United States
Environmental Protection
Agency

Office of Water
Washington, DC 20460

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September 2014

Proceedings of the 2014 National Forum on Contaminants in Fish



Alexandria, Virginia – September 21-24, 2014

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ACKNOWLEDGMENTS

The U.S. Environmental Protection Agency would like to thank the steering committee for their support in developing the 2014 National Forum on Contaminants in Fish. The steering committee included the following individuals:

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INTRODUCTION

From September 22-24, 2014, representatives of states, U.S. territories, tribes, federal agencies, and other interested organizations and individuals attended the 2014 National Forum on Contaminants in Fish in Alexandria, Virginia. The U.S. Environmental Protection Agency (EPA) sponsored the Forum.

The 2014 Forum was the twelfth National Fish Forum. The first Forum was convened in 1990, and regular Forums have been held every few years. The location of the Forum has rotated around the country and has included Alexandria, Virginia (1994, 1995, 1997, 1999); Chicago, Illinois (2001); Burlington, Vermont (2002); San Diego, California (2004); Baltimore, Maryland (2005); Portland, Maine (2007); Portland, Oregon (2009); and Alexandria, Virginia (2014).

Early Forums were attended by representatives from states and tribes, but as public interest in fish consumption 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 other agencies, including the U.S. Food and Drug Administration (FDA), the U.S. Geological Survey (USGS), as well as representatives from other countries, routinely participate in the Forum.

The agenda for each Forum is developed by a steering committee, generally composed of representatives of state, tribal, and federal agencies. The agenda was developed to provide a variety of perspectives and approaches to assessing and communicating public health risks associated with consumption of contaminated fish. The Forums present the latest science and public health policies.

Topics for the 2014 National Forum on Contaminants in Fish included:

- Fish Sampling and Analysis
- Federal, State, and Tribal Advisory Coordination
- Emerging Issue – Harmful Algal Blooms and Fish Consumption
- Risk Assessment, Epidemiology, and Toxicology
- Health Benefits and Risk Management
- Communications to the Public

In addition to the technical presentation sessions, a poster session was held to further the exchange of ideas and share state and tribal outreach materials related to fish advisories. States and tribes were also invited to bring samples of their outreach/communication materials for display and distribution at the Forum.

This document contains the proceedings of the Forum, including the agenda, abstracts of presentations, and slides used by the presenters.

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SECTION I AGENDA

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SECTION I AGENDA

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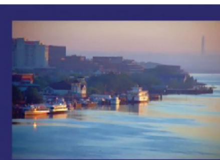
2014 National Forum on Contaminants in Fish



EPA

Alexandria, Virginia / September 22-24, 2014

Agenda

Sunday, September 21

5:00pm - 8:00pm **Early Registration**

Monday, September 22

7:00am - 5:30pm **Registration**

7:30am - 8:00am **Visit Poster and Outreach Display**

8:00am - 8:40am **Welcome and Introductions**
Elizabeth Southerland, Director
Office of Science and Technology
U.S. Environmental Protection Agency

SESSION 1:
Fish Sampling and Analysis

Moderator: Rick Greene, Delaware Department of Natural Resources and Environmental Control

8:40am - 8:45am **Introduction**
Rick Greene

8:45am - 9:05am **Mercury and Legacy Organic Compounds in Fish from U.S. Rivers – A National Perspective**
John Wathen, U.S. Environmental Protection Agency

9:05am - 9:25am **Perfluorinated Compounds in Fish from U.S. Urban Rivers and the Great Lakes**
Leanne Stahl, U.S. Environmental Protection Agency

9:25am - 9:45am **Identifying Emerging Contaminants for Monitoring in State Fish Programs**
Beth Murphy, U.S. Environmental Protection Agency

9:45am - 10:05am **Safety Testing of Gulf of Mexico Reef Fish after the BP Oil Spill**
Tim Fitzgerald, Environmental Defense Fund

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2014 National Forum on Contaminants in Fish

Agenda

Monday, September 22 CONTINUED

10:05am - 10:20am **Question and Answer Session**

10:20am - 10:35am **Break**

SESSION 2:
Federal, State, and Tribal Advisory Coordination

Moderator: Rick Greene, Delaware Department of Natural Resources and Environmental Control

10:35am - 10:40am **Introduction**
Rick Greene

10:40am - 11:10am **State-Tribal Partnership for Developing Advisories for Cook Inlet**
Bob Gerlach, Alaska
Michael Opheim and Tracie Merrill, Seldovia Village Tribe

11:10am - 11:40am **State-Tribal Partnership for Developing Advisories for the Upper Columbia River/Lake Roosevelt**
Liz Carr, Washington
Cindy Marchand, Confederated Tribes of the Colville Reservation

11:40am - 12:10pm **State-Tribal Partnership for Updating the Advisory for Clear Lake**
Margy Gassel, California
Sarah Ryan, Big Valley Rancheria Band of Pomo Indians

12:10pm - 1:40pm **Lunch (on your own)**

1:40pm - 2:10pm **State-Tribal Partnership for Developing Advisories for the St. Lawrence River Watershed**
Faith Schottenfeld, New York
Tony David, Saint Regis Mohawk Tribe

2:10pm - 2:30pm **Communication of Fish Advisories between States and Federal Lands: Results from a Survey of 21 Western National Parks**
David Wong, U.S. Department of the Interior, National Park Service

2:30pm - 2:50pm **How EPA Utilizes Fish Advisories as Institutional Controls at Superfund Sites**
Steve Ridenour, U.S. Environmental Protection Agency

EPA 2014 National Forum on Contaminants in Fish

Agenda

Monday, September 22 *CONTINUED*

2:50pm - 3:05pm Question and Answer Session

3:05pm - 3:20pm Break

SESSION 3:
Emerging Issue - Harmful Algal Blooms and Fish Consumption
Moderator: Amy D. Kyle, University of California – Berkeley, School of Public Health

3:20pm - 3:40pm Introduction and Overview: Significance of Cyanotoxins for Human Health
Amy D. Kyle

3:40pm - 4:05pm Analytical Methods and Seasonal Variations of Selected Cyanotoxins in Lake, Fish, and Plant Tissue in Nebraska
Dan Snow, University of Nebraska – Lincoln

4:05pm - 4:30pm Considerations for Fish Advisory Programs for Cyanotoxins in Fish
Tom Hornshaw, Illinois Environmental Protection Agency

4:30pm - 4:55pm Cyanotoxin Toxicity: Fish and Human Health Assessment
Lesley V. D'Anglada, U.S. Environmental Protection Agency

4:55pm - 5:10pm Question and Answer Session

5:10pm - 5:30pm Break

5:30pm - 6:00pm Visit Poster and Outreach Display

Tuesday, September 23

7:30am - 5:30pm Registration

7:30am - 8:00am Visit Poster and Outreach Display

SESSION 4:
Risk Assessment, Epidemiology, and Toxicology
Moderator: Alan Stern , New Jersey Department of Environmental Protection

8:00am - 8:05am Introduction
Alan Stern

8:05am - 8:25am PFOA – PFOS Health Effects: Draft Office of Water Health Assessments
Joyce Donohue, U.S. Environmental Protection Agency

2014 National Forum on Contaminants in Fish

Agenda

Tuesday, September 23 *CONTINUED*

8:25am - 8:45am **EPA's Dioxin Reassessment and Toxicity-Equivalence Factors for Dioxin-Like Compounds**
Jeff Swartout, U.S. Environmental Protection Agency

8:45am - 9:05am **EPA's Reassessment of the RfD for PCBs: Key Issues to Be Addressed**
Geniece Lehmann, U.S. Environmental Protection Agency

9:05am - 9:25am **Co-occurrence of PCBs and Mercury in Fish Tissue: Is There a Case for Additivity Based on Common Developmental Endpoints?**
Vince Cogliano, U.S. Environmental Protection Agency

9:25am - 9:45am **National Time Trends in Environmental Exposures and Fish Consumption in U.S. Women of Reproductive Age (NHANES 1999-2012)**
Rebecca Birch, Westat

9:45am - 10:00am **Question and Answer Session**

10:00am - 10:15am **Break**

10:15am - 10:35am **Implications of Recent Epidemiological Evidence on Effects of Methylmercury for Fish Consumption Advice**
Ned Groth, Gelfond Fund

10:35am - 10:55am **Neurodevelopment Effects of Methylmercury**
Glenn Rice, U.S. Environmental Protection Agency

10:55am - 11:15am **Epidemiological Evidence of Fish Consumption, Methylmercury Exposure, and Risk of Cardiovascular Diseases in Adults**
Jyrki Virtanen, University of Eastern Finland

11:15am - 11:35am **Status of IRIS Update for Organic and Inorganic Mercury**
Vince Cogliano, U.S. Environmental Protection Agency

11:35am - 11:50am **Question and Answer Session**

11:50am - 1:00pm **Lunch (on your own)**

2014 National Forum on Contaminants in Fish

Agenda

Tuesday, September 23 CONTINUED

SESSION 5:
Health Benefits and Risk Management

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

1:00pm - 1:05pm	**Introduction** *Robert Brodberg*
1:05pm - 1:25pm	**Fatty Acid Content in Fish Species from the Great Lakes and Nearby Watersheds** *Meghan Williams, Wisconsin Department of Natural Resources*
1:25pm - 1:45pm	**Great Lakes Basin Fish Consumption, Vitamin D, Selenium, Fatty Acids, Contaminant Distributions and Associations in 154 Wisconsin Anglers** *Henry Anderson, Wisconsin Division of Public Health*
1:45pm - 2:05pm	**Mercury–Nutrient Signatures in Seafood and in Blood of Seafood Consumers** *Roxanne Karimi, Stony Brook University*
2:25pm - 2:45pm	**Mercury, Selenium, and Selenium:Mercury Ratios in Fish and Risk Management** *Joanna Burger, Rutgers University, and Michael Gochfeld*
2:45pm - 3:00pm	**Question and Answer Session**
3:00pm - 3:15pm	**Break**
3:15pm - 3:35pm	**Risks and Benefits of Fish Consumption for Cardiovascular Diseases** *Dariush Mozaffarian, Harvard Medical School, Tufts University*
3:35pm - 3:55pm	**Maternal Fish Intake during Pregnancy and Child Cognition** *Emily Oken, Harvard Medical School*
3:55pm - 4:15pm	**FDA Assessment of Net Effects on Neurodevelopment from Eating Commercial Fish During Pregnancy** *Phil Spiller, U.S. Food and Drug Administration*

2014 National Forum on Contaminants in Fish

Agenda

Tuesday, September 23 CONTINUED

4:15pm - 4:35pm **Risk-Benefit of Consuming Lake Erie Fish**
Satyendra Bhavsar, Ontario Ministry of the Environment and Climate Change

4:35pm - 5:05pm **Updated Approach for Balancing the Risks and Benefits of Fish Consumption on Neurodevelopmental Endpoints**
Gary Ginsberg, Connecticut Department of Public Health

5:05pm - 5:30pm **Question and Answer Session**

Wednesday, September 24

7:30am - 1:00pm **Registration**

8:00am - 9:00am **Visit Poster and Outreach Display**

SESSION 6:
Communications to the Public
Moderator: Barbara Knuth, Cornell University, Department of Natural Resources

9:00am - 9:05am **Introduction**
Barbara Knuth

9:05am - 9:25am **Dissemination of Information about FDA's Seafood-Associated Rhabdomyolysis, Puffer Fish Poisoning and Ciguatera Fish Poisoning Research Project**
Karen Swajian, U.S. Food and Drug Administration

9:25am - 9:45am **Consumer Understanding of the Benefits and Risks of Fish Consumption During Pregnancy**
Amy Lando, U.S. Food and Drug Administration

9:45am - 10:05am **Improving Communication of Fish Advisories: Providing Benefits and Risk Information to Increase Consumer Knowledge**
Mario Teisl, University of Maine

10:05am - 10:25am **Communicating Fish Advisory Information to Women of Childbearing Age**
Nancy Connelly, Cornell University

10:25am - 10:45am **Urban Anglers' Fish Consumption and Response to Advisory Messages**
Bruce Lauber, Cornell University

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Agenda

Wednesday, September 23 CONTINUED

10:45am - 11:00am **Question and Answer Session**

11:00am - 11:15am **Break**

11:15am - 11:35am **Fish Advisory Outreach to Urban and Rural Alaska Stakeholders**
Ali Hamade, Alaska Section of Epidemiology

11:35am - 11:55am **Engaging Healthcare in Environmental Exposure Risk Reduction**
Michael Hatcher, U.S. Agency for Toxic Substances and Disease Registry

11:55am - 12:15pm **Fish Consumption for Clinicians: Increasing Knowledge of the Risks and Benefits of Fish and Evaluating Clinical Screening for Mercury**
Susan Buchanan, University of Illinois - Chicago

12:15pm - 12:45pm **Communicating Information to Reduce Mercury Exposures in Women of Childbearing Age**
Pat McCann, Minnesota Department of Health

12:45pm - 1:00pm **Question and Answer Session**

1:00pm - Adjourn **Wrap-up: General Forum Moderator**
Jeff Bigler
Office of Science and Technology
U.S. Environmental Protection Agency

SECTION II BIOSKETCHES, ABSTRACTS, PRESENTATIONS, AND QUESTIONS AND ANSWERS

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SECTION II BIOSKETCHS, ABSTRACTS, PRESENTATIONS, AND QUESTIONS AND ANSWERS

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SECTION II-A WELCOME

Welcoming Remarks

Elizabeth Southerland, U.S. Environmental Protection Agency

Biosketch

Dr. Elizabeth Southerland has a Ph.D. in Environmental Sciences and Engineering from Virginia Tech University. She is currently the Director of the Office of Science and Technology in the U.S. Environmental Protection Agency (EPA) Office of Water. She is responsible for promulgating best available treatment technology permit limits for industries, developing aquatic life and human health water quality criteria under the Clean Water Act, deriving maximum contaminant level goals and health advisories under the Safe Drinking Water Act, approving or disapproving state water quality standards, and overseeing EPA's national fish advisory and beach contamination programs. Dr. Southerland has also worked in EPA's Superfund Program, the State of Virginia's Water Quality Program, and private consulting.

Welcome Address

Good morning, everyone. I am so happy to be here representing the U.S. Environmental Protection Agency (EPA) and to welcome you to the 12th National Forum on Contaminants in Fish. EPA's Fish Forum brings together representatives and experts from the states, tribes, federal agencies, industry, environmental advocacy groups, community representatives, healthcare organizations, and academia. The goal of the Fish Forum is to present and discuss the latest science and public health policies pertaining to the health risks and benefits of fish consumption. The plenary sessions will include a variety of perspectives and approaches to assessing and communicating public health risks and benefits related to fish consumption. In addition to the sessions, we also have the posters and outreach materials located at the back of the room. This information is available for attendees throughout the Fish Forum.

The first Fish Forum was held in 1990 in Pittsburgh, Pennsylvania, which was co-sponsored with the American Fisheries Society. I was actually there as well as other "old-timers" who attended back in 1990, including Rick Greene from Delaware, our first moderator this morning; Brian Toal from Connecticut; Tom Hornshaw from Illinois; Henry Anderson from Wisconsin; and Jeff Bigler from EPA's Office of Water who has planned and chaired the Fish Forum since 1994. Did I miss anyone? Subsequent Fish Forums have been held every few years since then.

We have many great presentations ahead, but first I want to thank the 2014 Fish Forum Steering Committee. The committee included Robert Brodberg from the California Environmental Protection Agency, Office of Environmental Health Assessment; Razelle Hoffman-Contois from the Vermont Department of Health; Dave McBride from the Washington State Department of Health; Pat McCann from the Minnesota Department of Health; Sharee Rusnak from the Connecticut Department of Public Health; Jackie Fisher from EPA's Great Lakes National Program Office; and Jeff Bigler from EPA.

First, I'll provide an overview of EPA's fish advisory and fish contamination activities—past, present, and future. Some of our other Agency activities include reduction of bioaccumulative contaminants in fish and documentation of the nature and extent of fish contaminants. As you know, the Fish Advisory Program has been active at EPA for several decades now. In 1990, at the first Fish Forum, we developed a plan to help EPA identify technical assistance to aid states and tribes in developing and maintaining fish advisory programs. In 1993, EPA developed the first National Listing of Fish Advisories, a compilation of information on locally issued fish advisories and safe eating guidelines. In 1994, we issued the first in a series of comprehensive national technical guidance documents on developing and managing local fish advisories. We also updated the guidance in 1997 and again in 2000.

In 2001, EPA and the U.S. Food and Drug Administration (FDA) simultaneously issued fish consumption advice. FDA issued advice that addressed commercial fish and EPA issued advice that addressed locally caught fish. In 2004, EPA and FDA collaborated to jointly issue the public health advisory about mercury in fish and shellfish.

Our studies of fish contaminants have been underway almost as long. In 1998, EPA launched the National Study of Chemical Residues in Lake Fish Tissue. In 2006, EPA began the National Pilot Study of Pharmaceuticals and Personal Care Products in Fish Tissue. In 2008, EPA initiated the 2008-09 National Rivers and Streams Assessment Fish Tissue Study. In 2010, EPA conducted the Great Lakes Human Health Fish Tissue Study under EPA's National Coastal Condition Assessment Fish Tissue Study. In 2013, EPA began the 2013-14 National Rivers and Streams Assessment Fish Fillet Study.

Some of EPA's recent activities in the Fish Advisory Program include the draft joint EPA/FDA National Mercury Advisory, which everyone knows has been out for public comment since June 2014. It is not on the agenda this year because we are in the middle of the comment period. I would strongly encourage everyone to comment at regulations.gov. The date for closure of public comment will be published in a future notice in the Federal Register.

EPA's other activities related to the Fish Advisory Program include the National Listing of Fish Advisories, which we have done annually from 1994 to 2014. The listing was originally developed to assist with providing information to the public. As you know, the National Health and Nutrition Examination Survey (NHANES) analyzes fish consumption and blood or serum contaminant data to assess national trends. Last year, EPA released the NHANES report on blood-mercury and fish consumption for women of childbearing age using data from 1999 to 2010. While nationally the blood-mercury levels appeared to decrease significantly and then taper off, overall fish consumption did not appear to change (about two ounces per week). We are currently updating the analysis now to incorporate 2011 and 2012 mercury data. We will be tackling other chemicals next year.

In April 2014, we published a report on fish consumption rates in the United States. The report provided an update to our 2000 fish consumption rates analysis. We are also conducting multiple national and regional studies of fresh water fish contamination related to human health. We added human health fish tissue studies to the National Aquatic Resource Surveys. We have also conducted studies of contaminants of emerging concern (CECs), which developed data on CECs in fish related to human health. In 2009, we published CEC results on pharmaceuticals and personal care products. In 2013, we published CEC results on polybrominated diphenyl ether. In 2014, we published CEC results on perfluorinated compounds.

As we look ahead to the future, we are scheduled to begin implementing the new joint EPA/FDA National Mercury Advisory in 2015. We will be redesigning the National Listing of Fish Advisories beginning this year. After we redesign the National Listing of Fish Advisories, EPA will no longer need to provide the national summary of advisory information online because states and tribes will be maintaining their own advisory websites. This is a big accomplishment for all. Thanks to all the states and tribes that are issuing advisories. EPA believes that pointing people to the state and tribal websites will give the public more accurate and timely information. This will allow EPA to focus on collecting and compiling all the fish tissue data used for making advisory determinations by states and tribes and making that information available to the public all in one place.

EPA will also be focused on analyzing and publishing trends for PFCs, using methods similar to the blood-mercury approach from NHANES. EPA will also draft new national guidance for conducting fish consumption surveys and guidance for assessing the effectiveness of local fish advisories. EPA will release these draft guidance documents for review by all state and tribal advisory programs in 2015.

Elsewhere in the Agency, EPA conducts complementary activities that address fish contaminants, which can be sorted into two general categories: 1) reducing bioaccumulative contaminants in fish and 2) documenting the nature and extent of fish contamination. Some of EPA's activities to reduce bioaccumulative contaminants include reducing discharges to water; reducing emissions to air; reducing contaminant concentrations in soil and sediment; implementing the Great Lakes Binational Toxics Strategy; and addressing persistent, bioaccumulative, and toxic chemicals. Other activities include revisions to human health criteria; monitoring fish in the Great Lakes; and fish monitoring efforts for rivers, lakes, wetlands, and coasts. EPA also routinely evaluates bioaccumulation in fish during review of pesticide registrations.

As you can see, we have been quite busy across the Agency to make fish safer for consumption. EPA intends to continue doing what we can toward this goal. Thank you for coming, and we are looking forward to your participation in the Fish Forum.

Welcome Presentation – Elizabeth Southerland

United States Environmental Protection Agency

Welcome!
Opening Remarks by
Elizabeth Southerland,
U.S. Environmental Protection Agency

2014 National Forum on Contaminants in Fish
September 22-24 / Alexandria, Virginia

United States Environmental Protection Agency
2014 National Forum on Contaminants in Fish
September 21-24 / Alexandria, Virginia

EPA has sponsored 11 Forums before this one:

YEAR	LOCATION	CO-SPONSOR
1990	Pittsburgh, Pennsylvania	American Fisheries Society
1995	Alexandria, Virginia	American Fisheries Society
1997	Alexandria, Virginia	American Fisheries Society
1999	Alexandria, Virginia	American Fisheries Society
2001	Chicago, Illinois	Minnesota Department of Health
2002	Burlington, Vermont	New Hampshire Department of Health
2004	San Diego, California	California EPA and the Agency for Toxic Substances and Disease Registry
2005	Baltimore, Maryland	Maryland Department of Environment
2007	Portland, Maine	Maine Department of Health
2009	Portland, Oregon	Oregon Department of Health

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United States Environmental Protection Agency
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BIG THANKS GO TO:

Our Steering Committee

- Robert K. Brodberg, Cal/EPA, Office of Environmental Health Hazard Assessment
- Razelle Hoffman-Contois, Vermont Department of Health
- Dave McBride, Washington State Department of Health
- Pat McCann, Minnesota Department of Health
- Sharee Rusnak, Connecticut Department of Public Health
- Jackie Fisher, USEPA, Great Lakes National Program Office
- Jeffrey Bigler, USEPA, Office of Water

Our Contract Support

- EnDyna, Inc: Kurd Ali, Danielle Murray
- Amy D. Kyle, University of California, Berkeley School of Public Health
- RTI, International: Patricia Cunningham, Amy Wesley

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2014 National Forum on Contaminants in Fish
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Presentation Overview

- EPA's Fish Advisory and Fish Contamination Activities in OW:
  - Past,
  - Present, and
  - Future.
- Other Agency Activities:
  - To reduce bioaccumulative contaminants in fish, and
  - To document the nature and extent of fish contamination.

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EPA'S FISH ADVISORY AND FISH CONTAMINATION ACTIVITIES

History

- EPA's **Fish Advisory Program** active for several decades now!
  - In 1990, plan to assist states and tribes.
  - In 1993, first National Listing of Fish Advisories (NLFA).
  - In 1994, first comprehensive national technical guidance.
  - In 2001, EPA and FDA simultaneously issued fish consumption advice.
  - In 2004, EPA and FDA collaborated to jointly issue the advisory.

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United States Environmental Protection Agency
2014 National Forum on Contaminants in Fish
September 21-24 / Alexandria, Virginia

EPA'S FISH ADVISORY AND FISH CONTAMINATION ACTIVITIES

History

- Our **studies of fish contamination** have been underway almost as long:
  - In 1998, National Study of Chemical Residues in Lake Fish Tissue,
  - In 2006, National Pilot study of Pharmaceuticals and Personal Care Products,
  - In 2008, 2008-09 National Rivers and Streams Assessment Fish Tissue Study,
  - In 2010, Great Lakes Human health Fish Tissue Study, and
  - In 2013, 2013-14 National Rivers and Streams Assessment Fish Fillet Study.

