conservation Management Institute at Virginia Tech received a grant from the Chesapeake Bay Program (CBP) to (1) identify populations at risk for consuming contaminated self-caught fish and (2) examine the fish consumption advisories and protocols to identify possible improvements. In June, July, and August, 2004, we conducted 8 weeks of on-site angler interviews in the three regions of concern: Baltimore, MD (135 interviews); Washington, DC (247 interviews); and the Tidewater area of Virginia (493 interviews). The three regions had several key differences in the status of their advisories. The Baltimore area had just received a new set of advisories accompanied by an aggressive, multimedia outreach campaign approximately a month before our interviews began. The Washington, DC, area advisories had been in effect, unchanged, with a less-aggressive outreach campaign for about 10 years. In Virginia, only one very mild advisory was in effect during the whole sampling period (with one additional advisory effective halfway through), and outreach was relatively low-key.

These differences were clearly reflected in the fish consumption patterns and advisory awareness levels among anglers and their households. Perhaps most reflective of this relationship is that 91% of Virginia anglers said they consumed their catch at least part of the time, whereas 53% of Baltimore anglers, and only 37% of Washington, DC, anglers reported similarly. In all cases, a significant portion of anglers (85%, 65%, and 54%, respectively), including some anglers who do not eat the fish themselves, reported that they sometimes give their fish to others. When asked specifically about advisories, 85% of Baltimore anglers were aware of them, and 56% of Washington, DC, anglers were aware. This question was not asked of Virginia anglers, but very few mentioned the advisories during the interview. Unfortunately, of the anglers who consume their catch in all three regions, the most popular species for consumption are still those under advisory, including catfish (a no-consumption species in all three regions), white perch, striped bass, largemouth bass, and blue crab. In fact, a large proportion of the consumption instances reported (51% in Washington, DC; 78% in Baltimore) exceeded advisory recommendations, even though anglers overwhelmingly indicated that they believed advisories were important to follow. The one sociodemographic factor that stood out as a critical risk factor in Baltimore and Washington, DC, was race. African Americans in Baltimore and minorities in general in Washington, DC, appear to be at an increased risk because they more often consumed their catch, more often provided their catch to their families, placed a higher importance on the reduction of food expenses as a motivation to fish, and were less likely to prepare their fish using risk-reducing techniques than other races, primarily white anglers. In Virginia, where advisories are a relatively new occurrence and outreach is less aggressive, all ethnic groups were at an increased risk.

Additional analyses of angler interviews included the effectiveness of various dissemination modes in both reaching anglers (creating awareness) and changing consumption behavior. Follow-up stakeholder meetings also resulted in some suggestions for bridging the cultural gaps that may lead to lower levels of advisory compliance among certain groups. We offer some suggestions for addressing these issues in each of the three regions.

Children's Consumption of Commercial and Sport-caught Fish: Findings from a Twelve State Study

Pamela Imm, Lynda Knobeloch, and H.A. Anderson, Division of Public Health, Madison, WI.

Is TEQ Enrichment of PCBs in Fish Tissue a Common Phenomenon? Implications for Risk Assessment

Russell E. Keenan and John H. Samuelian, AMEC Earth & Environmental, Inc., Portland, ME

When fish tissues are analyzed for PCBs, some public health agencies have recommended analyzing for "dioxin-like" PCB congeners and converting the results into dioxin toxic equivalency (TEQ) concentrations for use in risk assessments based on the cancer slope factor (CSF) for 2,3,7,8-tetrachlorodibenzo-p-dioxin. This recommendation implies that environmental PCBs possess enriched toxicity compared to that of the commercial PCB test mixtures upon which U.S. EPA's upper-bound PCB CSF is based. Because the highest PCB test mixture contained 46.4 mg-TEQ/kg-PCB, the PCB CSF by definition is protective of exposures to PCBs containing TEQ levels less than or equal to this concentration. Our analysis revealed that fish fillet PCB samples taken from a large variety of PCB-impacted waterways across the United States that varied in the type of PCBs that were the source of the contamination had mean and 95% statistical confidence limit TEQ levels lower than 46.4 mg-TEQ/Kg-PCB. Consequently, the use of the PCB CSF appears to be adequately protective for evaluating potential cancer risks of PCB mixtures found in these fish tissues. There does not appear to be a need to use the TEQ approach to ensure that cancer risks are not underestimated. Implications for risk assessment and public health protection are discussed.

Outreach Strategies to Sensitive Populations Regarding Mercury in Fish

Karen Knaebel, Vermont Department of Environmental Conservation, Waterbury, VT.

Special efforts have been made in Vermont to reach women of childbearing age, pregnant women, nursing mothers, and parents of young children. Health providers, childbirth educators, midwifes, doulas, naturopathic physicians, nutritionists, childcare providers, and nurses were given materials and instruction to provide this information to their clients. Also, populations where fish is a staple in their diet were provided information through tribal education, pow wow meetings, and refugee resettlement programs. Other avenues to get the word out to the general public included posting advisories at fishing access areas, libraries, stores that sell fishing licenses, schools, physician offices, and direct mailings to newly married couples. To measure the success of outreach to pregnant women, a survey is currently being conducted of mothers of newborns as to their knowledge of the advisories, their fish consumption patterns during pregnancy, and a measure of behavior change based on this knowledge. As a part of the outreach, an animated video and video games that cover various aspects of mercury in the environment were developed for use by 8th-grade students.