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Welcome Presentation – Elizabeth Southerland

EPA United States Environmental Protection Agency
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EPA'S FISH ADVISORY AND FISH CONTAMINATION ACTIVITIES

Recent Activities in the Fish Advisory Program

Draft Joint EPA/FDA National Mercury Advisory

- Out for public comment since June 2014.
- Not on the agenda this year since the comment period is still open.
- The date for closure of public comment will be published in the Federal Register.

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EPA'S FISH ADVISORY AND FISH CONTAMINATION ACTIVITIES

Recent Activities in the Fish Advisory Program

National Listing of Fish Advisories

- Annually for 20 years: between 1994 and 2014.

NHANES Analyses

- To assess national trends of fish consumption and blood or serum contaminants.

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EPA'S FISH ADVISORY AND FISH CONTAMINATION ACTIVITIES

Recent Activities in the Fish Advisory Program

Fish Consumption Rate Analysis

- April 2014 report on fish consumption rates in the U.S.
- Updates EPA's 2000 analysis: two significant changes to the methodology.
- EPA used new rates to revise national ambient water quality criteria.

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EPA'S FISH ADVISORY AND FISH CONTAMINATION ACTIVITIES

Recent Activities in the Fish Contamination Program

Studies of Fish in Fresh Water

- Human health fish tissue studies for National Aquatic Resource Surveys (NARS)
  - National Rivers and Streams Assessment.
  - The Great Lakes portion of the National Coastal Condition Assessment.
  - More about NARS later in my remarks.

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EPA United States Environmental Protection Agency
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EPA'S FISH ADVISORY AND FISH CONTAMINATION ACTIVITIES

Recent Activities in the Fish Contamination Program

Studies of Contaminants of Emerging Concern (CECs)

- Develop data and publish results on CECs in fish related to human health.
  - 2009: pharmaceuticals and personal care products (PPCPs).
  - 2013: polybrominated diphenyl ether (PBDE).
  - 2014: perfluorinated compounds (PFCs).

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EPA United States Environmental Protection Agency
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EPA'S FISH ADVISORY AND FISH CONTAMINATION ACTIVITIES

Looking Ahead

Implementing the Updated Joint National Mercury Advisory
- Begin implementing the new revised Advisory in 2015.

Redesigning the National Listing of Fish Advisories
- EPA shifting focus to making available to the public:
  - the tissue data used by states and tribes to make their advisory determinations, and
  - EPA's fish tissue data from NARS.

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Welcome Presentation – Elizabeth Southerland

United States Environmental Protection Agency
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EPA'S FISH ADVISORY AND FISH CONTAMINATION ACTIVITIES

Looking Ahead

Analyzing Other Chemicals in 2015 Using NHANES

- Perfluorinated compounds (PFCs).
- Polybrominated diphenyl ethers (PBDEs).
- Polychlorinated biphenyls (PCBs).

Drafting New National Guidance in 2015

- Conducting Fish Consumption Surveys.
- Assessing Effectiveness of Local Fish Advisories.

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Activities Elsewhere in the Agency

Reducing Bioaccumulative contaminants in fish

- Reducing Discharges to Water and Air.
- Reducing Concentrations in Soils and Sediments.
- Other Strategies.

Documenting the nature and extent of fish contamination

- Updating Human Health Criteria.
- Fish Monitoring Programs.
- Evaluating Pollutants for Bioaccumulative Potential.

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United States Environmental Protection Agency
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EPA ACTIVITIES TO REDUCE BIOACCUMULATIVE CONTAMINANTS

Updates since the last fish forum

Reducing Discharges to Water

- Effluent Limitations Guideline for Steam Electric Industry.
- Ongoing review of industries.

Reducing Emissions to Air

- 2012 MACT rule to limit mercury and other toxics from power plants.
- 2013 MACT updated emission limits for new electric generating units.

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EPA ACTIVITIES TO REDUCE BIOACCUMULATIVE CONTAMINANTS

Updates since the last fish forum

Reducing Concentrations in Soils and Sediment

- Ongoing Superfund cleanups:
  - Specific guidance for cleaning up PCBs and dioxins.
  - Water quality standards used as target for clean-ups.

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EPA ACTIVITIES TO REDUCE BIOACCUMULATIVE CONTAMINANTS

Updates Since the Last Fish Forum

Implementing the 1997 Great Lakes Binational Toxics Strategy

- As of 2008, 13 of the 17 goals achieved.
- Currently addressing remaining 4 goals.

Addressing Persistent, Bioaccumulative and Toxic Chemicals through P2

- PBT Profiler Tool is a component of EPA's Pollution Prevention (P2) program.

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United States Environmental Protection Agency
2014 National Forum on Contaminants in Fish
September 21-24 / Alexandria, Virginia

EPA ACTIVITIES TO DOCUMENT FISH CONTAMINATION

Updates Since the Last Fish Forum

May 2014 Revisions to Human Health Criteria

- 94 chemical pollutants.
- Used our updated fish consumption rates.

Monitoring Fish in the Great Lakes

- National fish monitoring program (collaboration with HQ).
- Emerging Chemical Surveillance Program.

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Welcome Presentation – Elizabeth Southerland

EPA United States Environmental Protection Agency
2014 National Forum on Contaminants in Fish
September 21-24 / Alexandria, Virginia

EPA ACTIVITIES TO
DOCUMENT FISH CONTAMINATION
Updates Since the Last Fish Forum

Continuing Fish Monitoring Under National Aquatic Resource Surveys (NARS)

- Statistical surveys with state, tribal, and other federal agency partners:
  - Rivers,
  - Lakes,
  - Wetlands, and
  - Coasts.
- OST contributes human health data for Rivers and Great Lakes.

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EPA United States Environmental Protection Agency
2014 National Forum on Contaminants in Fish
September 21-24 / Alexandria, Virginia

EPA ACTIVITIES TO
DOCUMENT FISH CONTAMINATION
Updates Since the Last Fish Forum

Evaluating Pesticides for Bioaccumulative Potential

- Routinely evaluates bioaccumulation in fish during review of pesticide registrations:
  - Requires manufacturers to provide data on bioaccumulation.
  - Uses same basic approach as in OW's criteria guidance.

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EPA United States Environmental Protection Agency
2014 National Forum on Contaminants in Fish
September 21-24 / Alexandria, Virginia

In Closing

- EPA has been actively engaged in efforts to make fish safer for consumption.
- The Agency intends to continue to do what we can toward this goal.
- Thank your for coming to the Forum, we look forward to your participation!
- Any questions?

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EPA United States Environmental Protection Agency
2014 National Forum on Contaminants in Fish
September 21-24 / Alexandria, Virginia

Have a Great Forum!

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Questions and Answers

Q. Under the Legacy Act, EPA's Great Lakes National Program Office does remediation work in the Great Lakes states. Millions of dollars are spent annually, with most efforts focused on sediment remediation. Could some of the funding be used for purposes beyond sediment remediation? (Fisher)

A. She is aware of one pilot example within the Superfund program that is focused more on making sure that discharges do not reach sediments.

Q. As a physician, he sees patients who consume large quantities of fish. These patients are high-end vulnerable consumers (greater than 90%) who have elevated mercury levels. They are interested in these high-end vulnerable consumers who are not captured by the numbers in recent research. (Gochfeld)

A. The research for the 2014 NHANES report used a random statistical analysis and the numbers are for the average consumer. The study design for the national surveys currently does not include looking at subsistence fish consumption. In 2015, EPA expects to issue new draft guidance that will hopefully show state and local agencies how to conduct local or regional research studies on high-end consumers.

Q. How is EPA going to deal with tribal fish consumption? How should we address suppression of tribal fish consumption?(Burger)

A. The Spokane Tribe did a survey of high fish consumption rates, and found over 800 grams per day (compared to 20 grams/day for the average consumer). This is just a current snapshot of fishing in tribal waters. It is also important to consider heritage issues for tribes. The new draft guidance will address both heritage issues and suppression of fish consumption issues. In addition, some tribes are pushing for water quality standards.

Q. What funding will be coming for biomonitoring surveys of fish? (Anderson)

A. EPA is not currently planning new initiatives for biomonitoring of fish. The mobilization cost for collection of fish is the major part of the total costs for such surveys. EPA's Office of Science and Technology (OST) is piggybacking monitoring efforts onto other studies to reduce mobilization costs. Through this approach, OST can use smaller levels of funding to get additional analyzes done through national surveys and Great Lakes surveys.

Comment: Most of EPA's current funding is going to clean up contaminated sediments and only a relatively small amount to biomonitoring or sampling surveys. (Anderson)

Q. Are there any recent efforts to coordinate internationally on fish advisories? (Anderson)

A. She is not aware of any EPA effort underway to coordinate internationally. We know that polychlorinated biphenyls (PCBs) and mercury are global concerns.

Comment: He is not aware of any recent EPA effort to coordinate internationally either. We have to go back and look at the international perspective. (Bigler)

Q. Where can you find information on Superfund remediation efforts? How do you assess cleanup of contaminated sediments? (Marcella Thompson)

A. Look at EPA's website for information on each Superfund site. The cleanup approach is usually dredging sediments and covering with a cap of clean sediment. However, the water column may still have a higher PCB number than the water quality standard. It may not be technically feasible to meet water quality criteria because of PCB diffusion through sediment into the water. Generally, EPA says the cleanup benefit is that the number of fish meals can be increased versus the previous ban on fish consumption. If you can get one fish meal per month to show that fish consumption is again possible, you have a benefit from the cleanup.

SECTION II-B SESSION 1: FISH SAMPLING AND ANALYSIS

Introduction

Moderator:
Rick Greene, Delaware Department of Natural Resources and Environmental Control

Biosketch
Dr. Rick Greene works for the Delaware Department of Natural Resources and Environmental Control. He has managed Delaware's fish contaminant monitoring and advisory program since its inception in 1993 and has been involved in all advisories issued by Delaware. He holds a Ph.D. in Environmental Engineering from the University of Delaware where his research focused on congener-specific partitioning and trophic transfer of PCBs. Dr. Greene's recent work includes the first full-scale remediation project in North America to use direct placement of activated carbon in sediments to sequester PCBs and reduce bioaccumulation.

Presentations
Mercury and Legacy Organic Compounds in Fish from U.S. Rivers – A National Perspective
John Wathen, U.S. Environmental Protection Agency

Perfluorinated Compounds in Fish from U.S. Urban Rivers and the Great Lakes
Leanne Stahl, U.S. Environmental Protection Agency

Identifying Emerging Contaminants for Monitoring in State Fish Programs
Beth Murphy, U.S. Environmental Protection Agency

Safety Testing of Gulf of Mexico Reef Fish after the BP Oil Spill
Tim Fitzgerald, Environmental Defense Fund

Mercury and Legacy Organic Compounds in Fish from U.S. Rivers – A National Perspective

John Wathen, U.S. Environmental Protection Agency

Biosketch

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

Abstract

Mercury and persistent halogenated organic compounds occur in fish tissue in U.S. lakes, rivers, and streams. Mercury, polychlorinated biphenyls (PCBs), and DDT occurring in fish tissue are the leading cause of fish consumption advisories. EPA's Office of Water and Office of Research and Development collaborated to conduct a statistically based survey of persistent and bioaccumulative contaminants in fish from U.S. rivers. This national fish survey was conducted June through October in 2008 and 2009 within EPA's National Rivers and Streams Assessment (NRSA), a probability-based survey designed to assess the condition of the nation's streams and rivers. NRSA field teams applied consistent methods nationwide to collect single 5-fish composite samples consisting of adults of comparable length of the same fish species at 541 randomly selected river locations (≥ 5th order) in the lower 48 states. Largemouth and smallmouth bass were the primary species collected for the study, accounting for 34% and 24% of all fish composites, respectively. Homogenate samples were analyzed for mercury by AA and a suite of approximately 50 organo-halogen compounds including PCBs (21 congeners), polybrominated diphenyl ethers (PBDEs) (8 congeners), chlordane, and DDT compounds and degradation products, and other pesticides (aldrin, dieldrin, mirex, and endosulfan) by GC-ECD. Samples were collected from both non-urban (379 sites) and urban locations (162 sites). All samples contained mercury above the quantitation level, and study data indicate that PCBs, PBDEs, chlordane, and DDT compounds occur at quantifiable levels in almost every fish sample collected for the study. Both human health and aquatic life thresholds are applied to fish tissue concentrations of mercury and these four organo-halogen contaminant groups from both urban and non-urban sites and within three eco-regions. In addition, we are examining the percentages of co-occurrence of four organic compound groups at concentrations above the respective contaminant group medians.

Mercury and Legacy Organic Compounds in Fish from U.S. Rivers – A National Perspective

2014 National Forum on Contaminants in Fish
September 22, 2014
Alexandria, Virginia

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Disclaimer
The views expressed in this presentation are those of the authors and do not necessarily reflect the views or policies of the U.S. EPA or those of the U.S. Government

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National Rivers and Streams Assessment

- 1,924 sites on rivers within the conterminous U.S.
- Fish tissue indicator collected at 542 sites on rivers =>5th order
- Represent 51,663 river miles
- Mercury data- (n=541/542) sites: 162 Urban
  379 Non-urban
- Legacy organic cont. data- (*n*=540/542) sites:
  163 Urban
  377 Non-urban

3

Data are Nationally Representative

- 50 analytes x 540 sites = 27,000 data points
- Randomized site selection process yields data and weighted means that are representative :
  - Nationally
  - By Ecoregion (3)
  - Between Urban and Non-urban sub-populations
  - For predominant species .
- Mercury fillet tissue results converted to whole fish values for wildlife impact estimation.
- Some unweighted site data depictions and analyses are not nationally representative.

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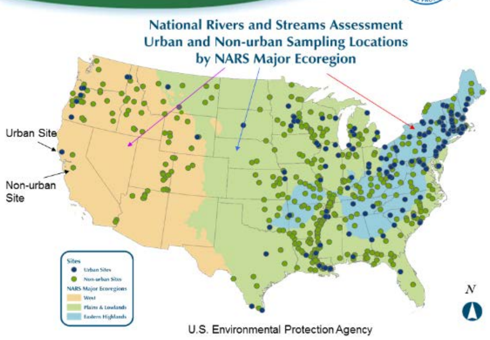
NRSA Sampling Locations *n* = 542



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Sample Collection

- Sampling conducted 2008-2009.
- Single composite sample was collected from each site:
  - Five adult fish
  - Same species (ubiquitous, abundant, easily identified, consumed by humans, large)
  - Similar size (min>75% max).
- Fillets were composited using the batch method.

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SESSION 1: FISH SAMPLING AND ANALYSIS
Mercury and Legacy Organic Compounds in Fish from U.S. Rivers – A National Perspective – John Wathen

NRSA Analyses

541 sites: Mercury

Direct Mercury Analyzer EPA method 7473

(Journal article submitted for publication)

Organic Analytes for 540 Sites

21 PCB Congeners PCB 8-209

8 PBDE Congeners: BDE 47, 66, 99,100, 138, 153, 154, 183

Method: **GC-ECD**

(Journal article in preparation)

20 Organochlorine pesticides

Aldrin	4,4'-DDT
alpha-BHC	Dieldrin
gamma-BHC	Endosulfan II
alpha-Chlordane	Endrin
gamma-Chlordane	Heptachlor
2,4'-DDD	Heptachlor epoxide
4,4'-DDD	Hexachlorobenzene
4,4'-DDE	Mirex
2,4'-DDT	cis-Nonachlor
	trans-Nonachlor
	Oxychlordane

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Analytes not included

Additional Fish Tissue Analytes not reported here:

541 Sites-

Selenium: ICP-OES

Moisture: Karl Fisher titration

Lipids: Gravimetric method

163 urban sites-

13 PFCs (HPLC-MS/MS) **(Next talk coming up)**

4 synthetic musks and two of their metabolites (Presented SETAC 2011)

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Presentation Contents

In this presentation:

- Mercury Results: Human Health and Ecological thresholds & subgroup analysis
- Legacy Organics Results: Human Health and Ecological thresholds & subgroup analysis
- Co-occurrence of organic compounds
- Co-occurrence of Hg and PCBs

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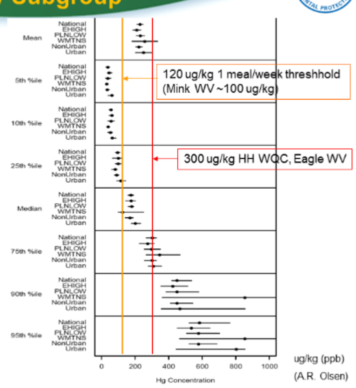
Hg Statistics

Statistic *(Hg ww ug/kg)	National *n* =541	Non-Urban *n* =379	Urban *n*=162	EHIGH *n* =190	PLNLOW *n* =280	WMTS *n* =71
River Miles	51,663	40,752	10,911	14,738	29,739	7,186
River km	83,145	65,586	17,559	23,718	47,861	11,564
50th %ile*	175.6	170.5	200.6	176.0	180.1	125.3
95th %ile*	583.6	578.8	803.3	535.2	578.8	**854.1**
Mean*	228.9	223.3	250.2	210.0	231.4	**257.5**
Max. *	1,419	1,419	854	854	1,419	1,272

Hg Weighted Percentile Data by Subgroup



Summary of Mercury (Hg) Results

- All (100%) of the 541 fish fillet samples analyzed for Hg content >3.33 ug/kg (ppb) quantitation limit for the method.
- **Weighted values for 137/541 samples (25.4%) exceeded the EPA HHWQC for Hg of 300 ug/kg,**
  - = 13,071 river miles (21,154 km)/ 51,663 miles (83,143 km) of sampled U.S. rivers
  - Compare with **48.9%** of U.S. lakes in NFLTS
- **No statistically-significant differences among sub-groups:**
  - **Non-urban/urban sites:**
  - **Eco regions (EHIGH, PLNLOW, WMTS).**
- Wildlife Risk:
  - Risk to piscivorous avian species (eagle) are similar to risks for humans at 300 ug/kg (@two meals per month level),
  - Mink are more at risk than the avian species (and humans) @ the HH 1 meal per week (fillet) threshold of 120 ug/kg.
- Data anomalies in WMTS samples likely attributable to natural localized CA Hg source (geothermal area/Hg mining history).

SESSION 1: FISH SAMPLING AND ANALYSIS
Mercury and Legacy Organic Compounds in Fish from U.S. Rivers – A National Perspective

Occurrence of Legacy Organic Compounds vs Hg

- Different elements, different chemistries
- Divergent sources, distribution patterns, transport mechanisms
- All end up in fish
- Focus of organics analysis is on PCBs, PBDEs, Chlordane, and DDT, Dieldrin

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PCBs

Detected in 93% of samples. Data are for 21 out of 209 PCB Congeners- Therefore, results are **VERY** Conservative.

	Detects	Mean(ug/kg)	Max (ug/kg)	%>SV (12 ug/kg)
National Data	505/540	32.7	856	48.0%
Non Urban Sites	343/377	26.9	412	42.0%
Urban Sites	162/163	**54.2**	**856**	**69.3%**

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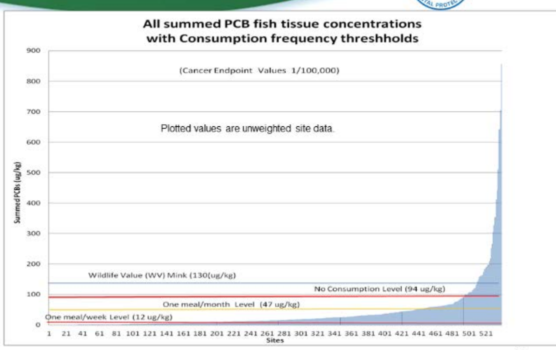
Summed PCBs (21 of 209 congeners) in Fish Tissue Samples



Note: Unweighted site data

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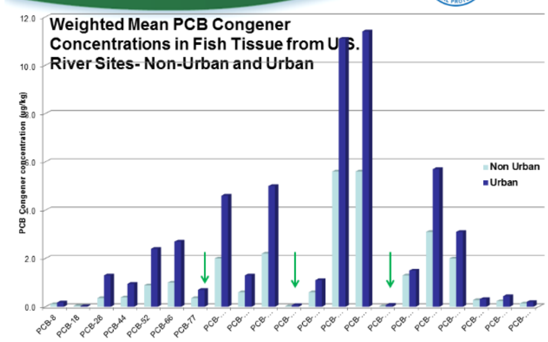
Mean PCB Congener Concentrations



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PBDEs

Lower concentrations, 1 Urban Site exceeded high (210 ug/kg) HH SV. Data are for 8 PBDE Congeners that represent most of the contaminant mass.