Mercury in Scales as an Assessment Method for Predicting Muscle Tissue Mercury Concentrations in Largemouth Bass

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This study is the first of two related studies designed to predict total mercury (Hg) concentrations in fish tissue without the necessity of sacrificing the fish. In this study, the relationship between total Hg concentration in fish scales and in tissues of largemouth bass (*Micropterus salmoides*) from 20 freshwater sites was developed and evaluated to determine whether scale analysis would allow a non-lethal and convenient method for predicting Hg concentrations in tissues. The relationship of total Hg concentrations between untreated scale samples and tissues showed high variance. Several different scale treatments were tried to increase the coefficient of determination, and thereby, to enhance the effectiveness of this predictive technique. Washing treatments with acetone, deionized water, solutions of a detergent, and a soap were used in conjunction with ultra sonication to treat scales. The use of a mild soap solution with heating and ultrasonication increased the r^2 the most (from 0.69 [untreated scales] to 0.89). As a result of variance remaining in this relationship and with the inclusion variance in scale analysis, rather wide predictions of tissue concentrations from scale analysis were obtained. Scale analysis can be used to establish the acceptability of fish given a criterion based on Hg concentration in fish muscle tissue and also appears to have potential for assessing general trends in contamination, for comparison of levels from different geographical areas, and as a first level screen for assessing Hg contamination at sites.

Hexabromocyclododecane in Chesapeake Bay Fish

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Hexabromocyclododecane (HBCD) is a brominated flame retardant commonly used in polystyrene foams. Global demand for HBCD was 16,700 tons in 2001, making it the third most widely used brominated flame retardant. Commercial HBCD mixtures contain three diastereomers: alpha, beta, and gamma. This study used LC/MS/MS to analyze 52 composite fish samples from the Chesapeake Bay and its tributaries. The majority of the samples were between 0-20 ng HBCD/g lipid, with a few samples, notably channel catfish and striped bass, with concentrations between 40-80 ng HBCD/g lipid. These concentrations are similar to previous research conducted in Europe. HBCD concentrations were not correlated with PCB and BDE concentrations measured from the same composite samples. This indicates that the sources, transport processes, or bioavailability of HBCDs are different from PCBs and BDEs. The HBCD alpha form occurred most frequently, however in some species, gammaHBCD was the dominant stereoisomer. This indicates differences in metabolic processes between fish species. This study is the first of its kind for the Chesapeake Bay and represents a baseline of HBCD concentrations in Mid-Atlantic fisheries. HBCD production may increase as a result of the phase out of other forms of flame retardants. Therefore, continued monitoring and research into the environmental consequences of HBCDs are needed.

Seafood Contaminant Testing and Labeling Program

Henry Lovejoy, Seafood Safe, LLC, Dover, NH.

Seafood contaminant testing and labeling program helps consumers maximize the health benefits of seafood. Solution for consumers receiving confusing/conflicting messages. Proactive industry-sponsored approach. Autonomous independent structure consists of

- Advisory panel (Dr. Knuth, Cornell University; Dr. Carpenter, SUNY Albany)
- Sampling program (SureFish)
- Participating labs (Axys Analytical—PCBs; Brooks Rand—mercury)
- Consumer advocacy organization (Environmental Defense)

Program highlights

- Precautionary principle
- Recommendation based on women of childbearing age
- Consultation with client
- Customized testing protocols
- Positive industry message
- Medical community overwhelmingly recommends the consumption of seafood; majority of seafood is safe to consume

Guidance Derivation

- EPA's Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories
- EPA's Risk-Based Consumption Tables

Seafood Safe First Adopter = EcoFish
Consumption Recommendations for EcoFish Products: Alaskan Salmon 16+; S. American Mahimahi 7; California Calamari 16+; White Shrimp 16+; Oregon Tuna 6; Bay Scallops 16+; Alaskan Halibut 10; Organic Shrimp 16+.

Norwegian Surveillance of Seafood Safety

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Several surveillance programs with the aim of controlling and documenting the content of undesirable substances in marine foods are ongoing in Norway. Some of these programs are focused directly toward food quality while others are designed more for environmental monitoring than food monitoring. The latter includes several "hot spot" programs at sites and areas with known pollution and is financed through the Ministry of Environment.

Several of the programs aimed at food and marine feed quality were administered by the Directorate of Fisheries until January 1, 2004, but the responsibility was then taken over by the Norwegian Food Safety Authority (NFSA), which then also took over surveillance responsibilities of marine foods. The regular programs include

- Surveillance of marine feed and feed ingredients for aquaculture
- Surveillance of cultured bivalves
- Surveillance of medical residues in cultured fish, mainly salmon
- European Union (EU) program on dioxins in food, where Norway provides data on a large number of fish samples.

The National Institute of Nutrition and Seafood Research (NIFES) is responsible for running the above-mentioned programs also in 2004 and 2005 on behalf of the NFSA.

Since 1994, NIFES has also built up their own surveillance program focusing the concentration of undesirable substances in important wild-caught fish species. The aim is to deliver independent quality data for the government, consumers, and industry, and the data will eventually be used to show time trends. In this program, sampling frequencies of different marine species are selected based on their economic importance or by virtue of their catch volume (industrial fish). Sampling frequency is thereby every year or every second year for species such as salmon, cod, herring, and mackerel, while more infrequent for species like ling, tusk, and Greenland halibut.

NIFES has gradually built up its capacity for different chemical and microbiological analyses for the purpose of the surveillance. The portfolio now includes total metal content analyzed by ICP-MS; TBT and inorganic arsenic by LC-ICP-MS; dioxins and dioxin-like PCB's by HRGC-HRMSS; additional polybrominated flame retardants by GC-MS; PCB, PAH, and pesticides by GC-MS and also further compounds such as antioxidants. Speciation of metals now includes $Me\text{-}Hg^{+}$ by GC-ICP-MS. From this year on, analyses of a variety of nutrients such as vitamins, minerals, fatty acids, amino acids, and different carbohydrates will be included in this program. Examples of results will be presented, and results from the latter program can be found at www.nifes.no.

Colorado Fish Tissue Study: Mercury Concentrations in Fish in Selected Waterbodies, Sampled in 2004 and 2005

Lucia Machado, James Dominguez, Kenan Diker, PhD, Monitoring Unit, Water Quality Control Division, Colorado Department of Public Health and Environment.

PROBLEM: Fish spend all their life in a waterbody; due to bioconcentration and bioaccumulation mechanisms, mercury found in trace amounts in the water column may be found at high concentrations in fish. When such fish are consumed, they may pose a threat to human health.

OBJECTIVE: To investigate whether mercury concentrations in fish tissue are above levels of concern for human consumption or not. If they are, fish consumption advisories are issued for those waterbodies.

MATERIALS AND METHODS:

- 5-year monitoring plan to investigate mercury in fish in almost 100 lakes, reservoirs, and river segments in Colorado, starting in 2004.
- Waterbodies were chosen based on the following criteria:
  - A need to update existing fish consumption advisories.
  - The waterbody is a highly desirable fishery.
  - There are no historical data available.
- A total of 120 fish were collected per waterbody: 60 fish from two species; each species represented by fish of two sizes: larger and smaller, 30 of each size. Not possible at every waterbody. The outcome of the sampling effort depended on the natural diversity, abundance, and availability of fish in each lake.
- Samples consisted most often of material composited from three to five fish; a few samples consisted of material from a single fish. Always, the compositing scheme was such that the standard error was kept at 0.024 or less.
- Composite samples in this study met the following criteria:
  - All specimens in a composite were of the same species;
  - The smallest specimen in the composite was not smaller than 85% of the length of the largest specimen in the composite;
  - Fish composites were made from fish collected during the same sampling event.

RESULTS:

- 22 lakes and reservoirs were sampled in a 18-month period.
- A total of 1,253 samples were submitted for analysis.
- Of the five waterbodies with fish consumption advisories (FCAs) in Colorado, three were resampled, and all three will be updated and the FCAs maintained.
- At the current action level of 0.5 µg/kg, six additional waterbodies exceeded that value.
- Seven waterbodies had very low mercury concentrations in the tissue of the fish.
- Two waterbodies had mercury levels above 0.4 µg/kg.
- Fish species found with elevated mercury levels were northern pike, walleye, largemouth bass and smallmouth bass.
- All trout species sampled were found to have very low mercury levels.

CONCLUSIONS:

- There is a need for the State to continue evaluating mercury concentrations in fish in Colorado waterbodies.
- There is a need to evaluate the geographic distribution of mercury-impacted waterbodies.
- There is a need for the State to issue additional FCAs.
- Trout species do not pose a significant mercury contamination threat in any waterbody sampled.
- Large top predator fish should not be consumed, especially by certain subpopulations at larger risk.

The Monitoring Unit acknowledges the Division of Wildlife for all the collaboration and help collecting fish for this study. For more information, consult www.cdphe.state.co.us/wq/FishCon/FishCon.htm

Patterns of Hg Bioaccumulation and Transfer in Aquatic Food Webs across Multilake Studies in the Northeast U.S.

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The northeastern United States receives some of the highest levels of atmospheric mercury (Hg) deposition of any region in North America. Moreover, fish from many lakes in this region carry Hg burdens that present health risks to both human and wildlife consumers. The overarching goal of this study was to identify the attributes of lakes in this region that are most likely associated with high Hg burdens in fish. To accomplish this, we compared data collected in four separate multilake studies. Correlations among Hg in fish (four studies) or in zooplankton and fish (two studies) and numerous chemical, physical, land use, and ecological variables were compared across more than 150 lakes. The analysis produced three general findings. First, the most important predictors of Hg burdens in fish were similar among datasets. As found in past studies, key chemical covariates (e.g., pH, acid neutralizing capacity, and SO4) were negatively correlated with Hg bioaccumulation in the biota. However, negative correlations with several parameters that have not been previously identified (e.g., human land use variables and zooplankton density) were also found to be equally important predictors. Second, certain predictors unique to individual datasets and differences in lake population characteristics, sampling protocols, and fish species in each study likely explained some of the contrasting results that we found in the analyses. Third, lakes with high rates of Hg bioaccumulation and trophic transfer have low pH and low productivity with relatively undisturbed watersheds, suggesting that atmospheric deposition of Hg is the dominant or sole source of input. This study highlights several fundamental complexities when comparing datasets over different environmental conditions, but also underscores the utility of such comparisons for revealing key drivers of Hg trophic transfer among different types of lakes.

Sport-Caught Fish Consumption in Missouri: 2002 Mail Survey

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The Missouri Department of Conservation (MDC) and other state agencies collect fish contaminant data, which are provided to the Missouri Department of Health and Senior Services (DHSS) to determine if a fish consumption advisory is warranted. In an effort to ensure the accuracy and effectiveness of the advisories, MDC, with DHSS input, developed a survey to collect information on key fish consumption variables such as species consumed and rate of consumption as well as awareness and understanding of Missouri fish advisories.