	Detects	Mean(ug/kg)	Max (ug/kg)	>SV(sites)
National Data	497/540	11.7	311	1
Non Urban Sites	340/377	8.6	151	-0-
Urban Sites	157/163	**22.5**	**311**	**1**

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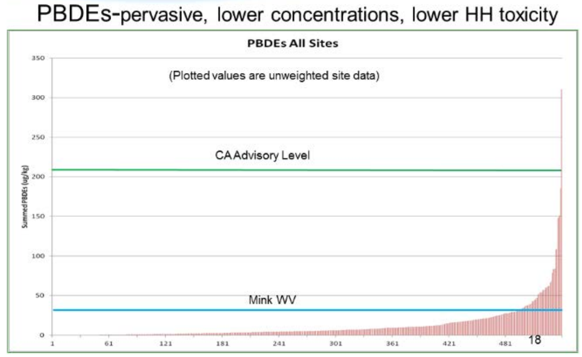
PBDEs

PBDEs-pervasive, lower concentrations, lower HH toxicity



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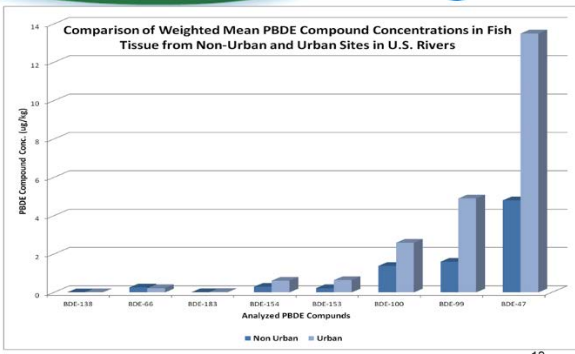
PBDEs



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Total Chlordane and Summed DDT(s)

Chlordane- 88.5% detects

	Detects	Mean(ug/kg)	Max (ug/kg)	Sites>SV
National Data	481/540	6.3	311	4
Non Urban Sites	325/377	5.1	87.1	1
Urban Sites	153/163	**10.4**	**311**	**3**

DDT(s)- **98.7% detects**

	Detects	Mean(ug/kg)	Max (ug/kg)	Sites>SV
National Data	533/540	13.8	294	16
Non Urban Sites	343/377	12.3	170	6
Urban Sites	162/163	**19.0**	**294**	**10**

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Human health screening values

Human health screening values (SVs)- I meal/week

Compound*	Non-cancer SV	Cancer SV
Chlordane (total)	1200	67
Dieldrin	120	1.5
DDT (summed)	120	69
PCBs (summed)	47	12
PBDEs (summed)	210@	NA

(*ug/kg wet weight)

- U.S. 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 Office of Water, Washington DC

@California sport fish advisory level

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Wildlife risk values (WVs)

Compound*	Mink WV	Kingfisher WV
Chlordane	830	4.5
Dieldrin	20	360
DDT (total)	360	155
PCBs (total)	130	440
PBDEs@	32	13 (Kestrel)

(*ug/kg wet weight)

**Lazorchak, J.M.et al. 2003. CONTAMINATION OF FISH IN STREAMS OF THE MID-ATLANTIC REGION: AN APPROACH TO REGIONAL INDICATOR SELECTION AND WILDLIFE ASSESSMENT. Environ Tox Chem. 22,3*

@Canadian Environmental Protection Act, 1999 Federal Environmental Quality Guidelines Feb. 2013

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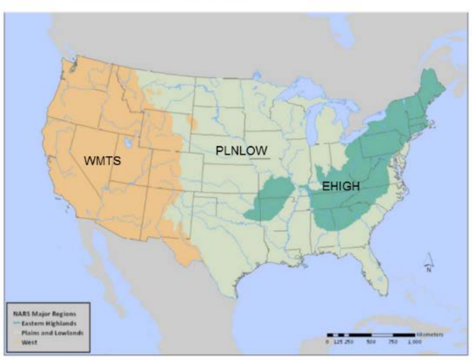
NARS Major Ecoregions (Review)



Differences Between Subgroups

Significance of Differences Between Subgroups

Compound Family	Non-urban/Urban		EHIGH/ PLNLOW		EHIGH/ WMTS		PLNLOW/ WMTS	
	Greater mean	P value	Greater mean	P value	Greater mean	P value	Greater mean	P value
PCBs Urb. EHIGH	**Urban**	0.006	**EHIGH**	0.032	**EHIGH**	<0.001	**PLN LOW**	0.0015
PBDEs No E-R diff.	**Urban**	<0.001	EHIGH	0.1	Same	None	WMTS	0.365
Chlordanes less WMTS	Urban	0.107	PLN LOW	0.2	**EHIGH**	<0.001	**PLN LOW**	<0.001
DDTs Urb.PLNLOW	**Urban**	0.017	**PLN LOW**	<0.001	WMTS	0.67	PLN LOW	0.7

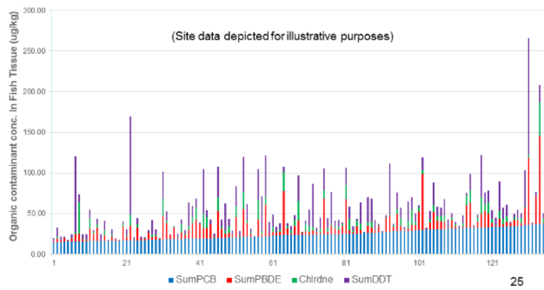
Comparisons based on Z-Tests using calculated weighted means and standard errors

SESSION 1: FISH SAMPLING AND ANALYSIS

Mercury and Legacy Organic Compounds in Fish from U.S. Rivers – A National Perspective – John Wathen

Combined PCB, PBDE, Chlordane, and DDT Concentrations

Third Quartile by Summed PCBs of Combined PCB, PBDE, Chlordane, and DDT Concentrations is Fish Fillet Tissue from U.S. Rivers (>5th order)



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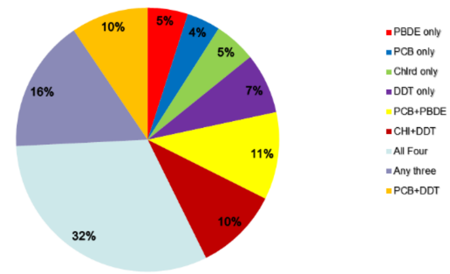
Co-occurrence of Organo-halogen Compounds

Co-occurrence of PCBs, PBDEs, Chlordane, and DDT above Respective Median Values



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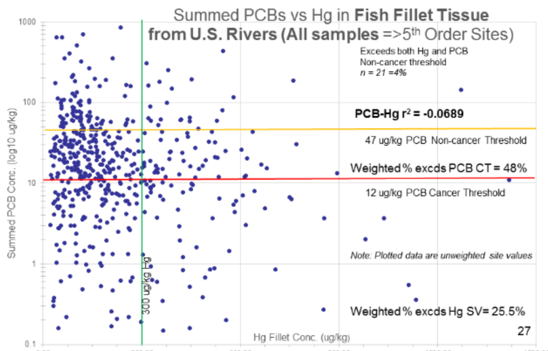
After M. Thomson & K. Boekelheide (2012)

Co-occurrence of PCBs and Hg



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Organics Synthesis 1- Weighted National Data

- PCBs, PBDEs, chlordane, DDT, and Dieldrin are pervasive in fish tissue from U.S. rivers
- Compound detects in fish tissue average 88.8% of river miles.
- The extent to which these compounds exceed risk-based screening values varies widely:
  - **PCBs- 48% of sites exceed 12 ug/kg (1/100,000) cancer threshold**
    (basis of 21 of 209 PCB Congeners)
  - PBDEs, Summed DDTs, and Total Chlordane individually exceed HH SVs at few sites.
- Extent of potential impacts depends on concentration, as well as SV or WV.
  - **WVs can yield risk levels divergent from HH SVs**

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Organics Synthesis 2- Sub-groups

- **PCBs, PBDEs, and DDT compounds concentrations are significantly higher in fish from urban sites**
- **PCBs concentrations are significantly higher in EHIGH**, relative other eco-regions.
- There is **no significant difference in PBDE** concentrations in fish tissue **among eco-regions**.*
- **DDT concentrations are significantly elevated in PLNLOW relative to EHIGH,** but not to WMTS(CA ag?)
- **No significant difference in chlordane concentrations between non-urban and urban sites.** (*Previous analysis of POTWs in urban locations indicated POTW source of chlordane and PBDEs in fish tissue – SETAC 2012).

Conclusions

- Monitoring of fish tissue for assessment and for fish consumption advisories continues to be important for new and legacy organic compounds, as well as Hg.
- Individual organo-halogen compounds seldom occur alone in fish tissue. Therefore, the presence and effects of any of these or other contaminants must be viewed in the context of co-occurring compounds.
- Any new persistent organic compounds can add to the existing overall organo-halogen (chlorinated, brominated, or fluorinated) burden in fish tissue potentially consumed by humans and wildlife.
- Occurrence and co-occurrence of contaminants depend on fish species and trophic level, and compound chemistry. Not all fish are created equal.

SESSION 1: FISH SAMPLING AND ANALYSIS
Mercury and Legacy Organic Compounds in Fish from U.S. Rivers – A National Perspective – John Wathen

Acknowledgements

This assessment was the product of the combined efforts of many:

- Co-authors: **Leanne Stahl** (OW-OST), James Lazorchak and Angela Batt (ORD-NERL, Cin.), Blaine Snyder (Tt), Harry McCarty (CSC)
  - Sampling was conducted by state, federal agency, and contractor crews
  - The NRSA is operated by our colleagues in the EPA Office of Wetlands, Oceans, and Watersheds; and
  - Statistical wizards in the EPA Office of Research and Development, Western Ecology Division are responsible for the sample design and for derivation of nationally- representative descriptive statistics
  - Mission support provided by Tetra Tech, CSC, and other contractors.

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FIN!

U.S. EPA Office of Water
Office of Science and Technology

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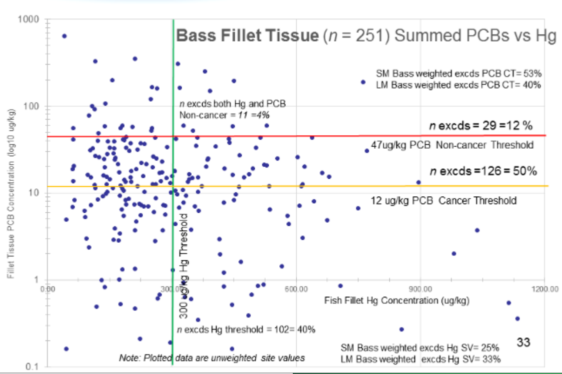
Co-occurrence of PCBs and Hg



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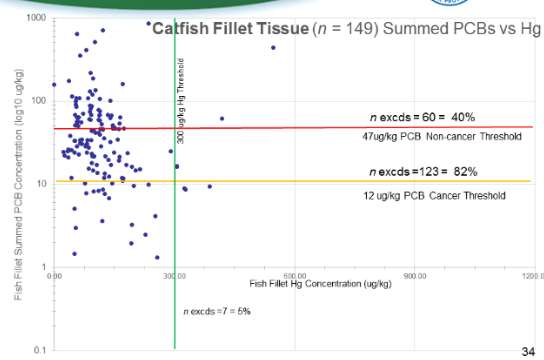
Co-occurrence of PCBs and Hg



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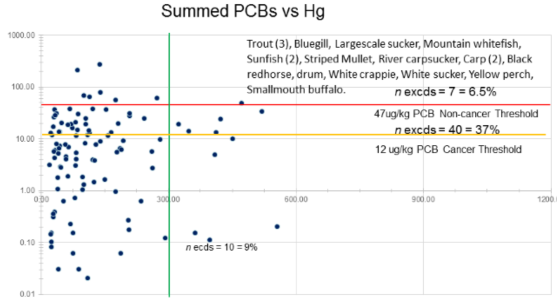
Co-occurrence of PCBs and Hg

Fillet Tissue from **Other Non-predator Species** (*n* = 107)
Summed PCBs vs Hg



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Questions and Answers

Note: There were no questions because the moderator asked that any questions be held until the general Q&A session at the end of this panel.

Perfluorinated Compounds in Fish from U.S. Urban Rivers and the Great Lakes

Leanne Stahl, U.S. Environmental Protection Agency

Biosketch

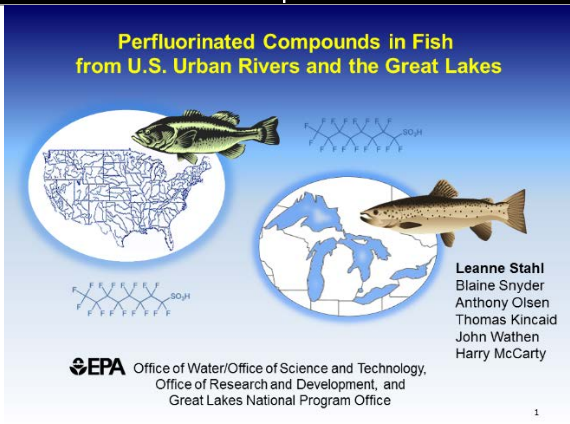
Leanne Stahl is an environmental scientist in the Office of Science and Technology (OST) within the U.S. Environmental Protection Agency (EPA) Office of Water. Since 1999, she has served as the Project Manager for a series of fish contamination studies conducted by OST, including the National Lake Fish Tissue Study, the National Pilot Study of Pharmaceuticals and Personal Care Products in Fish Tissue, the National Rivers and Streams Assessment Fish Tissue Study, and the Great Lakes Human Health Fish Tissue Study, and co-authored five technical journal articles reporting results from these studies. Leanne moved to EPA from the National Oceanic and Atmospheric Administration in 1990 and she worked in coastal and sediment contamination programs during her early years at EPA. Prior to joining federal service, she served as the fisheries specialist for a marine research team at the University of Washington in Seattle.

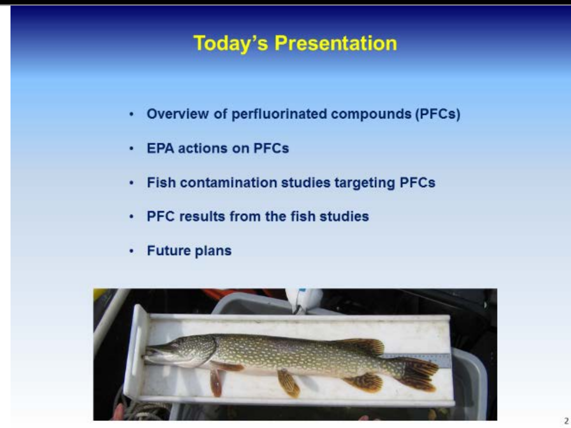
Abstract

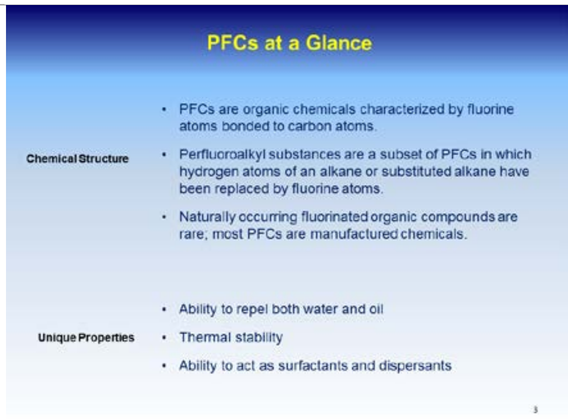
Perfluorinated compounds (PFCs) have recently received scientific and regulatory attention due to their broad environmental distribution, persistence, bioaccumulative potential, and toxicity. Studies suggest that fish consumption may be a source of human exposure to perfluorooctane sulfonate (PFOS) or long-chain perfluorocarboxylic acids. Most fish tissue literature related to PFC contamination focuses on marine fish and waters outside of the United States. To broaden assessments in U.S. fish, EPA conducted a national-scale study of urban rivers under the 2008-09 National Rivers and Streams Assessment (NRSA) and a regional-scale study of the Great Lakes under the 2010 National Coastal Condition Assessment (NCCA) to characterize PFC contamination in freshwater fish. EPA applied an unequal probability design in the NRSA Urban River Study and the NCCA Great Lakes Human Health Fish Tissue Study to randomly select 164 urban river sites and 157 nearshore Great Lakes sites for fish sample collection. Fillet tissue was analyzed for 13 PFCs using high-performance liquid chromatography tandem mass spectrometry. PFCs were detected in 80% of the urban river samples and 100% of the Great Lakes samples. Results showed that PFOS dominated in frequency of occurrence, followed by three longer-chain perfluorocarboxylic acids (perfluorodecanoic acid, perfluoroundecanoic acid, and perfluorododecanoic acid). Maximum PFOS concentrations (wet weight) were 127 and 80 ng/g in urban river and Great Lakes samples, respectively. The study results can be extrapolated to the sampled population of 17,059 kilometers (km) in urban rivers and to a nearshore area of 11,091 km^2 in the Great Lakes.

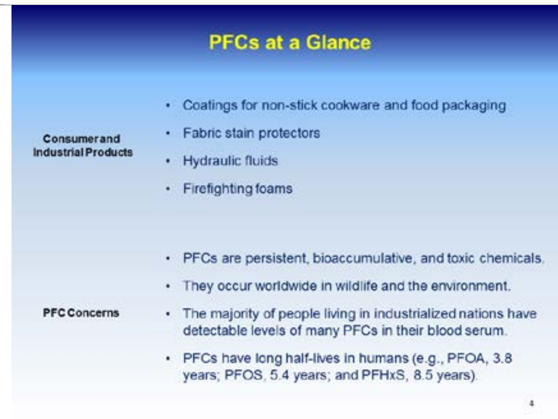
SESSION 1: FISH SAMPLING AND ANALYSIS

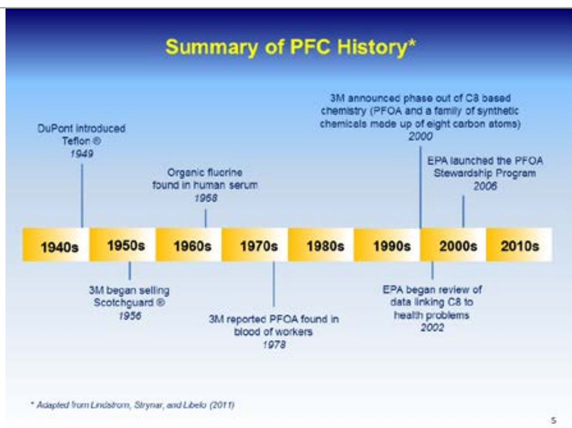
Perfluorinated Compounds in Fish from U.S. Urban Rivers and the Great Lakes – Leanne Stahl

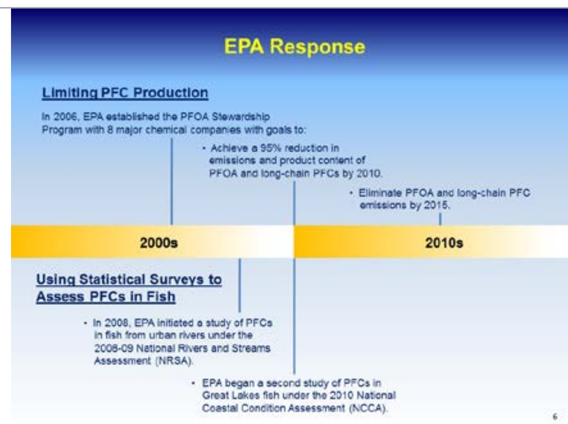












SESSION 1: FISH SAMPLING AND ANALYSIS

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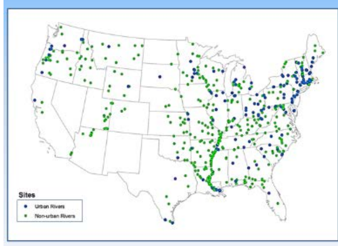
2008-09 NRSA Sampling Sites



For the 2008-09 NRSA:

- A framework of 1,800 sampling locations contained a statistically representative subset of 164 urban river sites that were 5th order or greater in size.
- Based on the statistical design of the study, the results apply to an estimated urban river length of 17,509 km (10,880 mi).

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2010 Great Lakes Sampling Sites

For the GLHHFTS:

- A framework of 225 U.S. sampling locations contained a statistically representative subset of 157 nearshore sites (defined by depths up to 30 m or distance up to 5 km from shore).
- Based on the statistical design of the study, the results apply to a Great Lakes nearshore surface area of an estimated 11,091 km^2 (4,282 mi^2).

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Fish Collection

- Various state, tribal, and federal agencies provided support for fish sample collection.
- Field teams collected one fish sample per site for analysis of PFCs.
- Fish samples consisted of:
  - Adult fish of the same species and similar size
  - Species commonly consumed in the study area
  - Ideally, five fish per sample
- Field teams used electrofishing to collect NRSA fish samples and a combination of hook and line and gillnetting to collect the Great Lakes fish samples.

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Fish Collection Results

For the NRSA:

- Fish collection yielded 162 composite samples (682 total fish) of 25 species.
- Three of the recommended target species -- smallmouth bass, largemouth bass, and channel catfish -- accounted for 70% of the composites (34%, 25%, and 11%, respectively).

For the GLHHFTS:

- Fish collection yielded 157 composite samples (423 total fish) of 18 species.
- Three of the recommended target species -- lake trout, smallmouth bass, and walleye -- accounted for 58% of the composites (31%, 14%, and 13%, respectively).

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Fish Tissue Analysis

- Fish were scaled and filleted in a laboratory to avoid contamination of the tissue.
  - Lateral muscle fillets were homogenized with skin on and the belly flap attached.
  - Fillets were composited using the batch method, which includes all the fillet tissue from each fish in the sample.
- Commercial laboratories analyzed fillet tissue samples for 13 PFCs using high performance liquid chromatography tandem mass spectrometry (HPLC-MS/MS).
- A single laboratory analyzed all the fillet samples for each of the fish studies.

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Perfluorinated Compounds

Abbreviation	Name	Formula	Example Uses
PFBA	Perfluorobutyric acid	C_3F_7COOH	Photographic film production
PFBS	Perfluorobutane sulfonate	$C_4F_9SO_3$	New Scotchgard® active ingredient
PFPeA	Perfluoropentanoic acid	C_4F_9COOH	Stain-proof coating breakdown product
PFHxA	Perfluorohexanoic acid	$C_5F_{11}COOH$	Stain-proof coating breakdown product
PFHxS	Perfluorhexane sulfonate	$C_6F_{13}SO_3$	Fire-fighting foams and carpet treatments
PFHpA	Perfluoroheptanoic acid	$C_6F_{13}COOH$	Stain-proof coating breakdown product
PFOA	Perfluorooctanoic acid	$C_7F_{15}COOH$	Teflon® and Gore-Tex® emulsifier
PFOS	Perfluorooctane sulfonate	$C_8F_{17}SO_3$	Original Scotchgard® active ingredient
PFOSA	Perfluorooctanesulfonamide	$C_8F_{17}SO_2NH_2$	Original Scotchgard® breakdown product
PFNA	Perfluorononanoic acid	$C_8F_{17}COOH$	Stain-proof coating breakdown product
PFDA	Perfluorodecanoic acid	$C_9F_{19}COOH$	Stain-proof coating breakdown product
PFUnA	Perfluoroundecanoic acid	$C_{10}F_{21}COOH$	Stain-proof coating breakdown product
PFDoA	Perfluorododecanoic acid	$C_{11}F_{23}COOH$	Stain-proof coating breakdown product

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Statistical Analysis Process

Statistical analysis of the PFC data for both fish studies incorporated elements of the probabilistic survey design and followed this process:

- determination of the final fish sampling site status (e.g. target, not accessible)
- adjustment of the survey design (sample) weights based on the site status
- estimation of the target population (number of sites that met the study definition of a target river or nearshore Great Lakes location)
- estimation of the number and proportion of sites in the sampled population (i.e., accessible target rivers or nearshore Great Lakes sites)
- estimation of percentiles and cumulative distribution of tissue concentrations by chemical for the sampled population of rivers or Great Lakes locations

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NRSA Urban River PFC Results

The urban river fillet samples are a set of nationally representative samples whose results can be extrapolated to the sampled population of 17,509 km (10,880 mi) of urban river length.

- **80%** of the urban river fillet samples contained detectable levels of PFCs.
- **6** of the 13 PFCs were detected in the urban river samples.
- **PFOS** occurred most frequently; it was detected in 73% of the samples.
- The median and maximum PFOS concentrations were 10.7 ng/g and 127 ng/g.

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Great Lakes PFC Results

The Great Lakes fillet samples are a set of regionally representative samples whose results can be extrapolated to a Great Lakes nearshore surface area of 11,091 km^2 (4,282 mi^2).

- **100%** of the Great Lakes fillet samples contained detectable levels of PFCs.
- **12** of the 13 PFCs were detected in the Great Lakes samples.
- **PFOS** was the dominant PFC; it was detected in all of these samples.
- The median and maximum PFOS concentrations were 15.2 ng/g and 80 ng/g.

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PFC Screening Values

Consumption	PFOS (ppb) Minnesota Department of Health*
Unrestricted	≤ 40
1 meal / week	>40 - 200
1 meal / month	>200 - 800
Do not eat	>800

* General population

- EPA has not developed national risk-based consumption limits or human health screening values for PFCs.
- The Minnesota Department of Health (MDH) included meal advice categories based on levels of PFOS in fish as part of their statewide Fish Consumption Advisory Program.
- The MDH sport fish advisory levels recommend consumption of only one meal of fish per week if PFOS concentrations are >40-200 ng/g (wet weight), one meal per month if levels are >200-800, and no consumption at levels greater than 800 ng/g.

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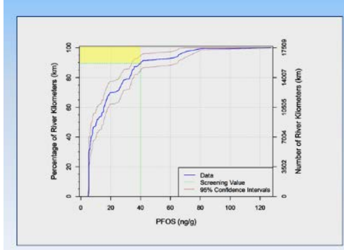
NRSA PFOS Cumulative Distribution Function



The application of PFOS human health screening values (SV) to the national probabilistic results for **urban rivers** indicates that:

- **10.6%** of the sampled population of U.S. urban rivers had PFOS tissue concentrations that exceeded the 40 ng/g SV recommending that fish consumption be restricted to no more than one meal per week.

This represents a total of **1,856 urban river km (1,153 mi)**.

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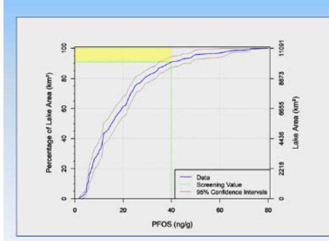
Great Lakes PFOS Cumulative Distribution Function



The application of PFOS human health screening values (SV) to the probabilistic results from the **Great Lakes** indicates that:

- **9.0%** of the Great Lakes sampled population had PFOS tissue concentrations that exceeded the 40 ng/g SV recommending that fish consumption be restricted to no more than one meal per week.

This represents a total of **998 km^2 (385 mi^2) of nearshore Great Lakes area.**

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Perfluorinated Compounds in Fish from U.S. Urban Rivers and the Great Lakes – Leanne Stahl

Recently Published

For more information:

Detailed PFC results and conclusions from these studies were recently published online in *Science of the Total Environment* on September 2, 2014.