A mail survey was sent to 2,379 selected individuals meeting the following criteria: had a valid Missouri hunting and fishing permit; had fished and consumed fish in 2002 (they or a family member); and had a woman of childbearing age or a child 12 years or younger in their household. A total of 1,621 people responded to the survey for a 69.6% response rate. Results indicated the most frequently consumed species were (in order of preference) crappie, channel catfish, bluegill, and largemouth bass. Filleting fish and removing/puncturing the skin were the most common methods of preparing the fish. Respondents (approximately 50%) would remove the red meat/mud line and other fatty tissues during preparation, especially women. Pan and deep frying were the predominant methods of cooking. The “all fish” daily consumption rates for all respondents at the 50th, 75th, 90th, and 95th percentiles were 50, 80.0, 113.4, and 140.0 grams/day with an estimated mean value of 38.7 grams/day. For children, the “all fish” daily consumption rates at the 50th, 75th, 90th, and 95th percentiles were 26.1, 36.6, 52.2, and 67.9 grams/day with an estimated mean value of 17.0 g/day. The percentile values were considered a better representation of the data than the mean values since the data were not normally distributed.

Most anglers were aware of health advisories, but were not specifically aware of the recent mercury advisory regarding largemouth bass consumption. The largemouth bass advisory recommends that pregnant women, women that may become pregnant, or children aged 12 years or less not consume largemouth bass greater than 12 inches in length. Survey data indicated that some individuals in these potentially sensitive populations likely did consume largemouth bass in 2002. Although there was a lack of knowledge regarding the mercury fish advisory, it may be a result not only of the methods used to disseminate the information, but also the receptiveness of anglers and others to the message. When asked if survey respondents perceived consumption of Missouri sport-caught fish to be risky or somewhat risky, only 12.9% indicated some concern, compared to 26.2% expressing concern for drinking tap water and 83.1% expressing concern for drinking alcohol. More awareness of, and response to, the mercury advisory may be gained by more effective methods of distribution. However, special attention must be paid to the public's concern for the issue and their willingness to follow the advisory.

Communicating Seafood Safety

Cara Muscio and Gef Flimlin, Rutgers Cooperative Research and Extension Monmouth, Ocean, and Atlantic Counties, Toms River, NJ.

Rutgers Cooperative Research and Extension is publishing a Web site intended to help consumers make appropriate seafood choices for their families. This site is based on a 2004 conference entitled "Seafood: Assessing the Benefits and the Risks." The site will present research-based information on the benefits and the risks of eating seafood, and will link to other organizations presenting pertinent information. In addition, a survey was designed to collect information on seafood consumption habits and perception of risk. A pretest of this survey was given to 100 faculty and staff of Cook College, Rutgers University.

The Use of Accelerated Solvent Extraction (ASE) in the Determination of PCBs, PBDEs, PCDDs and PCDFs in Fish Tissue Samples

B. Richter, S. Henderson, E. Francis, J. Peterson, and R. Carlson, Dionex, SLCTC, Salt Lake City, Utah.

The use of accelerated solvent extraction (ASE) has grown rapidly since its introduction in 1995. ASE is an extraction technique that utilizes elevated temperature and pressures with organic solvents or solvent mixtures to obtain rapid extractions with small volumes of solvents. ASE complies with the requirements of Method 3545A for the extraction of organochlorine pesticides (OCPs), semivolatile compounds (BNAs), chlorinated herbicides, polychlorinated biphenyls (PCBs), organophosphorus pesticides (OPP), polychlorinated dibenzo-*p*-dioxins and furans, diesel range organics (DROs) and waste oil organics (WOOs) from solid and semisolid samples. The advantages of ASE include short extraction times (generally less than 15 minutes) and small solvent quantities used (generally less than 50 mL) for extracting solid and semisolid samples.

ASE is also widely used for the extraction of pollutants and contaminants from animal tissues including fish. This presentation will discuss results of comparisons of data generated by ASE to those generated by conventional extraction methods such as sonication and Soxhlet. Data will be presented showing the recovery of PCBs, PBDEs, PCDDs, and PCDFs from fish and other aquatic animal tissues. In many cases, selective extractions can be performed using ASE that generate extracts free from lipids that can be injected onto GC or GC-MS systems without any further cleanup.

Fish Consumption Outreach at Supermarkets in Connecticut

Rusnak, Toal, and Ginsberg, Connecticut Department of Public Health, Hartford, CT

While the Connecticut Department of Public Health (CTDPH) has set advisories for fish caught from local waterbodies over the past 20 years, only in the last few years have we developed guidance for commercially available fish. This guidance has appeared as a sidebar on our pamphlets that focus on local fish consumption. Over the past 6 months we have developed a new pamphlet titled “A Woman’s Supermarket Guide to Fish Consumption.” The supermarket guidance is based upon the recent FDA/USEPA general consumption advisory and specific information on contaminant levels in individual species of commercial fish. The fact sheet emphasizes that a moderate level of fish consumption is part of a healthy diet during pregnancy and early life development. Some fish (flounder, haddock, light tuna, cod, shellfish, sardines, etc.) have lower levels of mercury and PCBs and so should be selected more often than others (halibut, tuna steak, white tuna, red snapper). Still other fish should not be eaten at all (swordfish, shark, king mackerel, tilefish, striped bass, large bluefish). CTDPH has partnered with a large supermarket chain for a pilot project in which these pamphlets are being distributed at the fish counter in a single store. At the end of a 6-month test period (December 1st) we will evaluate whether this is a useful method for education on commercial fish consumption and, if so, what the best avenues are for expansion of the pilot to additional stores and chains. A bill in the Connecticut legislature that would require posting of fish consumption warnings in the supermarket did not pass during the spring 2005 legislative session.

Mercury in Fin Clips as an Assessment Method for Predicting Muscle Tissue Mercury Concentrations in Largemouth Bass

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The relationship between total Hg concentration in clips from the caudal fin and muscle tissue of largemouth bass (*Micropterus salmoides*) was developed and evaluated to determine whether analysis of fin clips would allow a non-lethal and convenient method for predicting Hg concentrations in tissues. Clips of the caudal fin were taken from the inside section of the fin after it had been cleaned with a soap solution, scrubbed, and rinsed to remove mucus. The relationship of total Hg concentrations in fin clips and muscle tissue showed an r^2 of 0.82, which may be compared with an r^2 of 0.89 for Hg concentrations between scales and muscle tissue. Although the fin clip method of estimating Hg in tissues is more variable, the Hg concentration in fin clip samples [mean = 0.196 ug/g (dry)] was more than a factor of ten greater than in the scale samples [mean = 0.012 ug/g (dry)]. Therefore, the fin clip method may be more applicable than the scale method where Hg concentrations in largemouth bass tissues are low, or for other fish species that may have reduced Hg concentrations.

Mercury and Omega-3 Fatty Acids in Fish Sandwiches from Retail Restaurants

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Mercury (Hg) and omega-3 fatty acids in fish sandwiches sold at six retail restaurants were measured. Total mercury ranged from 0.005 to 0.132 ppm and was well below the U.S. Food and Drug Administration (FDA) action limit of 1 ppm. The sandwiches provided between 8 and 146% of the RfD for Hg for a 60 kg individual. The omega-3 fatty acid content eicosapentaenoic acid (EPA) plus docosahexaenoic acid (DHA) ranged from 0.021 to 0.259 g per fish sandwich.

Mercury and Omega-3 Long-Chain Fatty Acids in Canned Fish

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Canned tuna (n=240), salmon (n=16), and mackerel (n=16) were analyzed for mercury and fatty acids. Mean mercury residues were 188, 45, and 55 ppb, respectively, and were well below the FDA action level of 1000 ppb. "Chunk Light Tuna in Water" contained lower mercury (= 50 ppb) when compared to all other tuna products; however, other tuna products were higher in EPA eicosapentaenoic acid (EPA) plus docosahexaenoic acid (DHA). Salmon and mackerel had lower mercury residues, but provided higher EPA plus DHA, than canned tuna. This information will help women of childbearing age to limit their intake of mercury while obtaining important long-chain omega-3 fatty acids from fish.

Mercury Analysis for Fish Consumption Advisories

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Sportfish tissue (n=189) collected during 1999–2000 were analyzed for total mercury by inductively coupled plasma/atomic emission spectrophotometry (ICP/AES) and thermal decomposition, amalgamation/atomic absorption spectrophotometry (TDA/AAS) to compare methods. Total mercury measurements using these techniques were not significantly different ($\alpha = 0.05$). TDA/AAS is a precise technique for the analysis of total mercury in fish tissue and is also less expensive, easy to use, and rapid (6 min/assay).

Mercury residue data for sportfish samples (n=211) collected from lakes across the United States were statistically analyzed to develop a predictive model for total mercury. Significant parameters were the feeding pattern of the fish (i.e., bottom feeder vs. predator) and the sampling location ($p<0.05$). Regression models were developed for bottom-feeders ($p<0.0001$, r-square = 0.45) and predators ($p<0.0001$, r-square = 0.73).

A Rapid Method to Improve the Indiana Fish Consumption Advisory

Lasrado, J.A., C.R. Santerre[1], J.R. Stahl, T. Noltemeyer, and D.C. Deardorff
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Polychlorinated biphenyls (PCBs) in fish tissue were analyzed using enzyme-linked immunosorbent assay (ELISA) and gas chromatography/electron capture detection (GC/ECD) methods. Fish samples were collected in 2000–2001 during an Indiana fish survey. For fish tissue from 0.05 to 5.0 ppm, ELISA was not significantly different from GC/ECD ($p<0.05$). This research has demonstrated the effectiveness of using ELISA for analyzing fish samples. With this rapid assay, state agencies will be able to expand their monitoring programs and improve fish consumption advisories.

Semipermeable Membrane Devices (SPMDs) to Predict Total PCB in Fish Tissue

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Triolein-filled semipermeable membrane devices (SPMD) were immersed at three locations along the St. Joseph River in northern Indiana for 30 days to see if the PCB content of fish from the same location could be predicted with this model device. Triolein from the SPMDs was analyzed for PCB using enzyme-linked immunosorbent assay (ELISA) and compared to residues detected in fish collected from the same locations. There was a significant difference ($p<0.05$) in total PCB concentrations between SPMD samples from the three locations; however, due to variability in PCB residues between species and low PCB residues in SPMDs, a direct correlation between PCBs in fish and SPMDs could not be determined.

Case Studies of Mercury Exposure in Wisconsin.