- Stahl, L.L., Snyder, B.D., Olsen, A.R., Kincaid, T.M., Wathen, J.B., and McCarty, H.B. 2014. Perfluorinated compounds in fish from U.S. urban rivers and the Great Lakes. *Science of the Total Environment* 499: 185-195.

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Looking Ahead

EPA is repeating **statistically based fish contamination studies** in U.S. rivers and in the Great Lakes to generate data for analysis of national trends in river fish contamination and for analysis of regional trends in contaminant levels for Great Lakes fish.

- EPA is currently conducting the second study of contamination in fish fillet samples under the 2013-14 NRSA. Urban river samples will be analyzed for PFCs.
- Next year, EPA is planning to initiate the second Great Lakes Human Health Fish Fillet Tissue Study under the 2015 NCCA. PFCs are included in the list of target chemicals.

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Acknowledgments

These studies were made possible by the collaborative efforts of:

- U.S. EPA's Office of Water,
- EPA's Office of Research and Development,
- EPA's Great Lakes National Program Office (GLNPO), and
- a national network of state, tribal, and federal agency partners

Technical review and input was provided by:

- Joyce Donohue (EPA/OW)
- Andrew Lindstrom (EPA/ORD)
- Beth Murphy (EPA/GLNPO)

Technical support was provided by:

- Tetra Tech, Inc.
- CSC
- AXYS Analytical Services
- TestAmerica

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Please visit our posters:

- ***Assessment of Perfluorinated Compounds (PFCs) in Fish from U.S. Rivers and the Great Lakes***
- ***EPA's Assessment of Contaminants in Fish from U.S. Rivers***

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Questions and Answers

Q. Do you have any data on the co-occurrence of PFCs in fish samples? (Stern)

A. They have not looked at any data regarding the co-occurrence of PFCs. However, their data showed more than one PFC occurred in some fish tissue samples.

Q. How did you collect the fish samples, specifically what process was used for sampling and what people were used for collecting samples? Did you involve people who actually fish in the sampling process, such as recreational fishers? For example, recreational fishers can be used as citizen scientists. (Bawden)

A. The sampling was conducted primarily by state crews, who were coordinated by EPA's Office of Wetlands, Oceans and Watersheds (OWOW). Some private crews were also used in the sampling process as well as tribal crews and U.S. Geological Survey staff. OWOW prepared a manual about the standard protocols for sampling and posted it online. All crews had rigorous training on the standard sampling protocols.

Comment: At EPA's Research Triangle Park office in North Carolina, there are two EPA experts who have conducted local studies on PFCs in fish in North Carolina and Alabama. Andrew Lindstrom and Mike Strynar are experts on water and fish monitoring for PFCs. (Stahl)

Identifying Emerging Contaminants for Monitoring in State Fish Programs

Beth Murphy, U.S. Environmental Protection Agency

Biosketch

Elizabeth Murphy is the program manager for the Great Lakes Fish Monitoring and Surveillance Program (GLFMSP) in the U.S. Environmental Protection Agency (EPA) Great Lakes National Program Office (GLNPO). As program manager for a 30-plus year program, Ms. Murphy is responsible for monitoring and surveillance of historical and emerging contaminants in Great Lakes fish over time and determining the presence of new chemicals in fish tissue. She works very closely with the Great Lakes Consortium for Fish Consumption Advisories, Lakewide Action and Management Plans, Partner Agencies and Programs, and the Environment Canada National Fish Contaminant Monitoring and Surveillance Program to ensure that high quality data is used in decision making and reporting. Additionally, Ms. Murphy has been involved with a variety of education and outreach projects in GLNPO, including the creation of posters and other outreach materials. She made her video debut in a Chicago Emmy nominated Chicago Public Television series, City Science. Ms. Murphy received her B.S. in Environmental Science from North Carolina State University and her M.P.H. in Environmental Public Health from the University of Illinois at Chicago. In a past life, Beth enjoyed traveling the world and photographing it, both above and below the water. Now, she enjoys teaching her children about the Great Lakes and raising them to be good environmental stewards.

Abstract

Emerging contaminant surveillance was added in 2010 as a core function of GLFMSP, an EPA program operated by a cooperative agreement between GLNPO and the Clarkson University Research consortium. The goal of the surveillance is to qualify and quantify, when possible, new chemicals that are present in whole body top predators in Lakes Superior, Michigan, Huron, Erie, and Ontario. Results of this surveillance are becoming available and are summarized by the presentation, including methodology and the research paradigm used to identify chemicals and to share the information with state and tribal advisory programs for prioritization in monitoring.

Identifying Emerging Contaminants for Monitoring in State Fish Programs – Beth Murphy

Identifying Emerging Contaminants for Monitoring in State Fish Programs

Elizabeth Murphy
U.S. Environmental Protection Agency
Great Lakes National Program Office

Disclaimer: The views expressed in this presentation are those of the author(s) and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

Partners

- Clarkson Consortium
  - Thomas Holsen, Clarkson University
  - Bernard Crimmins, Clarkson University
  - Phillip Hopke, Clarkson University
  - James Pagano, SUNY Oswego
  - Michael Milligan, SUNY Fredonia
- Great Lakes Consortium for Fish Consumption Advisories
  - *DNRs*
  - *Health Departments*
- U.S. EPA OST
- Other Chemical Monitoring Programs

Great Lakes RESTORATION

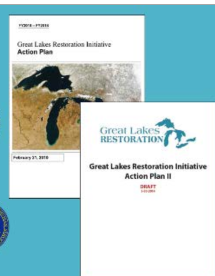
Presentation Overview

- Great Lakes Restoration Initiative
- Overview of the Great Lakes Fish Monitoring and Surveillance Program
- Established Partnerships
- Emerging Chemical Identification
- Additional Collaborations
- Recommendations

Great Lakes Restoration Initiative (GLRI)

Obama Administration Initiative

FY10: $475 million
FY11: $300 million
FY12: $300 million
FY13: $284 million
FY14: $300 million
FY15: $275 million*



Great Lakes RESTORATION

- Toxic Substances and Areas of Concern
- Invasive Species
- Nearshore Health and Nonpoint Source Pollution
- Habitat and Wildlife Protection and Restoration
- Accountability, Education, Monitoring, Evaluation, Communication, and Partnerships

Result and Action Oriented

3 principals – Action, Urgency, Accountability

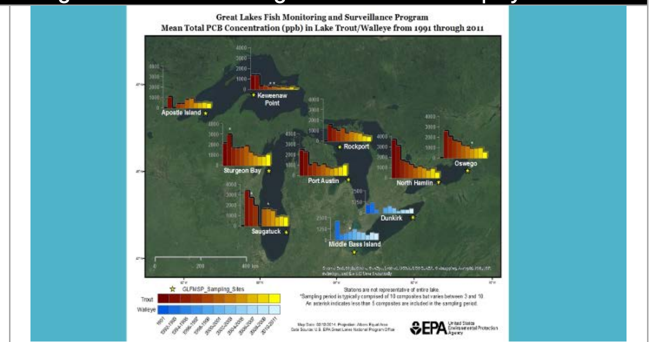
11 federal cabinet – level departments (16 Agencies)

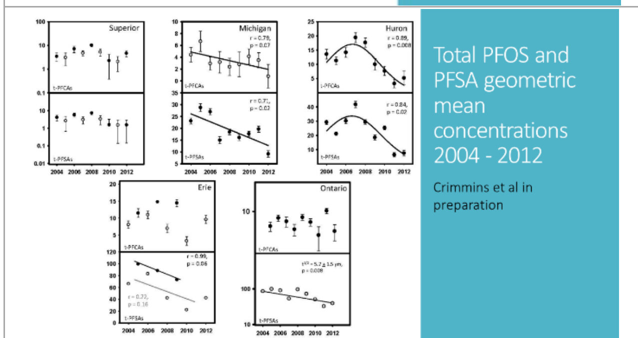
$1.2 Billion

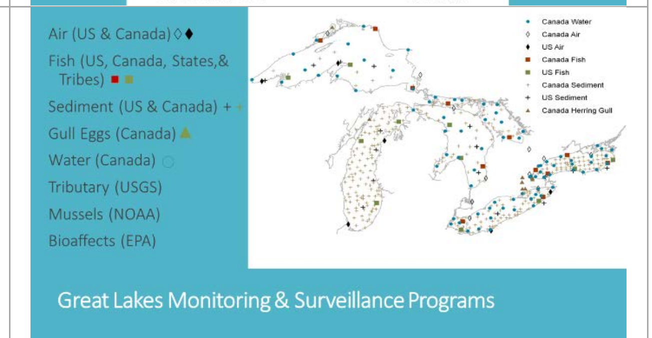
Action Plan 2 being developed

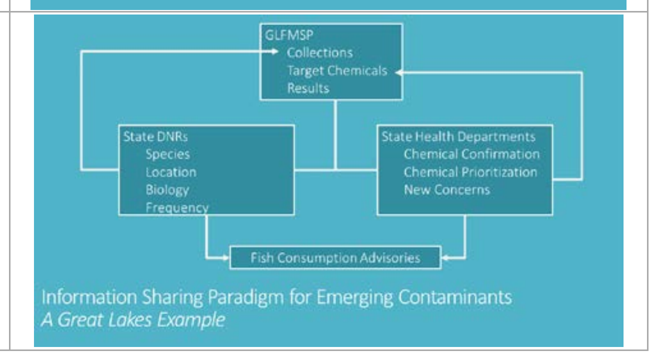
SESSION 1: FISH SAMPLING AND ANALYSIS

Identifying Emerging Contaminants for Monitoring in State Fish Programs – Beth Murphy



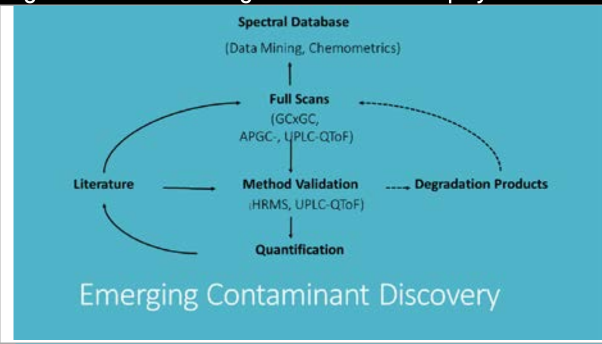


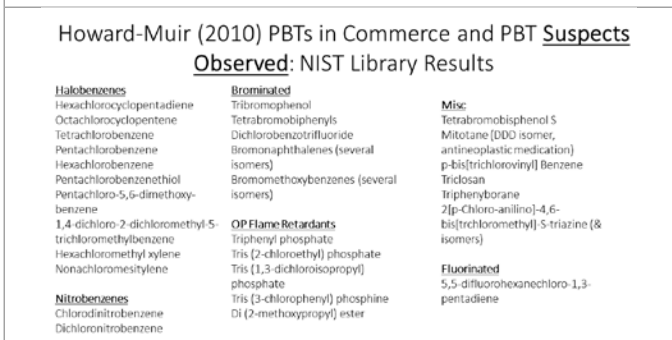


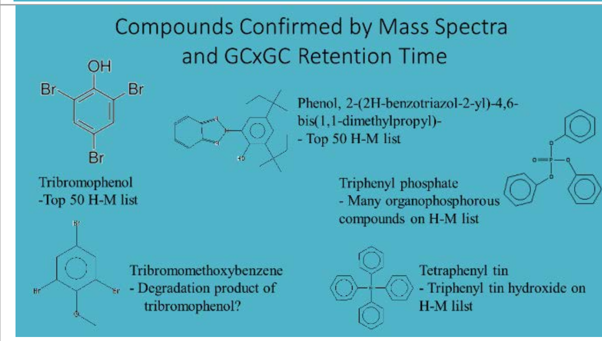


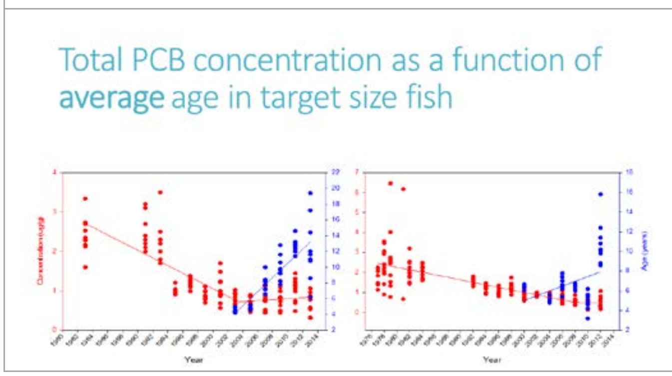
SESSION 1: FISH SAMPLING AND ANALYSIS

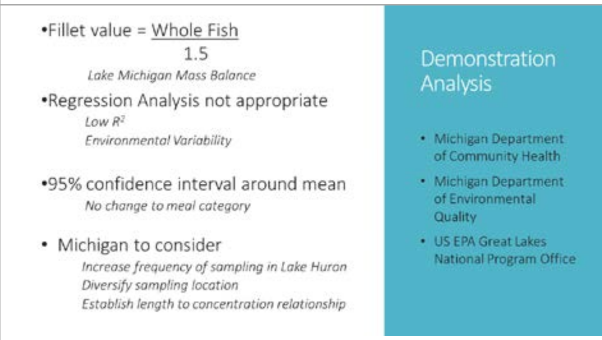
Identifying Emerging Contaminants for Monitoring in State Fish Programs – Beth Murphy











SESSION 1: FISH SAMPLING AND ANALYSIS

Identifying Emerging Contaminants for Monitoring in State Fish Programs – Beth Murphy

GLRI funded collaboration between the Clarkson Consortium and Great Lakes States*

Objectives:

1) Develop a standard reference material (SRM) consisting of Great Lakes lake trout tissue that can be used for inter-laboratory comparisons.

2) Provide analytical assistance and QA/QC support for fatty acids, perfluorinated compounds (PFCs) and toxaphene analyses.

Recommendations

- Information is key
  - Establish routine information sharing
  - Stay engaged
- Establish Priorities
- Be Flexible
  - Sample Share
- Seek out larger scale partners
  - Regional or National
  - Cost Share
- Don't limit collaborations
- Be Patient

Elizabeth Murphy murphy.Elizabeth@epa.gov 312-353-4227

Questions and Answers

Q. Why did you decide to use whole body versus fish fillet samples? Why did you not consider using both of them? (Pinkney)

A. This program started as an ecological program so they used whole body samples. Later the greater need turned out to be emerging contaminants so they kept using whole body samples.

Q. Did you consider any ongoing data streams from EPA or private sources to identify chemical targets? Are there any current data streams that would identify emerging contaminants? (Kyle)

A. They have been working with EPA's Office of Science and Technology, which is a good resource. EPA's Great Lakes National Program Office is using a "rifle and shotgun" approach. For the "rifle" approach, they use a targeted search for chemicals or compounds in high production within the Great Lakes region. This approach is based on the Great Lakes Water Quality Agreement. For the "shotgun" approach, they are looking at chemical peaks in samples and trying to identify chemicals or compounds of concern for which they should be following up on with additional monitoring.

Safety Testing of Gulf of Mexico Reef Fish after the BP Oil Spill

Tim Fitzgerald, Environmental Defense Fund

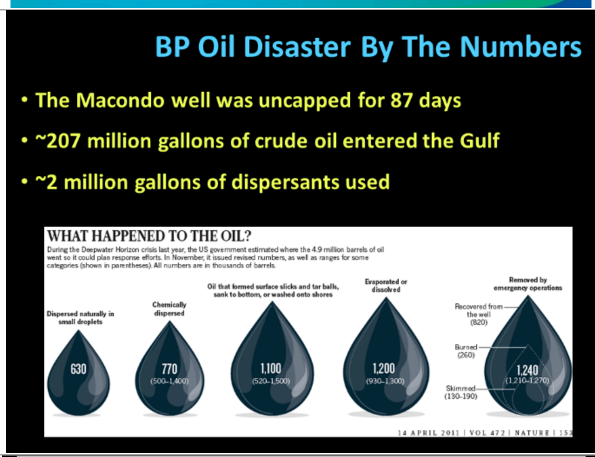
Biosketch

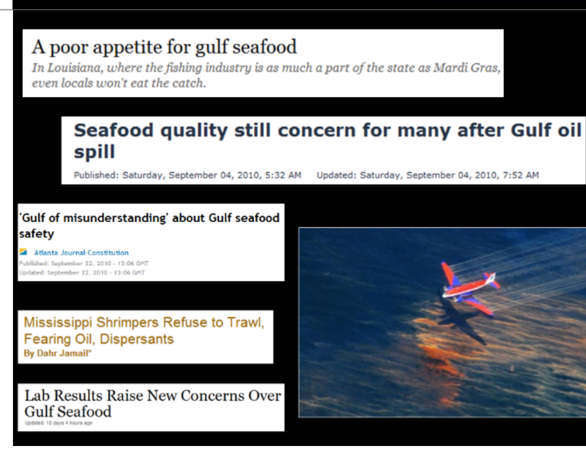
Tim Fitzgerald directs the Environmental Defense Fund sustainable seafood program, and specializes in the intersection of environmental sustainability and public health. Mr. Fitzgerald serves on the board of Ecofish LLC, Seafood Safe LLC, and Gulf Wild, and is an advisor to Fair Trade USA, SeaWeb's Kid Safe Seafood, and the Atlantic States Marine Fisheries Commission. Mr. Fitzgerald also develops sustainable sourcing policies for retailers, foodservice companies, restaurants, and other major seafood buyers. Mr. Fitzgerald earned his M.Sc. (2002) in Zoology from the University of Hawai'i, and his B.S. (1998) in Biology from Duke University. His graduate research focused on the behavioral ecology and sensory physiology of tropical sharks, making appearances on Discovery Channel's Shark Week and National Geographic Explorer. He is a frequent speaker on conservation and human health issues concerning the U.S. seafood market, and has been featured in the Wall Street Journal, New York Times, and NPR's Fresh Air, in addition to being invited to provide testimony in front of the President's Commission on the BP Deepwater Horizon Oil Spill.

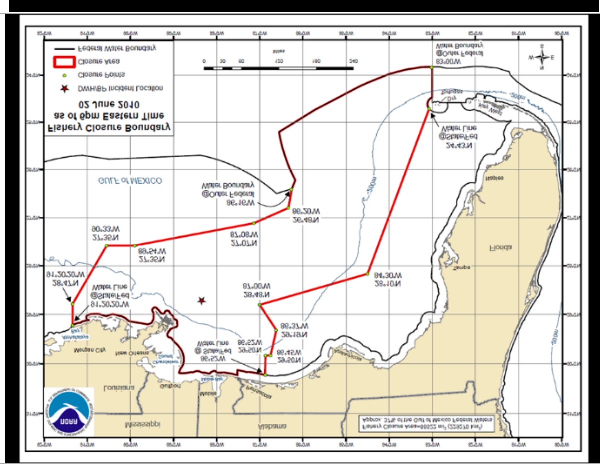
Abstract

The BP Deepwater Horizon oil spill posed a significant threat to the U.S. seafood industry. Invertebrates (shrimp, oyster, crab) and other nearshore species comprised the majority of post-spill testing by federal and state agencies. Deeper water finfish were sampled less frequently, despite population ranges that overlapped with affected waters. We conducted a voluntary testing program with Gulf of Mexico commercial fishermen to ensure the safety of their catch. Seven species of reef fish were tested for polycyclic aromatic hydrocarbons (PAHs), a suite of metals, and a constituent of Corexit dispersants. Two percent of samples had detectable levels of benzo(a)-pyrene-equivalents (a combined measure of carcinogenic potency across seven different PAHs), which were still below federal safety thresholds. PAH ratios for these samples suggest pyrogenic contamination − indicating potential sources other than Deepwater Horizon. Metals were largely absent (cadmium, lead) or consistent with levels previously reported (mercury, arsenic). One notable exception was tilefish, which showed mercury concentrations lower than expected. We did not detect dispersant in any of our samples, indicating that it was not present in these species during the study period. Our findings suggest minimal risk to public health from these seafoods as a result of the disaster; however, the most contaminated areas were not sampled through this program.

SESSION 1: FISH SAMPLING AND ANALYSIS
Safety Testing of Gulf of Mexico Reef Fish after the BP Oil Spill – Tim Fitzgerald







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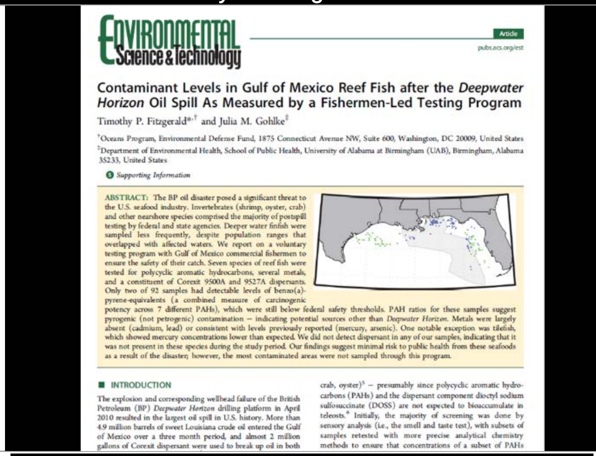


Environmental Science & Technology — Article — pubs.acs.org/est

Contaminant Levels in Gulf of Mexico Reef Fish after the *Deepwater Horizon* Oil Spill As Measured by a Fishermen-Led Testing Program

Timothy P. Fitzgerald*,† and Julia M. Gohlke‡

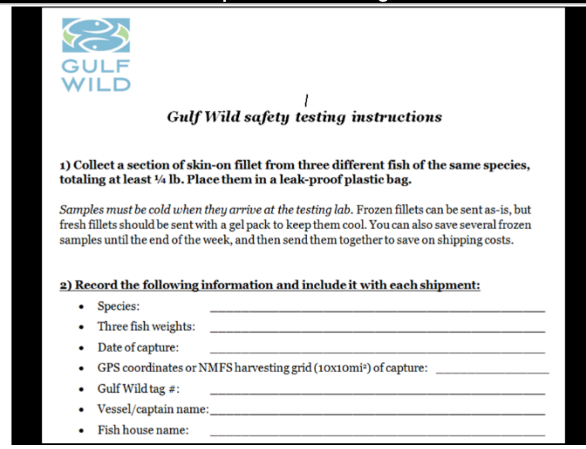
†Oceans Program, Environmental Defense Fund, 1875 Connecticut Avenue NW, Suite 600, Washington, DC 20009, United States
‡Department of Environmental Health, School of Public Health, University of Alabama at Birmingham (UAB), Birmingham, Alabama 35233, United States

Supporting Information

ABSTRACT: The BP oil disaster posed a significant threat to the U.S. seafood industry. Invertebrates (shrimp, oyster, crab) and other nearshore species comprised the majority of postspill testing by federal and state agencies. Deeper water finfish were sampled less frequently, despite population ranges that overlapped with affected waters. We report on a voluntary testing program with Gulf of Mexico commercial fishermen to ensure the safety of their catch. Seven species of reef fish were tested for polycyclic aromatic hydrocarbons, several metals, and a constituent of Corexit 9500A and 9527A dispersants. Only two of 92 samples had detectable levels of benzo(a)-pyrene-equivalents (a combined measure of carcinogenic potency across 7 different PAHs), which were still below federal safety thresholds. PAH ratios for these samples suggest pyrogenic (not petrogenic) contamination – indicating potential sources other than *Deepwater Horizon*. Metals were largely absent (cadmium, lead) or consistent with levels previously reported (mercury, arsenic). One notable exception was tilefish, which showed mercury concentrations lower than expected. We did not detect dispersant in any of our samples, indicating that it was not present in these species during the study period. Our findings suggest minimal risk to public health from these seafoods as a result of the disaster; however, the most contaminated areas were not sampled through this program.

■ INTRODUCTION

The explosion and corresponding wellhead failure of the British Petroleum (BP) *Deepwater Horizon* drilling platform in April 2010 resulted in the largest oil spill in U.S. history. More than 4.9 million barrels of sweet Louisiana crude oil entered the Gulf of Mexico over a three month period, and almost 2 million gallons of Corexit dispersant were used to break up oil in both crab, oyster)[5] – presumably since polycyclic aromatic hydrocarbons (PAHs) and the dispersant component dioctyl sodium sulfosuccinate (DOSS) are not expected to bioaccumulate in teleosts.[6] Initially, the majority of screening was done by sensory analysis (i.e., the smell and taste test), with subsets of samples retested with more precise analytical chemistry methods to ensure that concentrations of a subset of PAHs



GULF WILD

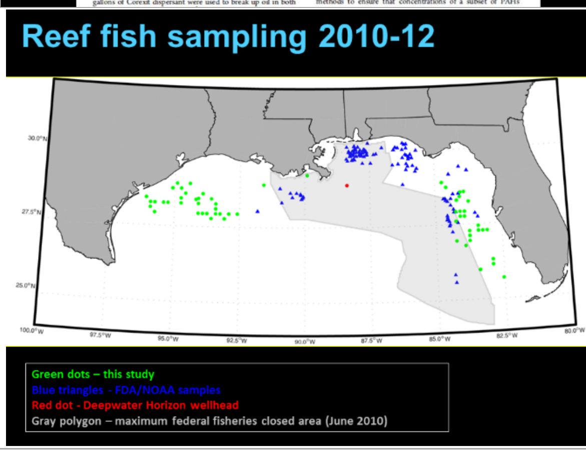
Gulf Wild safety testing instructions

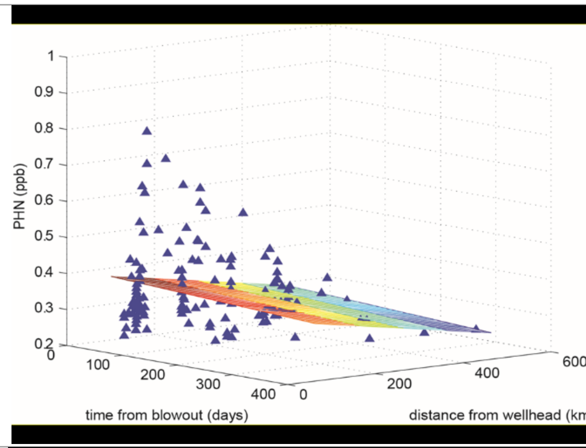
1) Collect a section of skin-on fillet from three different fish of the same species, totaling at least ¼ lb. Place them in a leak-proof plastic bag.

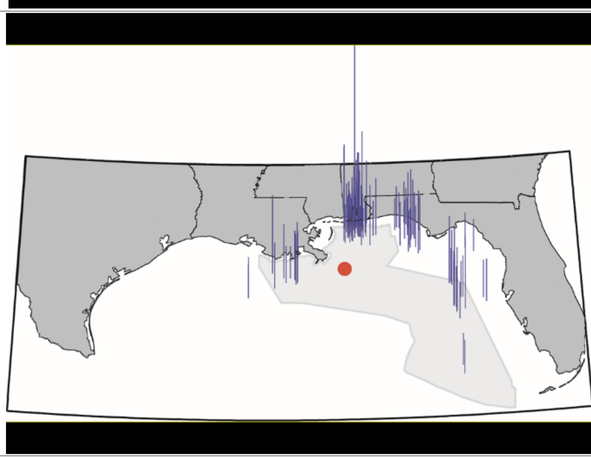
Samples must be cold when they arrive at the testing lab. Frozen fillets can be sent as-is, but fresh fillets should be sent with a gel pack to keep them cool. You can also save several frozen samples until the end of the week, and then send them together to save on shipping costs.

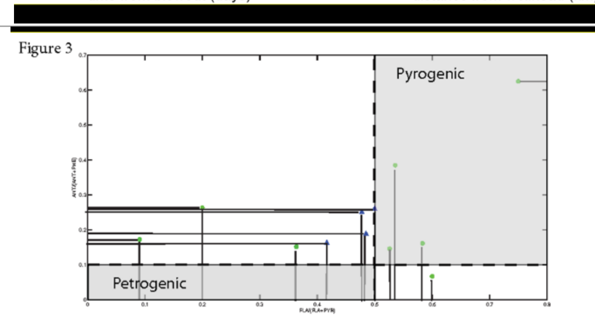
2) Record the following information and include it with each shipment:

- Species: ____________
- Three fish weights: ____________
- Date of capture: ____________
- GPS coordinates or NMFS harvesting grid (10x10mi²) of capture: ____________
- Gulf Wild tag #: ____________
- Vessel/captain name: ____________
- Fish house name: ____________









PAH ratio	Petrogenic values
ΣLMW/ΣHMW	>1
PHN/ANT and FLA/PYR	>10 and <1
ANT/ANT+PHN	<0.1
FLA/FLA+PYR	<0.4-0.5

SESSION 1: FISH SAMPLING AND ANALYSIS

Safety Testing of Gulf of Mexico Reef Fish after the BP Oil Spill – Tim Fitzgerald

Red snapper testing 2010-12

	Gov't standard	THIS STUDY
PAHs*	35 ppb BaPe	**0.00 ppb BaPe**
Dispersant*	150 ppm	**<0.05 ppm**
Arsenic**	87 ppm	**0.45 ppm**
Cadmium**	2.9 ppm	**<0.01 ppm**
Mercury**	0.29 ppm	**0.13 ppm**

* FDA/NOAA Deepwater Horizon Protocol

** EPA National Guidance for Sportfish Advisories

Grouper testing 2010-12

	Gov't standard	THIS STUDY
PAHs*	35 ppb BaPe	**0.53 ppb BaPe**
Dispersant*	150 ppm	**<0.05 ppm**
Arsenic**	87 ppm	**0.71 ppm**
Cadmium**	2.9 ppm	**<0.01 ppm**
Mercury**	0.29 ppm	**0.27 ppm**

* FDA/NOAA Deepwater Horizon Protocol

** EPA National Guidance for Sportfish Advisories

Tilefish testing 2010-12

	Gov't standard	THIS STUDY
PAHs*	35 ppb BaPe	**0.00 ppb BaPe**
Dispersant*	150 ppm	**<0.05 ppm**
Arsenic**	87 ppm	**9.05 ppm**
Cadmium**	2.9 ppm	**<0.01 ppm**
Mercury**	0.29 ppm	**0.55 ppm**

* FDA/NOAA Deepwater Horizon Protocol

** EPA National Guidance for Sportfish Advisories

MERCURY RESULTS IN COMPARISON

FISH	Hg (this study)	Hg (Karimi et al. 2012)*
Grouper	0.267 ppm (27)	0.395 ppm (662)
Red snapper	0.126 ppm (22)	0.202 ppm (231)
Tilefish	0.550 ppm (4)	1.445 ppm (61)

Gulf Wild®

- Comprehensive seafood assurance campaign
- Addresses issues of conservation, safety, traceability, authenticity, marketing
- Voluntary measures that are made possible by & *complement* management
- A new way to respond to fishery disasters

SESSION 1: FISH SAMPLING AND ANALYSIS
Safety Testing of Gulf of Mexico Reef Fish after the BP Oil Spill – Tim Fitzgerald

Questions and Answers

Note: There were no questions because the moderator moved directly into the general Q&A session at the end of this panel.

General Question and Answer Session

Q. At the Colorado Department of Health and Environment, they are getting resistance from their Department of Natural Resources, Fish and Wildlife biologists who are concerned about starting fish sampling for new contaminants. The Fish and Wildlife biologists are concerned about protecting fisheries (e.g., not depleting fish) and protecting tourism. How can fish be collected and monitored, given these issues? (Richardson)

A. EPA's Great Lakes National Program Office is a federal program collaborating with other federal programs. However, they collaborate with state departments of natural resources (DNRs) routinely for collecting and monitoring fish for mercury, etc. State DNRs are usually the best fish collectors, but they may want to collect fish for different purposes. In reality, the real hurdle for her program is finding laboratories that can conduct analyses for emerging contaminants. (Murphy)

Q. Because the Colorado Department of Natural Resources will not collect fish, do you have any other suggestions? (Richardson)

A. A contractor is probably the best solution. Under her program in the Great Lakes region, they have not had success with using citizen scientists to collect fish. (Murphy)

Comment: If you find a location within Colorado where emerging contaminants occur, then your DNR's biologists might provide assistance. That approach might allow you to show a "success story" to mitigate concerns about other issues. (Greene)

Q. Are people continuing to look at the food chain effects when monitoring for oil-related contaminants in Gulf of Mexico fish? You could look at the food chain for oil-related contaminants from crayfish all the way up to the fish eaten by consumers. (Burger)

A. There is a lot of research analyzing inshore fish that are lower in the food chain and caught from inshore areas in the Gulf of Mexico. He suggested looking for published studies on this research. (Fitzgerald)

Q. The data about arsenic levels in the Environmental Defense Fund (EDF) study are two times lower than data published in government studies. Why are there differences in these levels? (Ralston)

A. There was no relevant data in the federal databases for the three marine species researched in the EDF study (i.e., red snapper, grouper, tilefish). EDF tried to compare their results to tissue levels for marine species through fish tissue searches in EPA's National Listing of Fish Advisories, but that database did not have much information on these three marine species. EDF would have liked to make comparisons to existing data, but there was nothing great to compare to. (Fitzgerald)

Q. At the National Seafood Inspection Laboratory, they have found that you must present data along with the size of fish and also age. He questioned whether using the mean was helpful if you *do not keep track of the size of fish. He urged everyone to keep this in mind when doing sampling and to collect fish of a range of sizes. Also he recommended that it is best to look at individual fish versus composite samples when analyzing fish sampling results. (Lowery)*

A. After the moderator asked Beth Murphy whether she found their data changed with the size of fish, she replied that in their study it was the age of fish—not size—that was important. (Murphy)

A. After the moderator asked Leanne Stahl whether EPA could plot data based on the length of fish, she replied that EPA has that data. (Stahl)

A. The full data set of the EDF study is online. (Fitzgerald)

Q. You need to be mindful of your approach, and the approach for linking results to the consumer's health is difficult. Some data can get complex and the results may get misleading, especially when presented in laymen's terms. Focusing on popular fish and the size of fish may help communicate with the public. (Bhavsar)

A. There were no responses or comments from any of the panelists.

SECTION II-C SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION

Introduction

Moderator:
Rick Greene, Delaware Department of Natural Resources and Environmental Control

Biosketch
Dr. Rick Greene works for the Delaware Department of Natural Resources and Environmental Control. He has managed Delaware's fish contaminant monitoring and advisory program since its inception in 1993 and has been involved in all advisories issued by Delaware. He holds a Ph.D. in Environmental Engineering from the University of Delaware where his research focused on congener-specific partitioning and trophic transfer of PCBs. Dr. Greene's recent work includes the first full-scale remediation project in North America to use direct placement of activated carbon in sediments to sequester PCBs and reduce bioaccumulation.

Presentations
State-Tribal Partnership for Developing Advisories for Cook Inlet
Bob Gerlach, Alaska; Michael Opheim and Tracie Merrill, Seldovia Village Tribe

State-Tribal Partnership for Developing Advisories for the Upper Columbia River/Lake Roosevelt
Liz Carr, Washington; Cindy Marchand, Confederated Tribes of the Colville Reservation

State-Tribal Partnership for Updating the Advisory for Clear Lake
Margy Gassel, California; Sarah Ryan, Big Valley Rancheria Band of Pomo Indians

State-Tribal Partnership for Updating the Advisories for the St. Lawrence River Watershed
Faith Schottenfeld, New York; Tony David, Saint Regis Mohawk Tribe

Communication of Fish Advisories Between States and Federal Lands: Results from a Survey of 21 Western National Parks
David Wong, U.S. Department of the Interior, National Park Service

How EPA Utilizes Fish Advisories as Institutional Controls at Superfund Sites
Steve Ridenour, U.S. Environmental Protection Agency

State-Tribal Partnership for Developing Advisories for Cook Inlet

Bob Gerlach, Alaska; Michael Opheim and Tracie Merrill, Seldovia Village Tribe

Biosketch

Robert F. Gerlach

Dr. Robert F. Gerlach works for the Alaska Department of Environmental Conservation as the Alaska State Veterinarian. He is responsible for animal health regulations, animal disease surveillance, managing the state's Fish Monitoring Program, and is the state’s Fish Advisory Program Coordinator. Dr. Gerlach received his B.S. in Veterinary Science from the Pennsylvania State University and graduated with a Doctor of Veterinary Medicine from the University of Pennsylvania. He was attending veterinarian and post-doctoral fellow at the Lovelace Respiratory Research Institute in Albuquerque, New Mexico. In 1987, he moved to Alaska and worked in private practice until being hired by the state to manage the state’s Fish Monitoring Program. Working with state and federal partners, in addition to commercial, recreational, and subsistence fisherman, over 7,800 finfish and invertebrates have been collected and analyzed for environmental contaminants. The data generated by the program is used by the Alaska Department of Health and Social Services to develop fish consumption advice for Alaska residents.

Michael Opheim

Michael Opheim is of Aleut descent and currently resides in Seldovia, Alaska. Michael grew up harvesting from the land and sea with family members. Similar to most young Alaska men, he spent nine years as a commercial fisherman. He became the Environmental Coordinator for the Seldovia Village Tribe (SVT) in 2003. As the Environmental Coordinator, he is responsible for administration and management of the Indian General Assistance Program and other environmental projects. Under his leadership, the SVT Environmental Office has flourished bringing essential environmental projects to Seldovia that benefit the entire community. Mr. Opheim finds his best days are those days that allow him time in the field doing what he loves best. As the Environmental Coordinator, he has been able to travel throughout the state, establishing contacts and friends throughout tribal communities. Michael believes that we are stewards of our natural resources, and works to ensure those resources are available for future generations.

Tracie Merrill

Tracie Merrill has worked as the Environmental Assistant for the SVT in Seldovia, Alaska, since 2009. She is responsible for assisting SVT’s Environmental Coordinator in field work for the various environmental projects and programs being undertaken by the tribe: data entry, analysis, and management; technical report writing; and assisting in grant proposal writing. Ms. Merrill received her M.S. in Marine Biology from the University of Alaska – Fairbanks in 2008 and her B.S. in Marine Biology from the University of Maine – Machias in 2004. Prior to working for SVT, she worked as an Avian Science Technician, Marine Science Instructor, Naturalist, Fisheries Observer, and at a marine mammal stranding center and an aquarium in New Jersey.

Abstract

SVT’s Environmental Coordinator and Assistant will discuss: 1) a Fish Consumption Assessment undertaken for four villages in Cook Inlet, Alaska (Seldovia, Port Graham, Nanwalek, and Tyonek) between 2011 and 2012 to determine current fish and shellfish consumption rates of tribal members as well as consumption rates of other selected traditional foods, 2) results of this assessment, and 3)

collaboration with the U.S. Environmental Protection Agency and the Alaska Department of Environmental Conservation (ADEC) in this assessment as well as tissue sampling of sockeye salmon within Cook Inlet for contaminants in partnership with ADEC's Fish Tissue Monitoring Program.

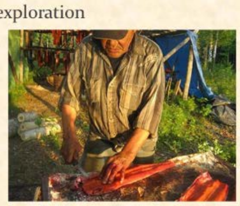
SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION
State-Tribal Partnership for Developing Advisories for Cook Inlet – Bob Gerlach

Population 640,000
229 Federally Recognized Tribes

3 million lakes 12,000 rivers 33,000 miles of coastline
Spanning 3 different seas: Arctic Ocean, Pacific Ocean, Bering Sea

Sources of Environmental Contaminants

- Local
  - Natural Geologic sources, forest fires
  - Cities and Industrial production
  - Military Sites
  - Resource Extraction- mines, oil exploration



- Long Range Transport
  - Atmospheric
  - Ocean Currents
  - Animal migration
  - Commercial transport

Fish Monitoring Program:

General Survey of Alaskan Fishes:
- Commercial , Subsistence, Recreational species
- Collaborative Effort for sample collection
  - Federal and State agencies, commercial, recreational and subsistence fish harvest
  - Outreach of data results

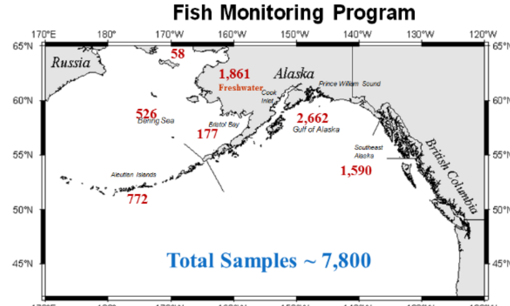
Selected coastal sites:
- Remote communities and villages
- Adjacent to anthropogenic activities:
  - cities, discharges/runoff
- Historic mining sites

Analyze Finfish and Invertebrates:

Evaluate contaminant levels in skinless fillet and whole fish from freshwater, estuaries and marine environments

- ***Data is used to:***
  - Determine if there are any areas, species, or contaminants that warrant more in-depth sampling and evaluation.
  - Provide Alaskan residents with information to make an informed dietary decision based on Risks and Benefits of eating. Alaskan Fish State wide and local advisories.
- **2014 Updated Fish Consumption Advice for Alaskans**

Areas Fish were Collected for the Fish Monitoring Program



Number of Fish Samples per Region

SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION
State-Tribal Partnership for Developing Advisories for Cook Inlet – Bob Gerlach

Fish Monitoring Program

ATKA MACKEREL	10
BURBOT	27
CAPELIN	45
CHAR-ARCTIC + DOLLY VARDEN	50
CRABS	368
CISCO	47
CLAMS, COCKLES, CHITON,SEA CUMBER	379
COD	195
EULACHON (Candlefish)	35
GEODUCK	132
GRAYLING	47
GREENLING	45
HALIBUT	1919
HERRING	32
IRISH LORD-RED	19
IRISH LORD-YELLOW	14
LAMPREY	10
LINGCOD	230
MUSSELS, BLUE	44
NORTHERN PIKE	572
OCTOPUS-SQUID	12
OYSTERS-SCALLOPS	141
POLLOCK	195
ROCKFISH-BLACK	79
ROCKFISH-DUSKY	66
PACIFIC OCEAN PERCH	83
ROCKFISH-YELLOWEYE	116
ROCKFISH SPECIES	66
SABLEFISH	249
SALMON-CHINOOK	479
SALMON-CHUM	302
SALMON-PINK	188
SALMON-RED	401
SALMON-SILVER	664
SAND LANCE	47
SHARK	111
SPINY DOGFISH	52
SHEEFISH	16
SKATE	186
SOLE, FLOUNDER	30
STICKLEBACK, SCULPIN	121
TROUT-LAKE	124
WHITEFISH	142

State Tribal Partnership with Cook Inlet Tribal Villages

- Communities of Seldovia, Port Gram, Nanwalek and Tyonek

ADEC Division of Water Triennial Review

- Recent studies have determined that the Fish Consumption Rate used in the current Human Health Criteria formula may not accurately reflect consumption rates in certain parts of Alaska
- Stakeholders have called for ADEC to review and revise the Human Health Criteria
- ADEC is working with many tribal organizations and communities to establish consumption rates

Assessment of Contaminants in Subsistence Foods of Cook Inlet

- Collaborative effort to design, collect and analyze fish samples
- Existing fish contaminant data for the area was provided
- ADEC involvement includes:
  - Assistance in drafting QAPP
  - Sampling SOP
  - Shipping and analytical analysis

Assessment of Contaminants in Subsistence Foods

- Analytes of interest:
  - Trace elements: THg, MeHg, As, Cd, Cu, Pb, Se
  - Organochlorine pesticides (18), Toxaphene, PCBs, PBDEs
- Data will be added to ADEC existing database
- Snapshot of contaminants in important subsistence foods
- Guidance for future work in Cook Inlet

- **Complex Issue:**
  - Varied sources of Environmental Contaminants
  - Site specific and regional differences
  - Possible Impacts on ecosystem health
    - Water quality
    - Animal health – food quality
    - Public health
  - Benefits of subsistence diet
  - Need for monitoring to determine presence and evaluate trends
  - Need for clear information to the public

SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION
State-Tribal Partnership for Developing Advisories for Cook Inlet – Bob Gerlach

Cook Inlet Subsistence Consumption Assessment and Sockeye Salmon Tissue Sampling Project



by Michael Opheim and Tracie Merrill
Seldovia Village Tribe

History/Background

- Communities/villages of Seldovia, Port Graham, Nanwalek, and Tyonek are all within the Cook Inlet region of Alaska – all are only accessible by boat or plane and all are small (populations range from 171 to 420); fishing communities
- Alaskan Native cultures within region: Aleut, Alutiiq, Yupik, Dena'ina
- Between 2011 and 2012, SVT staff conducted an assessment (i.e. survey) of Tribal Members from these 4 villages


Map of Cook Inlet:


History/Background (continued 1)

Assessment funded by Indian General Assistance Program (IGAP or GAP) unmet needs grant

Why did we want to do it?

- Concern about contaminants in the traditional foods our Tribal members eat (especially fish!) and exposure to these contaminants
- Believe there is an underestimation of fish consumption rates used to currently calculate ambient water quality criteria for human health
  - EPA = recommends 17.5 g/d = 0.62 oz (Powell 2011)
    DEC = uses 6.5 g/d = 0.23 oz (Powell 2011)

History/Background (continued 2)

- Last study (before this one) to look at fish consumption rates of Cook Inlet Tribal members was done by the Agency for Toxic Substances and Disease Registry (ATSDR 2009) - came up with a much higher average daily rate of fish consumption based on Port Graham Tribal members: 202 g/d = 7.1 oz
- Traditional foods comprise 40 % - 90 % of rural Alaskan diets (ATSDR 2009)
- No previous studies for Cook Inlet tribes examined consumption of particular fish parts, or how the frequency and process of particular cooking methods or breastfeeding influenced exposure to contaminants

Assessment activities:

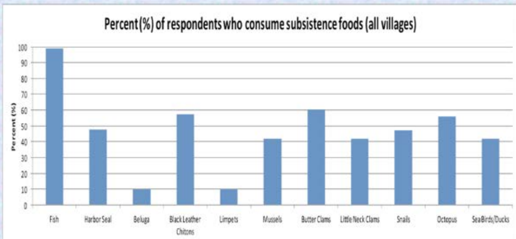
- Modeled project design on survey done by Columbia Inter-Tribal fish commission- 1994
- Coordinated with all the participating tribes
- Developed lots of documents
- Hired and trained two interviewers from each village
- Randomly interviewed 19 adult Tribal members (18 years old and up) from each village – SVT staff acted as monitors
- Use food models and recorders
- Adults were asked to give fish consumption information for the youngest child (under 18) in their households
- Final report and a summary report was written up

SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION

State-Tribal Partnership for Developing Advisories for Cook Inlet – Michael Opheim and Tracie Merrill

Findings:

- Total of 76 interviews
- Even number of female and male participants (38)
- Obtained dietary information for 35 children



Percent (%) of respondents (n=76) who consume subsistence foods. Weighted data. Seldovia data not included for beluga (n=57) or snails (n=57).

Cook Inlet Tribes (values for fish and non-fish consumers combined). Weighted.