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Many popular varieties of commercially sold fish, including tilefish, seabass, shark, and swordfish, contain enough mercury that eating them more than once or twice a month can lead to high mercury body burdens. Wisconsin has issued sport-fish consumption advice to all people of all ages since 1985. Wisconsin's advisory was revised in 2000 to address all inland waters and again in 2004 to integrate information about sport-caught fish with advice for commercially sold fish. Because of the increased popularity of fish as a source of dietary protein, a significant percentage of the U.S. population may be at risk of methylmercury-induced health problems. Although several studies have assessed exposure of children and women of childbearing age to mercury, very little is known about mercury body burdens among men or post-menopausal women. This article describes fish consumption and mercury exposure among 14 people who consumed fish twice or more per week and one individual who ate no fish. Steady-state blood mercury levels available for ten adults and one child ranged from < 5 to 58 ug/L and correlated well with dietary mercury intake estimates. Three of these individuals reported vague, subclinical symptoms such as mental confusion, sleep difficulty, balance problems, or visual disturbances that improved after their mercury levels returned to normal.

A Snapshot: Conversations with New Hampshire Grocery Shoppers on Fish Consumption Guidelines

Nancy Serrell, Outreach Director, Toxic Metals Research Program, Dartmouth College
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Risk assessments that form the basis of fish consumption advisories are developed by scientists and other experts and then communicated to the public. The traditional "deficiency" model of risk communication represents this as a linear process: the transfer of rational knowledge to a passive, knowledge-deficient public. However, a pilot study involving direct examination of the way lay people make meaning of information about fish consumption information in one specific context—a grocery store—suggests that audiences for fish consumption advisories are active participants in communication. When presented with new information on this topic, people must fit the new knowledge into their past experience and knowledge. Their beliefs and information exchanged through social networks also affect their determination of whether the information is relevant or meaningful and whether the messenger is trustworthy. In addition, many people approach this kind of information with specific questions in mind. This study suggests that audiences do not receive fish advisory information as much as interact with it, translating, transforming, and in some cases resisting the information presented.

Advances in Hg Testing Technology: Liquid Chromatography and Solid Phase Extraction Strategies with Applications for Environmental, Medical/Dental, and Fishing Industries.

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Despite advances in Hg analytical chemistry through the 1980s and 1990s, quantification of both monomethyl (MeHg) and mercuric (Hg^{II}) mercury in environmental matrixes is still very labor intensive and thus costly. The future of environmental Hg science holds the potential for widespread environmental monitoring in the form of TMDL development and assessments of Cap-and-Trade recipient areas, for human biomonitoring of expectant mothers, subsistence fisherpeoples, and occupationally exposed workers, and for industrial monitoring of manufacturing and water-treatment waste, dental effluents, and fishery stocks. In order to facilitate large-scale testing programs, new technologies for rapid, automated analyses need to be developed and made available. Quicksilver Scientific, LLC., is developing such systems using novel solid-phase extraction chemistries and liquid chromatographic speciation systems. Our core analytical system, which comprises a novel ion-chromatographic separation of MeHg and Hg^{II} complexes coupled to online cold-vapor generation and atomic fluorescence detection, is highly sensitive (absolute detection of < 1pg) and repeatable (typically < 5% RSD). The system is designed for automated introduction of a variety of prepared samples, with robust preparation chemistries specific to different matrixes (e.g., biologic tissues and fluids, sediments, water). Quantitative sample introduction is possible through a unique online trap and elute system, which, coupled to the low system detection limit, allows use of small sample quantities (e.g., 50 µL of blood or a single insect). We are also developing on-site tests for fish in order to facilitate the rapid turn-around needed to make widespread Hg testing feasible for the fishing industry; this test will also be applicable to testing dental effluents. Rapid throughput capabilities (with consequent lower costs) and on-site analyses should advance scientific understanding of this especially dynamic element, improve dietary recommendations for fish and safety of our food supply, and facilitate better control of Hg emissions to our environment.

A Description of Ohio's Sport Fish Consumption Advisory Program

Mylynda Shaskus , Ohio Environmental Protection Agency, Columbus, OH;
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The Ohio Environmental Protection Agency and Ohio Environmental Council have been working together for the past 2 years to increase fish advisory awareness in Ohio by improving and expanding outreach efforts to Ohioans. The Ohio Environmental Council has received several grants to develop and oversee fish consumption advisory outreach in numerous contaminated areas, as well as statewide to Women, Infants, and Children (WIC) program participants. Outreach has included the development and distribution of easy-to-understand graphical pamphlets for WIC participants in multiple languages, focused outreach in highly contaminated areas in Ohio, and training for WIC clinicians on fish advisory outreach. In addition, through the Cuyahoga County Board of Health, a creel survey was conducted on the Cuyahoga River to determine the level of subsistence fishing and advisory awareness. Future outreach efforts include outreach to Amish and Mennonite populations, and Chinese translations of outreach materials.

California's Delta Watershed Fish Project

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It has been estimated that 6% of U.S. women of childbearing age may be exposed to mercury at levels of health concern. This exposure is due primarily to consumption of fish. National advisories recommend that women of childbearing age limit consumption of all fish, regardless of source, because of mercury contamination. In California, elevated levels of mercury in fish have been found throughout the Sacramento-San Joaquin Delta watershed due to historic mercury and gold mining activities. The Delta is also an area with abundant fishing and an ethnically diverse population. To address this problem, the California Department of Health Services (DHS) coordinates the Delta Watershed Fish Project, an interorganizational effort to reduce exposure to mercury through research, outreach, education, and training. Recent project activities include