	Average ± SE	Median	95%
Total Fish			
All respondents (n=76)	94.8 ± 23.5	46.5	247.1
Males (n=38)	109.5 ± 39.2	54.1	290.8
Females (n=38)	79.8 ± 26.3	42.6	175.7
Fishers (n=68)	99.0 ± 26.1	48.6	253.2
Non-Fishers (n=8)	45.8 ± 19.4	25.0	110.8
18-39 years old (n=24)	99.4 ± 41.6	43.5	232.9
40-59 years old (n=30)	109.6 ± 48.9	48.6	316.7
60+years old (n=22)	62.5 ± 13.6	44.2	151.5
Shellfish (snails not included for Seldovia)			
	Average ± SE	Median	95%
All respondents (n=76)	12.0 ± 3.4	3.3	36.7
Males (n=38)	9.4 ± 3.5	2.1	29.7
Females (n=38)	14.7 ± 5.8	4.1	63.2
Fishers (n=68)	11.9 ± 3.6	2.9	34.5
Non-Fishers (n=8)	13.7 ± 8.9	3.5	50.2
18-39 years old (n=24)	8.4 ± 3.0	3.6	29.3
40-59 years old (n=30)	11.7 ± 4.5	1.2	47.3
60+years old (n=22)	18.3 ± 8.3	6.1	84.0
Total Seafood (snails not included for Seldovia)			
	Average ± SE	Median	95%
All respondents (n=76)	106.8 ± 23.9	55.3	267.1
Males (n=38)	118.9 ± 39.3	61.0	291.0
Females (n=38)	94.5 ± 27.7	50.2	241.1
Fishers (n=68)	110.9 ± 26.6	54.1	271.8
Non-Fishers (n=8)	59.5 ± 19.5	55.0	118.3
18-39 years old (n=24)	107.8 ± 42.7	51.5	242.2
40-59 years old (n=30)	121.2 ± 49.0	50.3	328.0
60+years old (n=22)	80.8 ± 17.8	60.8	259.1

Cook Inlet Tribes (all children). One outlier excluded. Weighted.

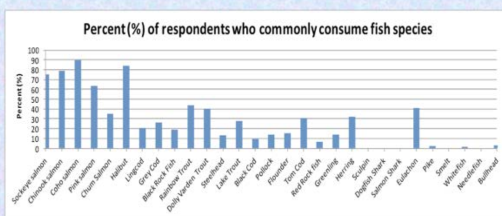
	Average ± SE	Median	95%
All (n=34)	58.0 ± 16.3	40.5	177.8
5 yrs old and younger (n=17)	34.9 ± 17.4	12.8	134.1
6 to 17 yrs old (n=17)	83.3 ± 25.8	67.3	203.7

Cook Inlet Tribes (only children who eat fish). One outlier excluded. Weighted.

	Average ± SE	Median	95%
All (n=30)	67.0 ± 17.5	40.5	186.6
5 yrs old and younger (n=13)	47.1 ± 20.9	31.8	151.8
6 to 17 yrs old (n=17)	83.3 ± 25.8	67.3	203.7

Tribe(s)	Average age children (who ate fish) started eating fish (months)	Percentage of women that have given birth	Percentage of women who have given birth who currently are breast-feeding or have breast-fed	Average age children (who were breast-fed) stopped being breast-fed (months)	Reference
Cook Inlet Tribes	11.8 (± 2.6 SE)	96.3%	68%	11.5 (± 2.3 SE)	This current assessment
Suquamish Indian Tribe	12				Suquamish 2000
Tulalip and Squaxin Island Tribes	39		43% and 75% of children had been breast-fed (respectively)	8 to 9	Toy et al. 1996
Columbia River Basin Tribes	13.1 (± 0.7 SE)	88%	42%	7.6 (± 0.6 SE)	CRITFC 1994

Women who breast-fed, consumed on average, 100.1 (± 38.5 SE) g/d of fish per day which is higher than the mean fish consumption rate found, in general, for women (79.8 (± 26.3 SE) g/d) within the tribal population.



Percent (%) of respondents (n=75) who commonly consume fish species. Weighted data. Seldovia data not included in this graph for the following species: pike, smelt, whitefish, needlefish, and bullhead

Table 3. Consumption of anadromous fish species by percent of total fish consumption per month. Percents are based on consumption of only listed fish species identified in questionnaire (based upon number of times fish species are eaten in a month and average fish portion sizes as indicated by respondents). Unweighted data. One outlier excluded from Port Graham's data.

Village	Fish Species										
	Sockeye salmon	Chinook salmon	Coho salmon	Pink salmon	Chum salmon	Dolly varden trout	Steelhead	Eulachon	Rainbow trout	Lake trout	Smelt
Seldovia (n=19)	24.7	10.3	14.0	8.8	4.1	0.6	0.0	1.4	0.7	0.4	N/A
Port Graham (n=18)	17.7	9.4	17.9	7.6	6.8	3.0	1.2	2.2	3.1	1.0	0.0
Nanwalek (n=19)	14.2	1.8	20.7	16.5	2.5	6.3	0.4	5.2	4.2	2.6	0.0
Tyonek (n=18)	9.2	40.6	24.2	0.9	0.9	1.3	2.3	9.2	2.7	1.6	0.0

Table 4. Consumption of non-anadromous fish species by percent of total fish consumption per month. Percents are based on consumption of only listed fish species identified in questionnaire (based upon number of times fish species are eaten in a month and average fish portion sizes as indicated by respondents). Unweighted data. One outlier excluded from Port Graham's data.

Village	Fish Species										
	Halibut	Lingcod	Grey cod	Black rockfish	Black cod	Pollock	Flounder	Tomcod	Red rockfish	Greenling	Herring
Seldovia (n=19)	19.8	1.9	4.6	0.7	1.0	2.9	0.0	1.0	0.7	0.8	1.7
Port Graham (n=18)	10.1	1.9	1.3	1.5	1.4	6.6	2.0	1.3	0.9	0.9	1.3
Nanwalek (n=19)	11.3	0.5	1.0	1.4	0.1	1.7	0.6	4.2	0.0	1.6	2.8
Tyonek (n=18)	5.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.1

SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION

State-Tribal Partnership for Developing Advisories for Cook Inlet – Michael Opheim and Tracie Merrill

- Top three sources of fish:
  - 80.8% of all respondents obtained their fish by personally harvesting the fish themselves and/or through family members
  - 9.7% from friends
  - 4.8% from ceremonies
- Most popular fish cooking methods were smoking, canning, pan-frying, and baking

Collaboration with ADEC, EPA, and other tribes (outside of partner tribes)

- Peer reviewing
- Have given numerous presentations
- Shared assessment documents
- Working closely with the Sun'aq Tribe of Kodiak
- From 2011-2013, DEC was undergoing a Triennial Review
  - Shared assessment final report with EPA and ADEC
  - Assisted consultant (hired by ADEC) with a literature review of dietary studies
  - Attended an informational workshop in Homer, AK, on permitting for oil and gas development and production in Cook Inlet

Okay, tribal members eat a lot of fish but what's in our fish?

- Funded by an EPA IGAP unmet needs grant to test 36 whole body sockeye salmon caught within Cook Inlet for contaminants– suppose to have happened this summer (2014) but by time QAPP approved, missed sockeye salmon runs so ???....
- Salmon will be tested through ADEC's fish tissue monitoring program following their protocols and documentation– analyzing free of charge for us
- Two samplers hired from each village to collect samples
  - 9 samples collected from around each village (4 villages)
  - composite samples made up of three whole body fish homogenized

What we have done so far:

- Lined up samplers
- Purchased supplies and got kits assembled
- Got QAPP approved
- Worked with ADEC (they have been great) to develop QAPP, sampling design, and methods
- Researched available contaminant data for fish and shellfish collected within Cook Inlet
- Created SOPs for samplers

Acknowledgements:

BIG THANKS TO:

- The Columbia River Basin tribes and Columbia River Inter-Tribal Fish Commission
- IGAP staff and Tribal council members of Port Graham, Nanwalek, and Tyonek
- Interviewers and samplers
- All the Tribal members who participated in assessment
- EPA
- ADEC – especially for helping us with our QAPP, project design, and lab analysis
- Alaska Native Tribal Health Consortium (ANTHC)

QUESTIONS???

Michael Opheim, SVT Environmental Coordinator
907-435-3247
mopheim@svt.org

Tracie Merrill, SVT Environmental Assistant
907-435-3261
tmerrill@svt.org

Seldovia Village Tribe

Tradition Integrated with Technology

Questions and Answers

Note: No questions were asked.

State-Tribal Partnership for Developing Advisories for the Upper Columbia River/Lake Roosevelt

Liz Carr, Washington; Cindy Marchand, Confederated Tribes of the Colville Reservation

Biosketch

Liz Carr
Liz Carr is the Fish Advisories Program Coordinator for the Office of Environmental Health, Safety, and Toxicology at the Washington State Department of Health. She received her B.S. in Marine Biology and M.S. in Environmental Studies from The Evergreen State College. She developed Washington State's Healthy Fish Guide using a social marketing approach that helps guide the public to eat fish high in health benefits and low in contaminants identified by toxicologists. With over 15 years' experience coordinating marine-related scientific research projects and environmental and public health programs, she is interested in the intersection of science, advocacy, policy, program development, and public education.

Cindy Marchand
Cindy Marchand is the CERCLA Coordinator for the Confederated Tribes of the Colville Reservation Office of Environmental Trust Boundary Waters Program. She is a graduate of Eastern Washington University receiving a B.A. in Interdisciplinary Studies with an emphasis in Business Administration, Economics, and Anthropology. Ms. Marchand works on the Remedial Investigation/Feasibility (RI/FS) Study on the Upper Columbia River/Lake Roosevelt Site in Washington State. She was the lead on the Upper Columbia River Tribal Consumption and Resource Use Study, the largest tribal survey ever conducted.

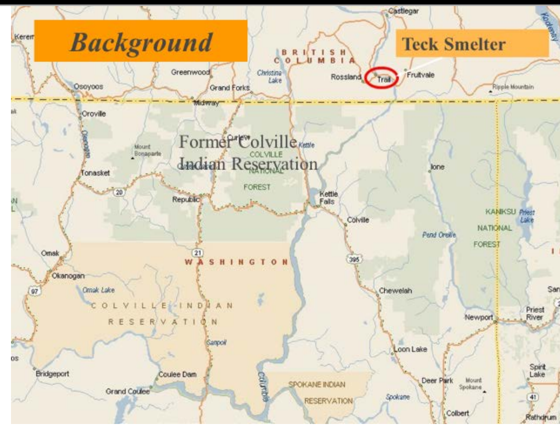
Abstract
RI/FS studies dating back to 2001, including the Upper Columbia River Tribal Consumption and Resource Use Study, are yielding critical information for visitors and residents wishing to safely swim, play, fish, and enjoy Lake Roosevelt. This session will demonstrate how federal, state, and tribal government and local groups partnered to summarize human health information resulting in unique fish advisory information and an in-progress survey to determine the effectiveness of these outreach materials that promote our common goal: to keep people eating fish.

SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION
State-Tribal Partnership for Developing Advisories for the Upper Columbia River/Lake Roosevelt – Liz Carr

Washington State Department of Health

State-Tribal Partnership for Developing Advisories for the Upper Columbia River/Lake Roosevelt

Creating a Citizen's Guide to Human Health Findings



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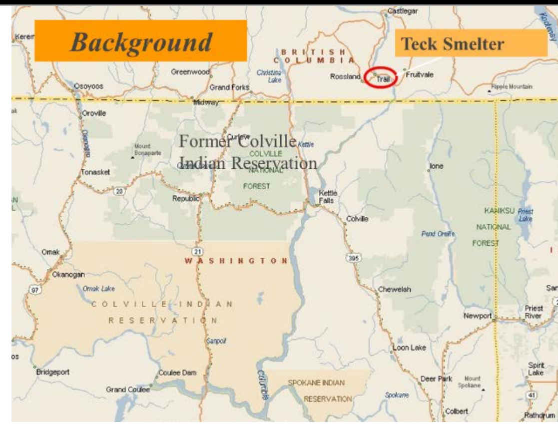
State-Tribal Partnership for Developing Advisories for the Upper Columbia River/Lake Roosevelt – Liz Carr



Teck Smelter, Trail BC

Tribal Involvement

- Early 90's federal, state, tribal entities & Lake Roosevelt Water Quality Council conduct baseline studies
- 1997-98 Tribes meet with State and Federal Agencies and Trustees to coordinate a comprehensive approach
- In 1999 Tribes petition EPA under CERCLA/Superfund to address sediment contamination

RI/FS Sampling/Studies Conducted

- Surface water sampling
- Beach sampling
- Sturgeon toxicity methods development
- Work Plan and other planning documents
- **Fish tissue sampling**
- Recreational Use Survey
- **Tribal Consumption and Resource Use Survey**
- Currently-Residential Soil Sampling/Upland Soil Sampling

Goals of the Survey

- Remedial Investigation/Feasibility Study (RI/FS)
- Potential Exposure Pathways from Resource Use
- Site specific data-How do we use these resources (food/non-food)

Survey Information

- The UCR Resources Survey is one of the largest ever done with a Tribal population in the nation
- Total of 5,469 surveys administered
- All surveys administered by Tribal Employees (24 Enrolled members and 2 descendents)

Results

2/3 of the people who were picked for the survey reported that they consume and/or use local resources **three or more** times per week.

SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION

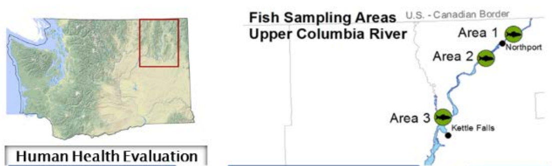
State-Tribal Partnership for Developing Advisories for the Upper Columbia River/Lake Roosevelt – Liz Carr and Cindy Marchand

Fish

- 83% of the Reservation population reported consuming fish. Majority of these fish are caught in various rivers, lakes, and creeks within the boundaries of the Colville Indian Reservation.

Avoidance of Resource Use

- 1,421 people responded affirmatively that they refrained from using or avoided any resources from the Upper Columbia River or Lake Roosevelt.
- The 993 people who avoid any resources or activities because of contamination or pollution specified that they avoid the following:
  - Fish: 97.55%
  - Activities: 26.85%
  - Animals other than fish: 19.31%
  - Plants: 12.90%



Human Health Evaluation

2300 Fish Samples: Burbot, Kokanee, Lake Whitefish, Largescale Sucker, Longnose Sucker, Mountain Whitefish, Rainbow Trout, Smallmouth Bass, Walleye → **385 chemicals, few of human health concern:** Mercury, PBDES, PCBs, Dioxins → **Drivers:** Mercury, PCBs

Health

Upper Columbia River/Lake Roosevelt Fish Advisory

2008: Fish Advisory issued: Burbot, largescale sucker – 1 meal per week
Walleye– Limit 2 meals per month.

2012: **DOH Updates Fish Advisory (Mercury & PCBs Drivers)**

Women who are or might become pregnant, nursing mothers, and young children:

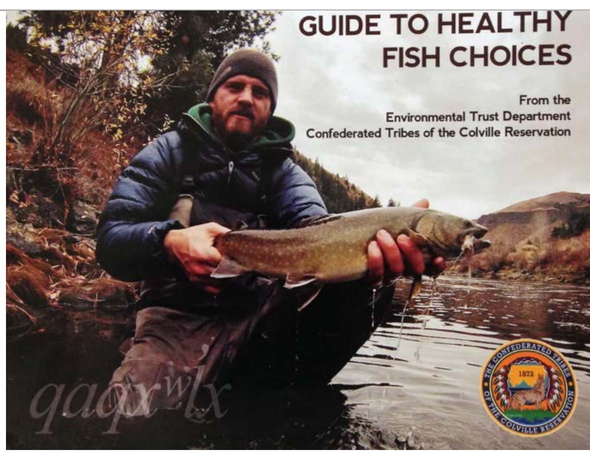
- Walleye, burbot, mountain whitefish, smallmouth bass – 1 meal per week
- Largescale Sucker – 2 meals per month
- Kokanee, lake whitefish, and rainbow trout– 2 to 3 meals per week.

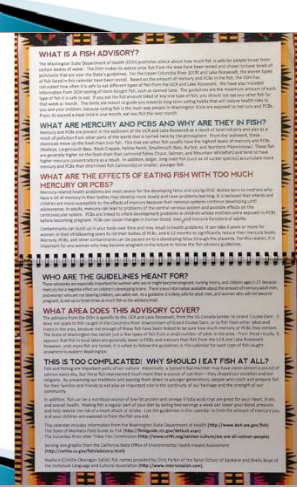
Statewide fish advisories due to mercury apply to UCR:

- Largemouth bass– 2 meals per month
- Northern pikeminnow– Do not eat

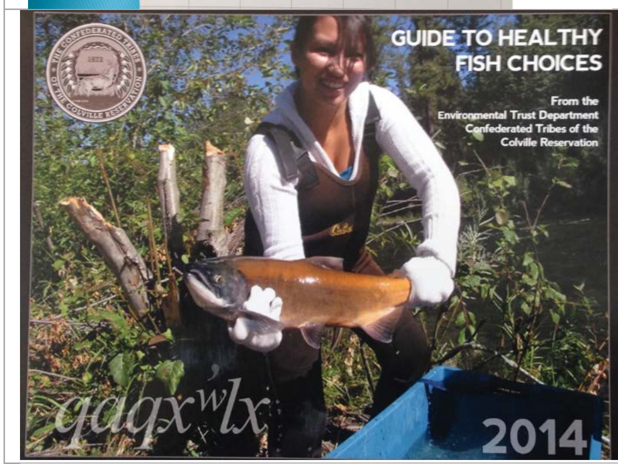
General Public : Everyone should limit largescale sucker to 4 meals per month (PCBs) and eat no more than 3 times the amount of the advisory fish.

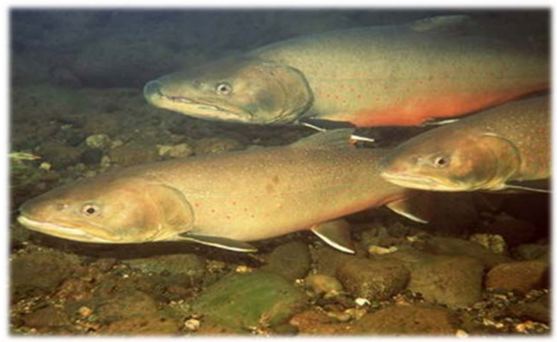
Health





SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION
State-Tribal Partnership for Developing Advisories for the Upper Columbia River/Lake Roosevelt – Liz Carr and Cindy Marchand





Upper Columbia River Fish Advisory– Outreach Workgroup

Citizens Groups/NGOs
Citizens for a Clean Columbia
Lake Roosevelt Forum

Tribal Government
Confederated Tribes of the Colville Reservation
Spokane Tribe of Indians

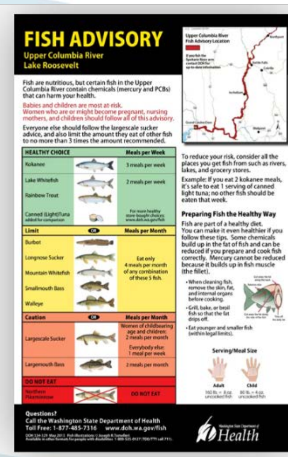
Local Health Departments
NE Tri County Health Department
Lincoln County Health Department

State Agencies
Department of Health
Department of Ecology

Federal Agencies
National Park Service
Environmental Protection Agency

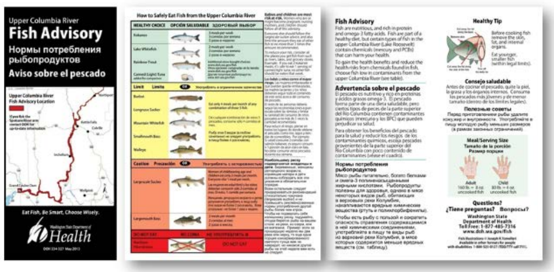
Fish Advisory

Poster 11 x 17
Flyer 8.5 x 11



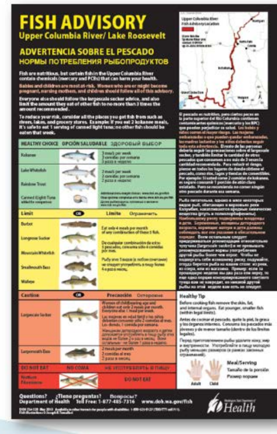
SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION
State-Tribal Partnership for Developing Advisories for the Upper Columbia River/Lake Roosevelt – Liz Carr and Cindy Marchand

Brochure : Translated into Spanish and Russian



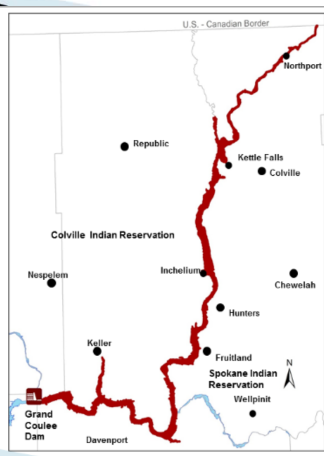
Poster 11 x 17
Flyer 8.5 x 11

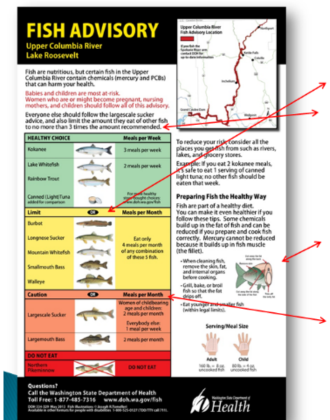
Translated
Spanish & Russian



Outreach Distribution

Boat Launches
Campground Kiosks
Fish Cleaning Stations
National Park Visitor Centers
Community Boards
Libraries
Local Health Departments
Post Offices
Tribal Health Clinics
Schools
Community Centers
Websites





Preliminary Survey Results
or
Most participants missed.

Everyone else– limit the amount they eat of the advisory fish to no more than 3 times the amount recommended.

Most participants missed.

Fish Preparation
Understood and said they would use.

Meals vs Servings
Majority of survey participants preferred serving over meal.
Servings per week
Servings per month

Thank you

Cindy Marchand, Colville Tribes

(509) 634-2075

Liz Carr, WA DOH

(360) 236- 3191

For more information
www.doh.wa.gov/fish

Questions and Answers

Note: There were no questions because the moderator moved along to the next speaker on this panel.

State-Tribal Partnership for Updating the Advisory for Clear Lake

Margy Gassel, California; Sarah Ryan, Big Valley Rancheria Band of Pomo Indians

Biosketch

Margy Gassel

Dr. Margy Gassel is a Research Scientist with the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA). She received a Bachelor's degree in Biology from the University of Tennessee, Knoxville, and a Master's degree and Ph.D. in Integrative Biology from the University of California at Berkeley. Dr. Gassel has worked with the Fish, Ecotoxicology, and Water Section since 1994, evaluating the health risks and benefits from fish consumption and developing and issuing advisories. She is involved in sampling design; fish consumption surveys; community outreach, education, and collaboration; and developing graphic presentations of advisory messages. In 2009, Dr. Gassel represented her agency on a marine debris research expedition to the North Pacific Gyre ("Great Pacific Garbage Patch") to investigate the role of marine debris in food web contamination.

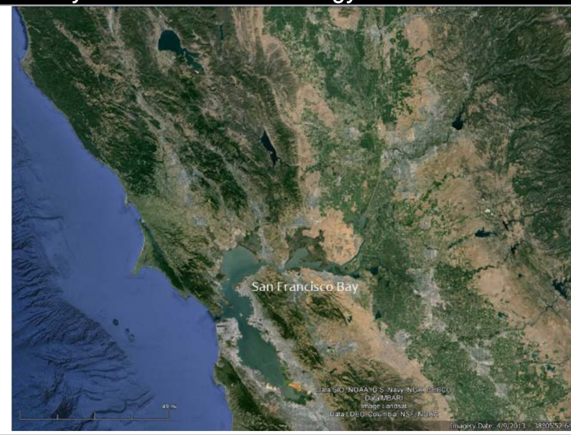
Sarah Ryan

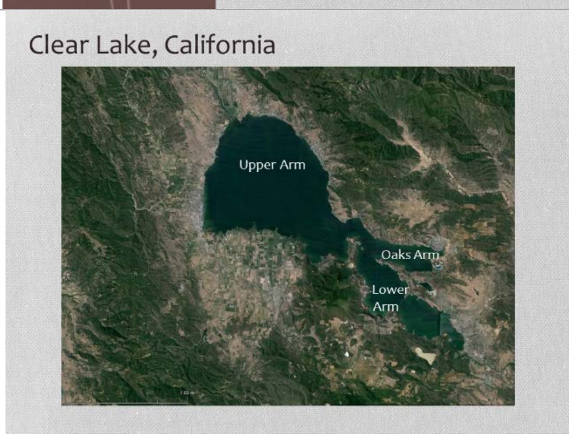
Sarah Ryan has worked for the Big Valley Rancheria Band of Pomo Indians since September 2001 and has been the Environmental Director since 2006. She has a degree in Government from the College of William and Mary in Virginia and has obtained various certifications for the environmental protection activities that she performs on a regular basis. Ms. Ryan has worked closely with tribal members, the Central Valley Regional Water Quality Board, and U.S. EPA Region 9 on water quality issues and fish consumption issues. This work includes algal toxin testing and water chemistry parameters and pesticide monitoring on Clear Lake and its tributaries, nutrient and mercury TMDL implementation measures on Clear Lake, and programmatic and policy development on regional water quality issues.

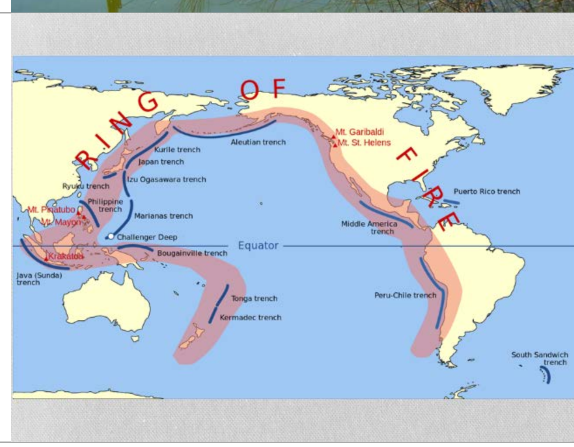
Abstract

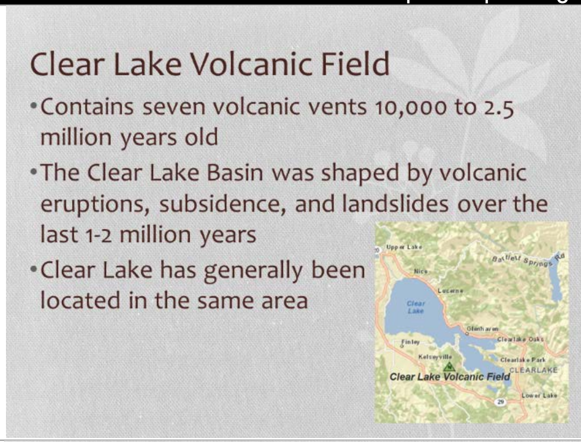
Clear Lake is a large natural lake located in the California Coast Range in Lake County, California. The Northern California Coast Range is naturally rich in mercury and other ores, and the Clear Lake Mining District in Lake County was one of the primary mercury producing districts in the late 1800s. Lake County is home to several bands of Pomo Indians and other Native Americans. The Elem Indian Colony of Pomo Indians is located adjacent to the Sulphur Bank Mercury Mine on the eastern shore of Clear Lake. OEHHA first provided advice for eating fish from Clear Lake in 1987 based on findings of mercury in fish collected from the lake. Since the original advisory was issued, further studies of mercury in Clear Lake were done, and OEHHA updated the advisory in 2005 and 2009. Like OEHHA's other advisories, however, only typical sport fish species were included in the advisory. Despite requests from the Big Valley Rancheria Band of Pomo Indians to include traditional tribal foods in the guidelines for Clear Lake, OEHHA was unable to obtain the necessary data until 2013. Once these data were received, OEHHA updated the advisory with input from tribal members. The updated advisory for Clear Lake now also includes species of interest to the tribe, such as clams. This accomplishment would not have been possible without collaboration with the tribal representatives.

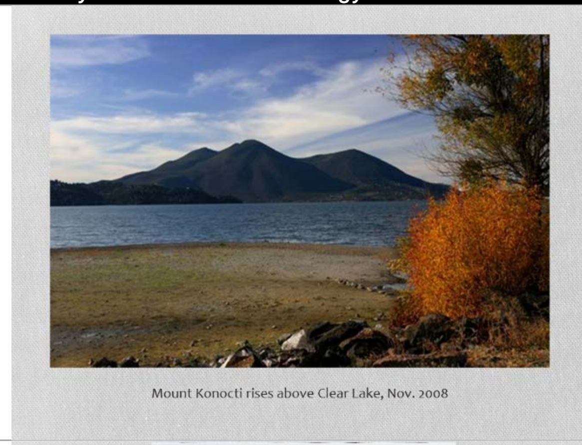
SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION
State-Tribal Partnership for Updating the Advisory for Clear Lake – Margy Gassel

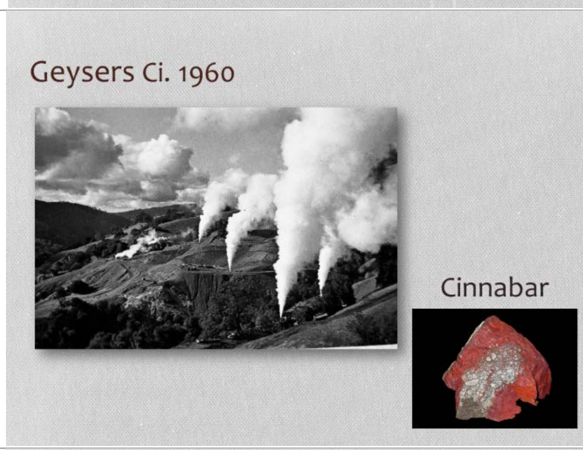


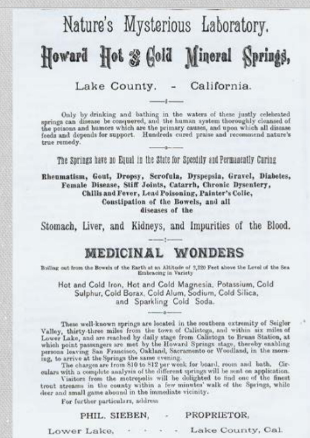







Mount Konocti rises above Clear Lake, Nov. 2008




Nature's Mysterious Laboratory.

Howard Hot & Cold Mineral Springs,

Lake County. - California.

Only by drinking and bathing in the waters of these justly celebrated springs can disease be conquered, and the human system thoroughly cleansed of the poisons and humors which are the primary causes, and upon which all disease feeds and depends for support. Hundreds cured praise and recommend nature's true remedy.

The Springs have no Equal in the State for Speedily and Permanently Curing

Rheumatism, Gout, Dropsy, Scrofula, Dyspepsia, Gravel, Diabetes, Female Disease, Stiff Joints, Catarrh, Chronic Dysentery, Chills and Fever, Lead Poisoning, Painter's Colic, Constipation of the Bowels, and all diseases of the

Stomach, Liver, and Kidneys, and Impurities of the Blood.

MEDICINAL WONDERS

Boiling out from the Bowels of the Earth at an Altitude of 2,220 Feet above the Level of the Sea Embracing in Variety

Hot and Cold Iron, Hot and Cold Magnesia, Potassium, Cold Sulphur, Cold Borax, Cold Alum, Sodium, Cold Silica, and Sparkling Cold Soda.

These well-known springs are located in the southern extremity of Seigler Valley, thirty-three miles from the town of Calistoga, and within six miles of Lower Lake, and are reached by daily stage from Calistoga to Bruns Station, at which point passengers are met by the Howard Springs stage, thereby enabling persons leaving San Francisco, Oakland, Sacramento or Woodland, in the morning, to arrive at the Springs the same evening.

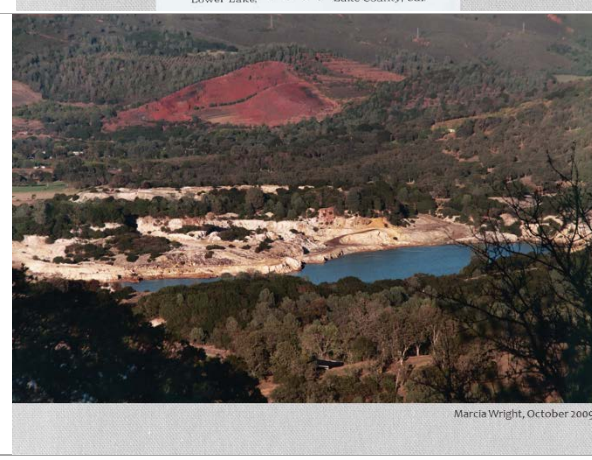
The charges are from $10 to $12 per week for board, room and bath. Circulars with a complete analysis of the different springs will be sent on application.

Visitors from the metropolis will be delighted to find one of the finest trout streams in the county within a few minutes' walk of the Springs, while deer and small game abound in the immediate vicinity.

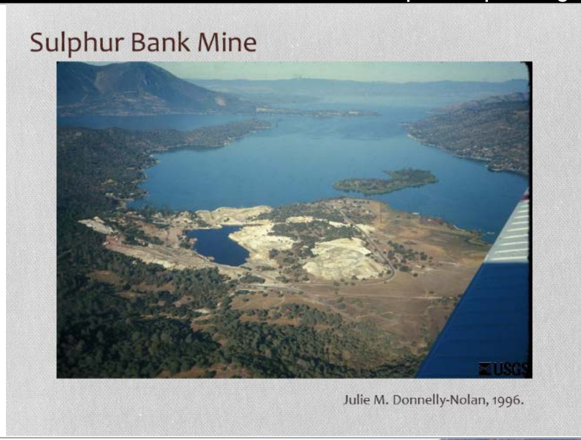
For further particulars, address

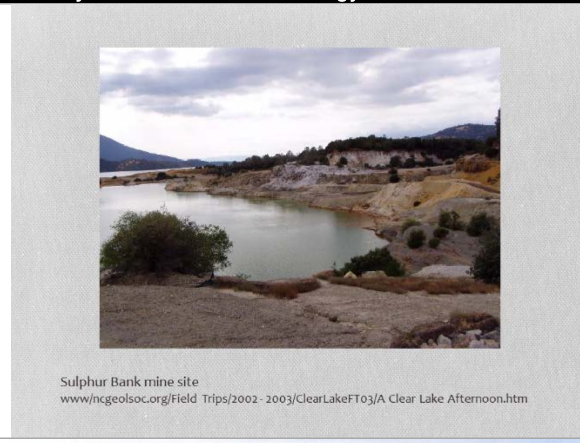
PHIL. SIEBEN, - PROPRIETOR,

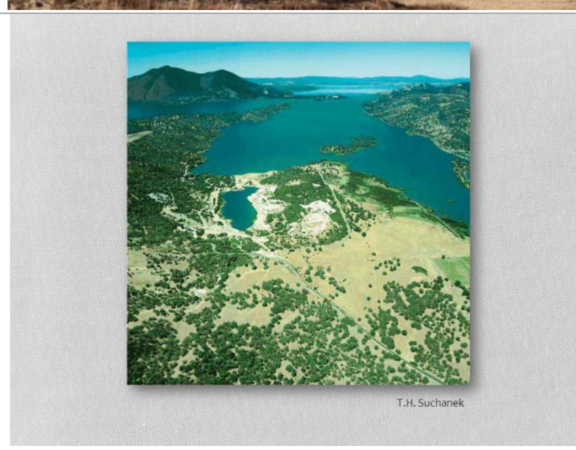
Lower Lake, - - - - Lake County, Cal.


Marcia Wright, October 2009

SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION
State-Tribal Partnership for Updating the Advisory for Clear Lake – Margy Gassel







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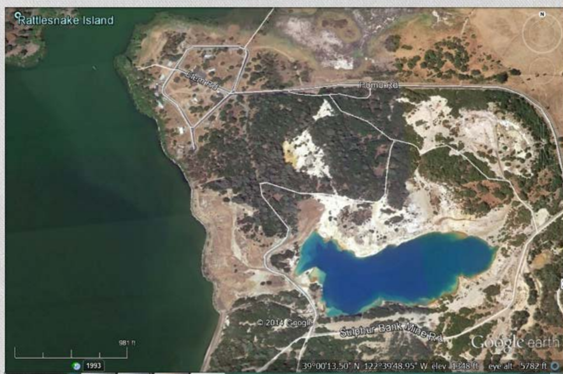

8/17/2013

USEPA Remediation

- Erosion control measures to stabilize the shoreline waste pile
- Removal of the contaminated soil from residential yards in the Elem Tribal Colony
- Construction of surface water controls to prevent overflows of contaminated water to Clear Lake
- Proper closure and abandonment of three geothermal wells at the mine property
- Contaminated mine waste removal from roadways and adjacent areas
- Installation of a test cap in Oaks Arm to cover contaminated sediments

Advisory History at Clear Lake

- 1987: OEHHA's first advisory for eating fish from Clear Lake
- 2005: OEHHA updated the Clear Lake advisory using data compiled to develop a Total Daily Maximum Load (TMDL)
- 2009: OEHHA updated its fish advisories and applied Advisory Tissue Levels to all advisories
- 2014: Clear Lake advisory updated to include species of interest to Tribe

State-Tribal Collaboration

- Big Valley Rancheria Band of Pomo Indians
  - Tribe approached state with concerns about species of interest to the Tribe
  - Requested OEHHA include species of interest in advisory
  - Sarah Ryan and John Gichuki provided detailed information on Native American Traditional Lake Foods
    - Historical and current consumption from Tribal elders, confirmed with younger members

Tribal Correspondence

"A large number of fish species, mussels, clams (and even some aquatic birds) that form significant ingredient in the protein supply to the tribal members were somehow left out in the fish advisory"

"Harvests from the lake may not directly target fish but could be a combination of fish, clams, mussels and some other aquatic organisms including birds and plants"

Main staple eaten year round – fish

- Fish (Sha) 10 lbs per family/2-3 lbs per day
  - Blackfish (extinct)
  - Hitch (extinct) not to be confused with Chai
  - Ah-ah-sha (extinct) yellow cat
  - Sha-pal (extinct) like steelhead
  - Dee-tah (extinct) like crappe
  - Sun Perch (extinct)
  - Bluegill
  - Trout
  - Bass
  - Catfish
- Whole fish baked or dried traditionally.
- Still consumed, although currently at smaller amounts.

Other Traditional Foods

Mudhens (American coots)
Eaten twice a week, 1 per person when available
Still consumed by a few Tribal members

Eggs (Xkoh) crane, duck, mudhen, grebe, etc.
As much as one could gather, as often as possible
Still consumed by a few Tribal members

Clams (August, September, October)
3-4 lbs per family per day (when desired)
At the present time, children collect as many clams through the summer to be cooked at home every day
boiled to open, floured and deep fried

Ducks (September – November)
When desired
Still consumed by a few Tribal members

Other Traditional Foods continued

Tules
Unable to get amount eaten. Still consumed.
Stalks eaten April – May
Roots eaten June – July

Cattails
New shoots eaten during the spring

List of Aquatic Organisms

1. Golden clam (*Corbicula fluminea)*
2. Pink Heelpsplitter- *Potamilus alatus* (Mussel)
3. Tule perch (*Hysterocarpus traskii traskii)*
4. Prickly sculpin (*Cottus asper*)
5. California roach (*Lavinia symmetricus*)
6. Clear lake split-tail (*Pogonichthys ciscoides*)
7. Threadfin shad (*Dorosoma petenense*)
8. Inland silverside (*Menidia beryllina*)
9. Mosquito fish (*Gambusia affinis*)
10. Mudhens (Ducks)

Obtaining Data Needed to Address Tribal Consumption

- Long-term mercury studies (1988-2004) at Clear Lake by University of California at Davis researchers
- 2013: OEHHA received dataset
  - Mussels, clams, crayfish, prickly sculpin, threadfin shad, inland silversides, and juvenile sport fish
  - Historical data from other programs (sport fish)
  - Supplemented with new sport fish data (NLFTS and SWAMP)

List of Aquatic Organisms 2

1. Golden clam (*Corbicula fluminea)* 
2. Pink Heelpsplitter- *Potamilus alatus* (Mussel) 
3. Tule perch (*Hysterocarpus traskii traskii)*
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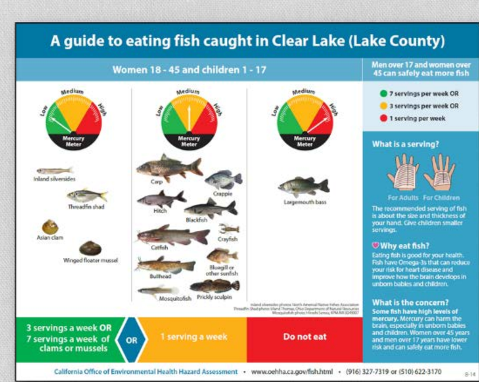
7. Threadfin shad (*Dorosoma petenense*) 
8. Inland silverside (*Menidia beryllina*) 
9. Mosquito fish (*Gambusia affinis*) 
10. Mudhens (Ducks)

Advisory Protocol Modifications

- Species—OEHHA previously did not evaluate and include small forage fish
- Whole fish—OEHHA generally advises eating the fillet only
- Tribal review—the Tribe asked to review the advisory report prior to its release



Mercury Contamination

"Although Clear Lake is one of the most mercury-contaminated lakes in the world, biota do not exhibit methylmercury concentrations as high as would be predicted based on the gross level of mercury loading."

Suchanek et al. Ecological Applications, 18(8) Supplement, 2008, pp. A12–A28

Acknowledgements

- Sarah Ryan and John Gichuki, Big Valley Rancheria Band of Pomo Indians
- Tom Suchanek, USGS
- Bob Brodberg, OEHHA

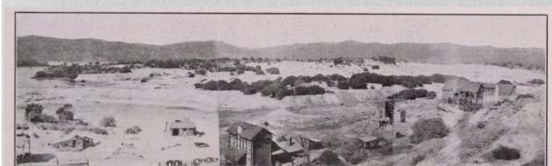
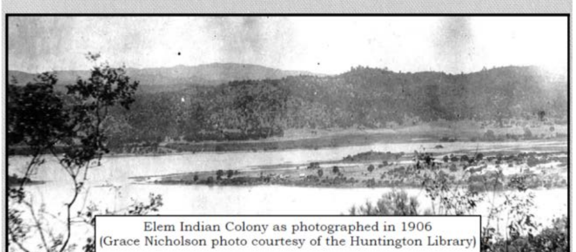
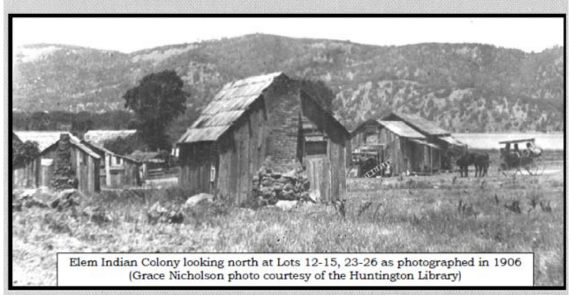


Photo No. 10. Panoramic view of the Sulphur Bank Mine, Lake County, showing surface workings and dumps. Looking northerly.



Elem Indian Colony as photographed in 1906
(Grace Nicholson photo courtesy of the Huntington Library)



Elem Indian Colony looking north at Lots 12-15, 23-26 as photographed in 1906
(Grace Nicholson photo courtesy of the Huntington Library)

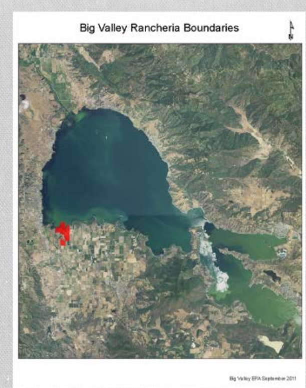
SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION
State-Tribal Partnership for Updating the Advisory for Clear Lake – Sarah Ryan

STATE-TRIBAL PARTNERSHIP FOR UPDATING THE ADVISORY FOR CLEAR LAKE

Margy Gassel, Ph.D.
California Office of Environmental Health Hazard Assessment (OEHHA)
Sarah Ryan
Environmental Protection Department, Big Valley Rancheria Band of Pomo Indians

Clear Lake

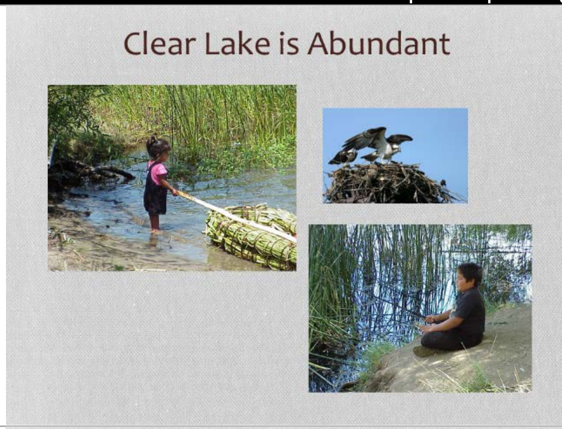
Sacramento River and San Joaquin River Basin, Central Valley Regional Water Quality Control Board, Region 5

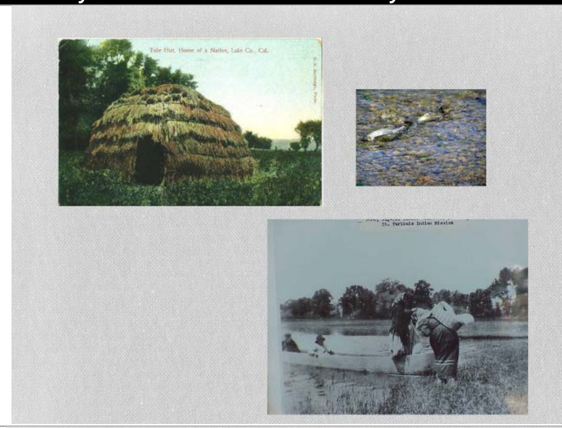


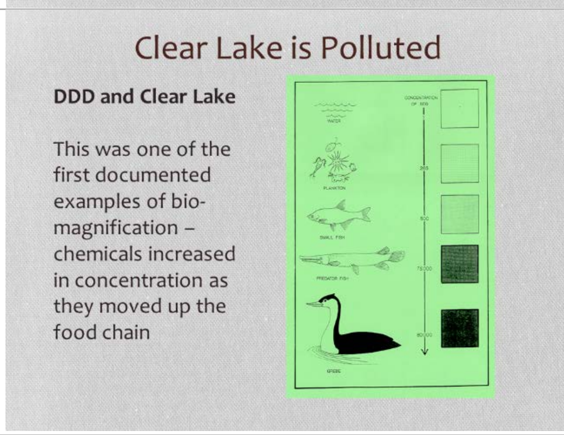
Clear Lake is the Largest, Natural Freshwater Lake in California

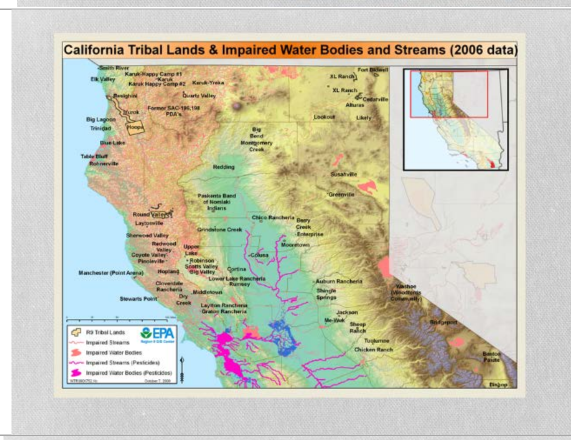
- Core samples of the lake's sediments taken by indicate that the lake is at least 480,000 years old.
- 100 miles of shoreline
- Surface area of 43,785 acres, 1,155,000 acre-foot capacity
- Average depth is 27 feet, max is 60 feet

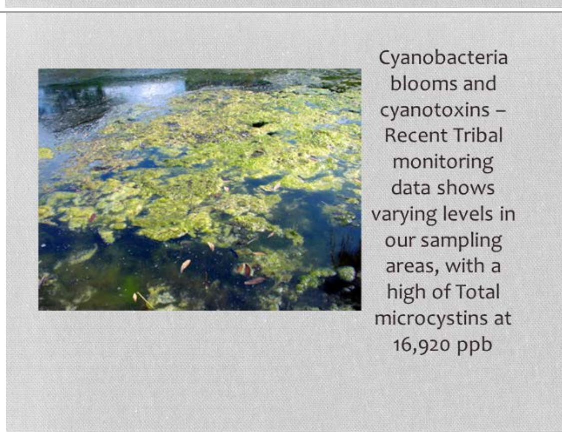
SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION
State-Tribal Partnership for Updating the Advisory for Clear Lake – Sarah Ryan











SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION

State-Tribal Partnership for Updating the Advisory for Clear Lake – Sarah Ryan

Tribal Concerns about Policies

- Traditional foods are not considered in guidelines and regulatory frameworks
- Traditional consumption rates are not accepted
- Disproportionate Tribal exposures to contaminants due to lifestyle and ceremonial obligations

Tribal Concerns about Policies (continued)

- Traditional Ecological Knowledge about land stewardship is not utilized
- Sharing of information does not always occur because of concern for misuse of data
- Importance of communication from agencies and Tribes to ensure that Tribal uses are protected

Overview of Traditional Lake Foods

Main staple eaten year round – fish

Fish (Sha) 10 lbs per family/2-3 lbs per day
Blackfish (extinct)
Hitch (extinct) not to be confused with Chai
Ah-ah-sha (extinct) yellow cat
Sha-pal (extinct) like steelhead
Dee-tah (extinct) like crappe
Sun Perch (extinct)
Bluegill
Trout
Bass
Catfish

Whole fish was eaten either baked or dried traditionally. Still consumed, although currently at smaller amounts.