- Survey of low-income women. DHS interviewed 500 women at a Women, Infants, and Children (WIC) clinic in the Delta about their fish consumption practices. Interviewers spoke six languages in order to include the ethnically diverse population served by the clinic. Nearly all women (95%) ate commercial fish and 30% ate sport fish. One in eight Asians exceeded sport fish advisories limits. Pregnancy status, ethnicity, age, and advisory awareness were all significant predictors of fish consumption.
- Stakeholder advisory group. DHS convened a stakeholder advisory group, comprised of community leaders, environmental organizations, and local agencies, to guide the project's outreach and education activities. The advisory group helps DHS to develop, translate, test, and distribute written materials (cards, brochures, posters, and warning signs) in multiple languages.
- Mini-grants. DHS awarded four $10,000 mini-grants to groups serving Cambodian, Latino, Russian, and African American communities to develop outreach and education activities. Mini-grant recipients have trained high school students as community educators, held community workshops, distributed materials at community events, and used ethnic media to disseminate messages about fish contamination.
- Training programs. DHS has developed a five-module training curriculum on fish contamination to assist public health agencies, health care providers, community groups, and others in educating the public about fish contamination issues in the Delta watershed. DHS offers "training for trainers" to help groups incorporate the curriculum into existing programs.

Recent Risk Communication Efforts in Maryland

Anna Soehl and Joseph Beaman, Maryland Department of the Environment.

The purpose of this poster is to provide an overview of the Maryland Department of the Environment's (MDE's) outreach efforts throughout Maryland on issues relating to the States' fish consumption advisory program. The poster will summarize method development and provide examples of utilized tools.

According to a summer 2004 Virginia Tech study, the vast majority of local Baltimore Harbor area recreational fishermen are highly aware of existing fish consumption guidelines. This is partly due to MDE's boost in fish consumption advisory outreach initiated in early May 2004. By posting signs at public fishing sites, providing guidelines on MDE's Web site, and distributing fish consumption brochures with specific health information, MDE contributed to this significant increase in public awareness.

However, in spite of the increase in public awareness, a large portion of the population interviewed during the Virginia Tech study did not follow the guidelines and consumed white perch and catfish more frequently than recommended. Also, a large percentage of those who eat crabs caught in Baltimore Harbor consume crab mustard, which goes against Baltimore Harbor recommendations. Thus, it is important for MDE to continue its outreach efforts.

In 2005, MDE and the Maryland Women, Infants & Children (WIC) program at the Department of Health and Mental Hygiene developed and published a simplified informational brochure entitled: "Fish Facts for Pregnant Women, Women Who May Become Pregnant, Nursing Mothers, and Children Age 6 and Younger." The new brochure contains national recommendations (U.S. EPA/FDA) relating to commercially caught fish and local information for recreationally caught fish from Maryland waters. The brochure is published in English and Spanish and is distributed to the general public, fishermen at Baltimore Harbor fishing locations, county environmental health departments, and new or expectant mothers visiting WIC clinics and other health outlets throughout Maryland.

For more information about Maryland's fish consumption advisory visit MDE's Fish Advisory Web site www.mde.state.md.us/fishadvisory/ or call MDE at 410-537-3906. The Virginia Tech Conservation Management Institute study can be obtained at http://www.cmiweb.org/human/publications/CBP_Fish_Advisory_2004/BaltimoreInterviewResults.pdf.

EPA's National Study of Chemical Residues in Lake Fish Tissue

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The Office of Water is conducting the largest national freshwater fish contamination survey undertaken by EPA. The National Lake Fish Tissue Study includes the largest set of chemicals studied in fish and is the first national fish contamination survey to have sampling sites statistically selected. Agencies in 47 states and three tribes, along with two other federal agencies, collaborated with EPA for 4 years to collect fish from 500 lakes and reservoirs in the lower 48 states. Sampling teams applied consistent methods nationwide to collect samples of predator and bottom-dwelling species from each lake. EPA is analyzing the fish tissue for 268 chemicals, including mercury, arsenic, PCBs, dioxins/furans, and pesticides. Preliminary results for the 4-year dataset show that mercury was detected in predator species at all 486 sites where predator samples were collected, while PCBs and dioxins/furans were detected in predator samples at more than 99% and 80% of these sites, respectively. When completed in 2006, this study will provide the first national estimates of mean concentrations of the 268 target chemicals in fish. It will also provide a national baseline for assessing progress of pollution control activities that limit release of these chemicals into the environment.

Mercury in Commercial Fish: Availability, Suitability, and Risk

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Most attention to the risks from fish consumption has focused on recreational anglers and self-caught fish, although most people eat fish that are purchased from stores. Fish were equally available in both upscale and downscale markets throughout New Jersey. In most cases, labels gave only a fish name and price, but not where the fish came from. Consumers would be able to make more informed choices if the provenance of fish were clearly stated. State agencies might improve information available to consumers by providing distributors and markets with guidelines about the types of information necessary for consumers to make informed decisions about the fish they eat. We then examined mercury levels in three types of fish (tuna, flounder, bluefish) commonly available in New Jersey stores, sampling different regions of the state—in communities with high and low per capita incomes, and from both supermarkets and specialty fish markets. We were interested in species-specific levels of mercury in New Jersey fish. Such information is critical for generating public health advice. There was only one regional difference; flounder from fish markets along the Jersey shore had higher mercury levels than flounder bought in other markets. We also examined mercury levels in six other commonly available fish and two shellfish from central New Jersey markets. There were significant differences in availability and in mercury levels among fish and shellfish. Both shrimp and scallops had total mercury levels below 0.02 ppm (wet weight). Large shrimp had significantly lower concentrations of mercury than small shrimp. For tuna, sea bass, croaker, whiting, scallops and shrimp, the levels of mercury were higher in New Jersey samples than those reported by the U.S. Food and Drug Administration. Consumers optimizing for easy availability (present in over 50% of markets) would select flounder, snapper, bluefish and tuna (tuna had the highest mercury value), and those selecting only for price would select whiting, porgy, croaker and bluefish (all with average mercury levels below 0.3 ppm wet weight). Flounder was the fish with the best relationship between availability, cost, and low mercury levels. From previous work, salmon provided the best tradeoff between low mercury and high omega-3 fatty acids (but high PCBs levels have been reported in farmed salmon). We suggest that state agencies responsible for protecting the health of their citizens should obtain information on fish availability in markets and fish preferences of diverse groups of citizens, and use this information to select fish for analysis of contaminant levels, providing data on the most commonly eaten fish that will aid their citizens in making informed decisions about risks from fish consumption.

Montrose Settlements Restoration Program: Providing Public Information to Restore Lost Fishing Services

David Witting and Milena VIljoen, Montrose Settlements Restoration Program, Long Beach, CA.

From the late 1940s to the early 1970s, millions of pounds of DDTs and PCBs were discharged from the Montrose Chemical Corporation and other industrial sources through a wastewater outfall into the ocean at White Point, near Los Angeles, California. After final settlement of litigation in 2000, a group of federal and California state natural resource agencies formed the Montrose Settlements Restoration Program (MSRP) and began preparing a Restoration Plan to address natural resource injuries resulting from these discharges.

For several decades, high levels of DDTs and PCBs have been found in several species of fish commonly caught by anglers along the Southern California coast. White croaker, surfperches, kelp bass, and other species of fish collected from several sites along the Los Angeles County and Orange County coasts carry concentrations of DDTs and PCBs in edible tissues that exceed the guidelines and standards set by federal and state agencies for safe consumption. This situation represents a loss of natural resource value to the public and constitutes a per se injury under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

The MSRP Restoration Plan includes projects to address these lost fishing services. The poster will describe MSRP's current work with EPA human health risk reduction efforts (which focus on which fish and areas should be avoided), and how MSRP will compliment that work with additional communication to further empower anglers with information that allows them to make sound decisions about where and for which species to fish. MSRP proposes to expand contamination information to encompass mercury. In addition, MSRP will provide outreach materials that establish the link between the ecology and life history of a particular species and its tendency to bioaccumulate contaminants. This effort aims not to simply reduce public exposures to contamination, but to enable and encourage people to continue to fish and to make knowledgeable choices about where, when, and for which species to fish.

Use of ReVA's Web-based Environmental Decision Toolkit (EDT) to Assess Vulnerability to Mercury Across the United States

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The problem of assessing risk from mercury across the nation is extremely complex involving integration of (1) our understanding of the methylation process in ecosystems, (2) the identification and spatial distribution of sensitive populations, and (3) the spatial pattern of mercury deposition. Unfortunately, both our understanding of the processes involved and the availability of data to make this assessment are currently imperfect, yet there are effective ways to make use of data and information that currently exist.

ORD's Regional Vulnerability Assessment (ReVA) Program was designed to develop and demonstrate methods to use existing data and models to inform environmental decision making regarding broad-scale comparative and cumulative risks. Focusing on the integration of available spatial data and model results, ReVA has developed a Web-based Environmental Decision Toolkit (EDT) that is the perfect vehicle for evaluating alternative ways of assessing the risks associated with mercury deposition from energy generating units and subsequent methylation into the more toxic methylmercury (MeHg) that accumulates in fish tissue. Given that there is no obvious "right" way to assess the risk from MeHg, a toolkit with the flexibility to consider and compare alternative data, model inputs, and assumptions and alternative ways to combine these inputs into indices of relative risk will allow a broader understanding of where the greatest uncertainties lie and where there is agreement among data and methods.

The EDT is a statistical toolkit that displays information spatially. The advantage of using a statistical package over a GIS is that it allows rapid reanalysis of data such that different combinations of variables can be displayed and compared quickly. This makes it ideal for problems that have a great deal of uncertainty or where a number of "what if" scenarios might be explored. Within the Hg-EDT,

- the raw data can be viewed and explored;
- choices can be made as to which data or model results are used in determining overall risk when multiple options exist;
- different weights for influential parameters can be set for estimating a methylation potential index;
- comparisons can be made between estimated values and monitored data; and
- distributions of sensitive populations, estimated indices of methylation potential, and estimated mercury deposition can be integrated into relative rankings of risk from mercury generated from energy generating units.

Pilot Survey of Fish Consumption Rates, Mercury Levels and Advisory Effectiveness in Coastal Alabama

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A survey was conducted by Oceana at the 2005 Alabama Deep Sea Fishing Rodeo to estimate a fish consumption rate among Gulf residents, as well as assess the effectiveness of state and federal advisories concerning mercury-contaminated seafood. Respondents were surveyed about fish consumption rates of fish landed at the Rodeo and seafood consumption in general. Mercury concentrations were also determined on 30 species of fish landed at the Rodeo and compared to fish preferences and consumption rates. Based on the responses of 63 Rodeo anglers and attendees, results demonstrate local seafood preferences, consumption patterns and rates, and variable knowledge of and adherence to fish consumption advisories. Preliminary data on fish preferences and their mercury levels indicate which species are in need of more monitoring and may require advisories. As this is a pilot survey, suggested modifications to the survey instrument are addressed as well.