Tules – unable to get amount eaten. Still consumed.
Stalks eaten April – May
Roots eaten June – July

Mudhens (American coots)
Eaten twice a week, 1 per person when available
Still consumed by a few Tribal members

Eggs (Xkoh) crane, duck, mudhen, grebe, etc.
As much as one could gather, as often as possible
Still consumed by a few Tribal members

Clams (August, September, October)
3-4 lbs per family per day (when desired)
At the present time, children collect as many clams through the summer to be cooked at home every day – boiled to open, floured and deep fried

Cattails
New shoots eaten during the spring

Ducks (September – November)
When desired
Still consumed by a few Tribal members

One thing we have observed is that a large number of fish species, mussels, clams (and even some aquatic birds) that form significant ingredient in the protein supply to the tribal members were somehow left out in the fish advisory maybe inadvertently, not considered fish (in the strict definition of fish) or for other reasons not clear to us. The list of aquatic organisms we have assembled (harvests from the lake may not directly target fish but could be a combination of fish, clams, mussels and some other aquatic organisms including birds and plants) are as follows

1. Golden clam (*Corbicula fluminea)*
2. Pink Heelpsplitter- *Potamilus alatus* (Mussel)
3. Tule perch (*Hysterocarpus traskii traskii)*
4. Prickly sculpin (*Cottus asper*)
5. California roach (*Lavinia symmetricus*)
6. Clear lake split-tail (*Pogonichthys ciscoides*)
7. Threadfin shad (*Dorosoma petenense*)
8. Inland silverside (*Menidia beryllina*)
9. Mosquito fish (*Gambusia affinis*)
10. Mudhens (Ducks)

Are there any efforts at the moment to update the fish advisory to consider some of these fish and other aquatic organisms of interest to the tribe. Thanks and have a nice day. John

Some Solutions?

- Incorporating Tribal scientists and Tribal data into guidelines.
- Ensure that local uses and users guide development of our work
- Face to face contact, visits from agencies, don't expect information to flow up through local government

Some Solutions? (continued)

- Tribal Fish Consumption Studies
- Adoption of cultural beneficial uses
- Adoption of subsistence fishing beneficial uses

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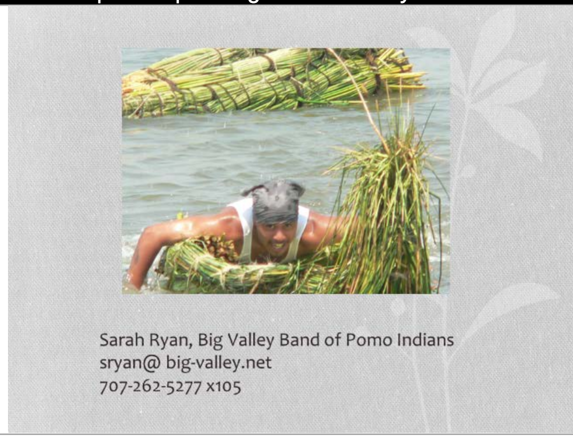


Questions and Answers

Note: There were no questions because the moderator adjourned the session for the lunch break.

State-Tribal Partnership for Developing Advisories for the St. Lawrence River Watershed

Faith Schottenfeld, New York; Tony David, Saint Regis Mohawk Tribe

Biosketch

Faith Schottenfeld

Dr. Faith Schottenfeld has been with the New York State Department of Health for 30 years, currently serving as Director of the Outreach and Education Group in the Center for Environmental Health. She has a Bachelor's degree from The University at Albany, a Master's degree from Cornell University, and a Doctorate in Education from Teachers College, Columbia University. Dr. Schottenfeld's particular area of interest is environmental risk communication. She works with a team of scientists and educators to create messages and materials that help people understand the complexities of fish advisories and the healthier options for consuming sport fish.

Anthony David

Anthony (Tony) David is the Program Manager of Water Resources for the Saint Regis Mohawk Tribe Environment Division at the Mohawk Territory of Akwesasne, located on the banks of the St. Lawrence River. While attending Cornell University, Mr. David developed a comprehensive risk framework for understanding the indirect costs of managing risk for indigenous communities, and presented this research at the 2005 Fish Forum. From 2006-2011, Mr. David served as a tribal representative on the U.S. Environmental Protection Agency (EPA) Tribal Science Council – a group dedicated to working with EPA to improve the communication of science issues in Indian Country. During this time, Mr. David focused on risk analysis issues and was invited to speak at a regional EPA Cumulative Risk Assessment Workshop in Chicago, Illinois, in 2009; and was a co-instructor for a training session on risk perception at the 2010 Tribal Science Council National Conference. Mr. David administers projects for his tribe dealing with water quality monitoring and standards, wetlands protection, fisheries population assessment, contaminant monitoring, and fish advisories.

Abstract

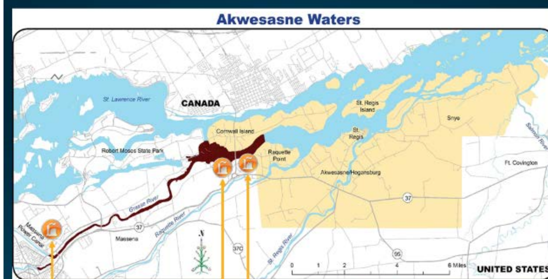
The Saint Regis Mohawk Tribe is beginning a period of recovery stemming from the abrupt loss of subsistence practices due to widespread releases of pollutants from three Superfund sites on the St. Lawrence River. Reductions in fish and game residues after over 30 years of monitoring are creating opportunities for tribal members to reclaim some aspects of long-held traditional hunting and fishing practices. The Saint Regis Mohawk Tribe, in collaboration with the New York State Department of Health (NYSDOH), developed an advisory program to educate the tribal community on the risks and benefits of consuming locally caught fish and game. Program components, including baseline surveys, were designed to assess existing consumption preferences, practices, and perceptions. Concepts and draft materials were honed in community focus groups, at community events, and in follow-up surveys. State and tribal partners worked closely throughout the project period, supported by funds from EPA's Great Lakes Restoration Initiative. Presenters will focus on both the process and products of this collaborative effort.

State-Tribal Partnership For Developing Advisories For The St. Lawrence River Watershed

Tony David, Program Manager
Water Resources, Saint Regis Mohawk Tribe

Faith Schottenfeld, Director, Outreach and Education, Center for Environmental Health, New York State Department of Health

Mohawk Territory of Akwesasne



Alcoa Massena Operations
General Motors-Central Foundry Division
Alcoa—Massena East (Reynolds Metal Co.)

Background

- 1954-1958 St. Lawrence-FDR Power Project
- 1958-1970s multiple pollution sources
- Late 1970s: fluorosis in cattle from Akwesasne
- 1980 era of monitoring extensive ecological contamination
- 3 Superfund Hazardous waste sites
- 1984 GM added to National Priority List
- NYSDOH targeted advisories: EAT NO FISH, ALL SPECIES
- 1986 SRMT fish advisory: M 1 meal/week; W/C: Eat None

Consequences of Prior Advisory

Direct Effects
- Decline in traditional hunting and fishing practices

Indirect Effects
- Loss of culture, traditions and language
- Loss traditional knowledge
- Loss of family activities

Complex Effects
- Health and well-being
- Fear and perception
- Forced colonization

Reclaiming Traditional Practices

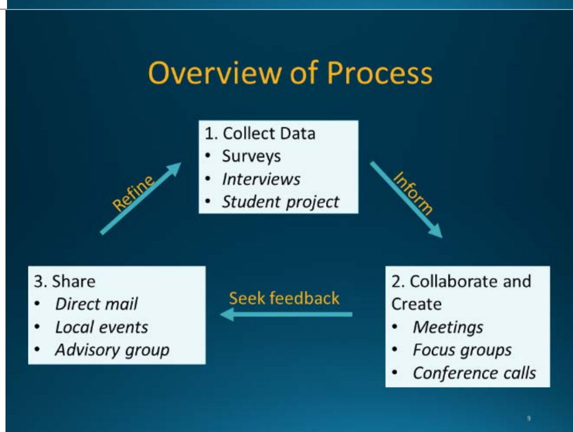
- 35 years later, advisories need update
- Decline in fish and game residues (PCBs)
- Record of Decision 2/3 Superfund sites
- Fishing, trapping, hunting practices a risk?
- What practices do people want to revive?
- Can these practices be revived safely?
  Recreational ⟷ Subsistence
- Explore how state can help

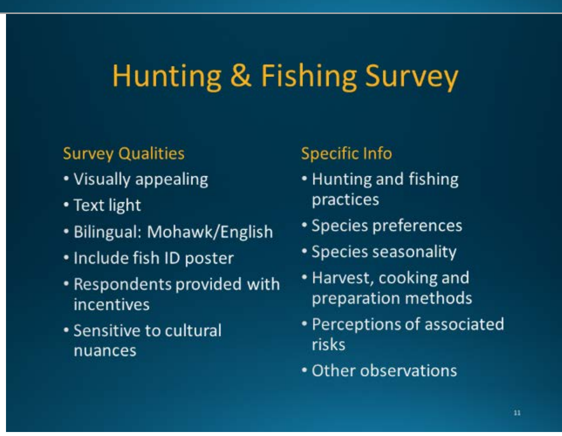
US EPA Great Lakes Restoration Initiative (GLRI) Grant

- Culturally appropriate fish and game advisories to include both benefit and risk information
- Community-based and iterative participatory model
- State-tribal partnership throughout process
- Collaboration with State Department of Environmental Conservation

SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION

State-Tribal Partnership for Developing Advisories for the St. Lawrence River Watershed – Faith Schottenfeld and Tony David





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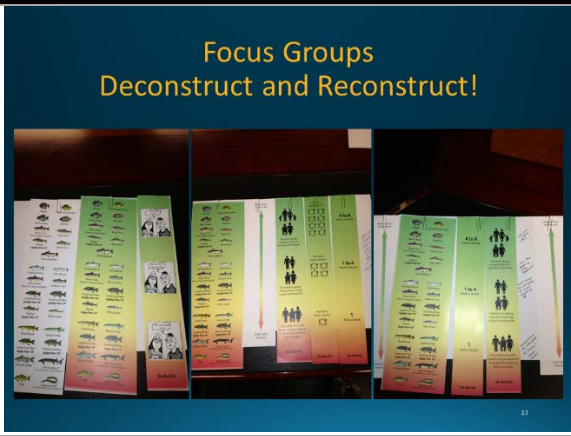

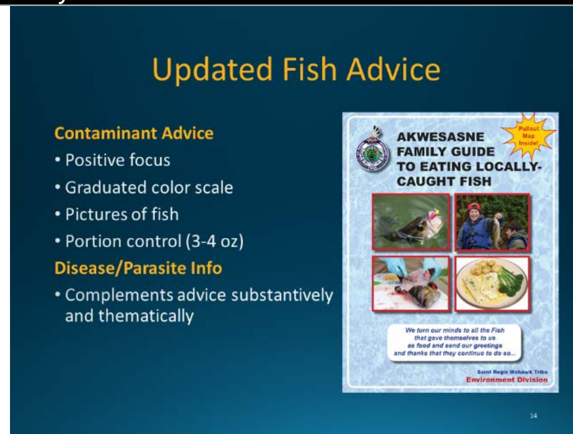

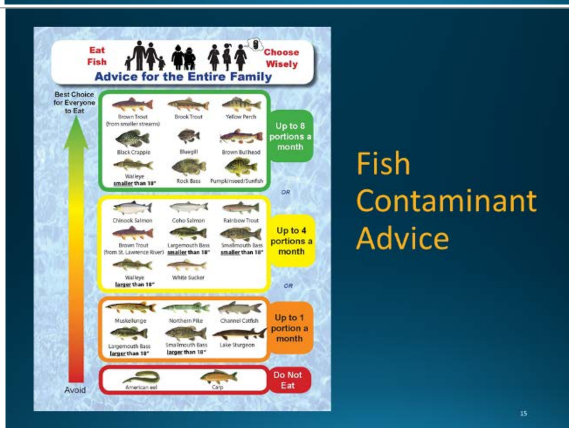

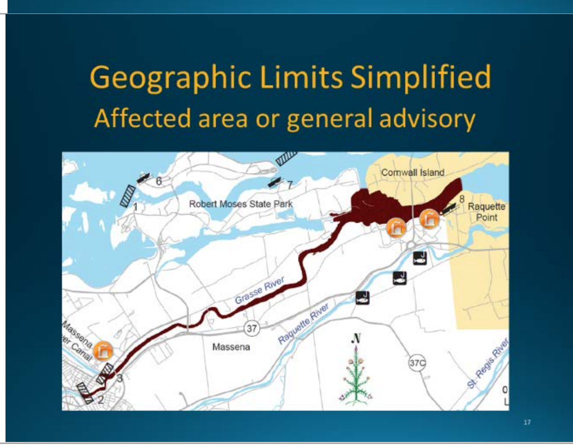

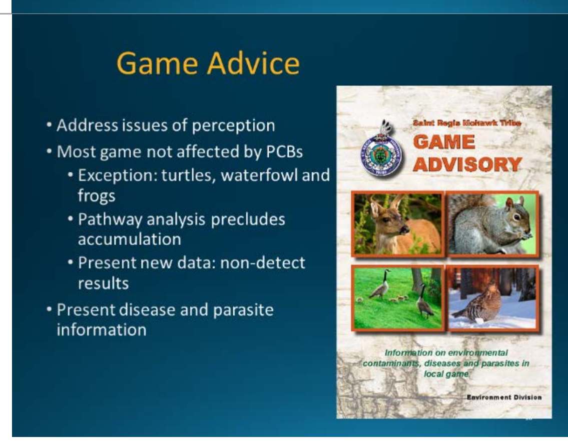

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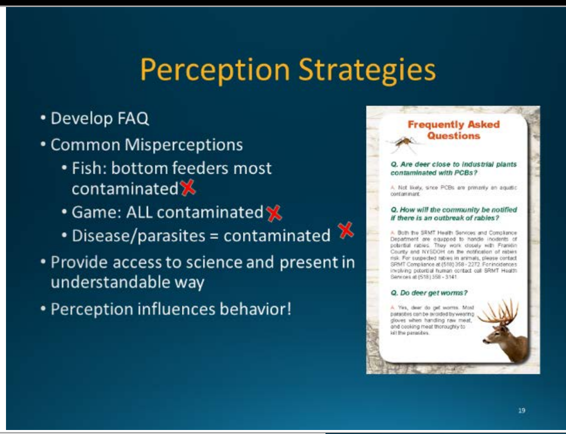
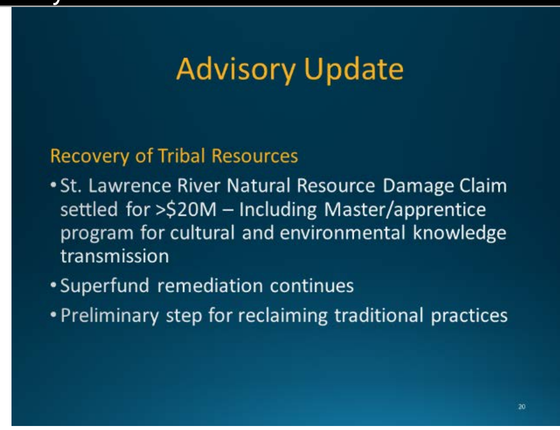
State-Tribal Partnership for Developing Advisories for the St. Lawrence River Watershed – Faith Schottenfeld and Tony David





Questions and Answers

Note: No questions were asked.

Communication of Fish Advisories Between States and Federal Lands: Results from a Survey of 21 Western National Parks

David Wong, U.S. Department of the Interior, National Park Service

Biosketch

Commander David Wong, M.D., is Chief of the Epidemiology Branch of the National Park Service, Office of Public Health in Albuquerque, New Mexico. His primary duties include responding to outbreaks and human disease case reports, developing surveillance systems, and coordinating park-based public health programs and research activities. He provides technical assistance, if requested, to U.S. Department of the Interior bureaus on potential public health issues related to contaminants in fish. Dr. Wong received his M.D. from Duke University. He completed his pediatrics residency at the Children's Hospital of Philadelphia and then joined the Epidemic Intelligence Service fellowship at Centers for Disease Control and Prevention.

Abstract

This presentation summarizes results from a 2014 survey of selected national park employees who are involved with disseminating information on fish consumption advisories to visitors. The survey was distributed only to the 21 western national parks that participated in the 2008–2012 Mercury in Fish study conducted by the U.S. Geological Survey and the National Park Service. Topics covered include attitudes and practices regarding how parks obtain information on fish advisories from states and how this information is shared with visitors.

SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION
Communication of Fish Advisories Between States and Federal Lands: Results from a Survey of 21

Communication of Fish Advisories Between States and Federal Lands:

Results from a survey of
21 Western National Parks

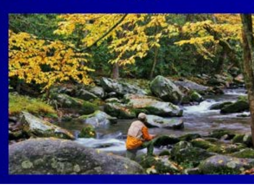
CDR David Wong, MD
NPS Office of Public Health
September 22, 2014

National Park Service (NPS)

- Created in 1916
- 401 NPS units in 50 states, DC, and 4 territories
  - National Parks (59), Historical Parks/Sites (124), Monuments (108)
- Total acreage ~ size of Montana
- 2013: 274 million visitors
- Employees: 22K FTEs, 25K concessioners, 200K volunteers

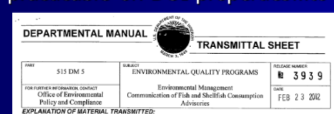
Fishing and National Parks

- Recreational fishing allowed >170 parks
  - Depends on park's authorizing legislation
  - Fishing regulations generally established in coordination with associated state(s)



DOI Policy on Fish Consumption Advisories

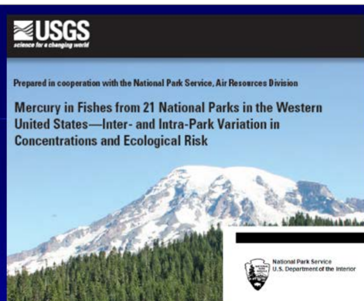
- 515 DM 5
  - Issued Feb 2012
  - First Department of the Interior policy supporting "communication of fish and shellfish consumption advisories when practicable on DOI properties...to anglers"



DEPARTMENTAL MANUAL TRANSMITTAL SHEET

515 DM 5	ENVIRONMENTAL QUALITY PROGRAMS	3939
Office of Environmental Policy and Compliance	Environmental Management Communication of Fish and Shellfish Consumption Advisories	FEB 23 2012

EXPLANATION OF MATERIAL TRANSMITTED:



USGS

Prepared in cooperation with the National Park Service, Air Resources Division

Mercury in Fishes from 21 National Parks in the Western United States—Inter- and Intra-Park Variation in Concentrations and Ecological Risk

National Park Service U.S. Department of the Interior USGS

National Park Service and USGS News Release

Release date: April 16, 2014

Elevated Levels of Mercury Found in Fish in Western U.S. National Parks

WASHINGTON — Mercury has been discovered in fish in some of the most remote national park lakes and streams in the western United States and Alaska. Mercury levels in some fish exceeded U.S. Environmental Protection Agency health thresholds for potential impacts to fish, birds, and humans.

Objectives

- Among subset of national parks:
  - Understand how information about fish consumption advisories is shared between states and parks and then ultimately disseminated to park visitors
  - Propose opportunities to improve interagency communication

SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION

Communication of Fish Advisories Between States and Federal Lands: Results from a Survey of 21

Methods

- Online survey of 21 national parks involved with USGS/NPS study
  - Focus on communication
    - Interagency and dissemination to park visitors
  - Limited to one response per park
    - "Employee most knowledgeable about or involved with disseminating fish consumption advisory information"
  - Anonymous
  - Survey open for 7 weeks (July 25–Sept 12)

Results

Response Rate by Region

- Overall, 95% response rate (20/21 parks)
- Alaska Region (4/4)
  - AK: Denali, Glacier Bay, Lake Clark, Wrangell-St. Elias
- Intermountain Region (9/9)
  - AZ: Grand Canyon
  - CO: Rocky Mountain, Great Sand Dunes, Mesa Verde
  - MT: Glacier
  - UT: Capitol Reef, Zion
  - WY: Grand Teton, Yellowstone

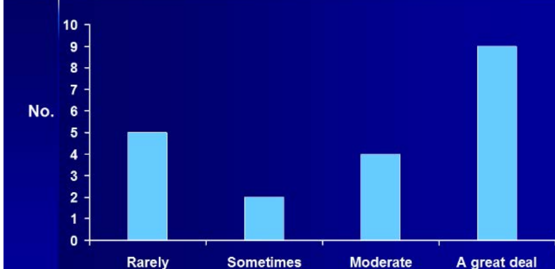
Response Rate by Region (continued)

- Pacific West Region (7/8)
  - CA: Lassen Volcanic, Sequoia-Kings Canyon, Yosemite
  - NV: Great Basin
  - OR: Crater Lake
  - WA: Mount Rainier, North Cascades, Olympic

Characteristics of Respondents

	No. Respondents
Job Title or Division (n=20)	
Fisheries/Aquatic Biologist	7
Other Resource Manager	10
Public Information Officer	2
Interpretation/Education	1
Years Worked in Current Position (n=20)	
2-10	12
11-20	5
21-31	3

How often does recreational fishing occur in your park? (n=20)



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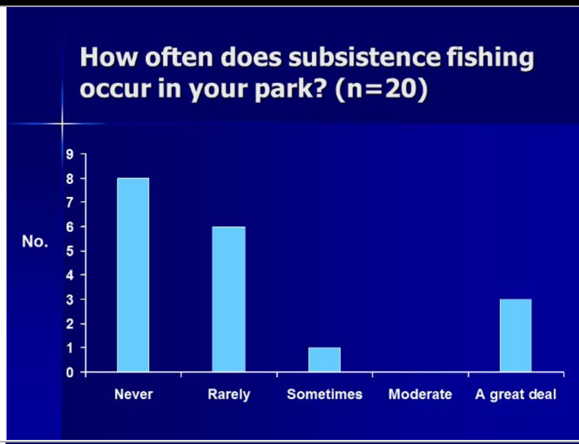
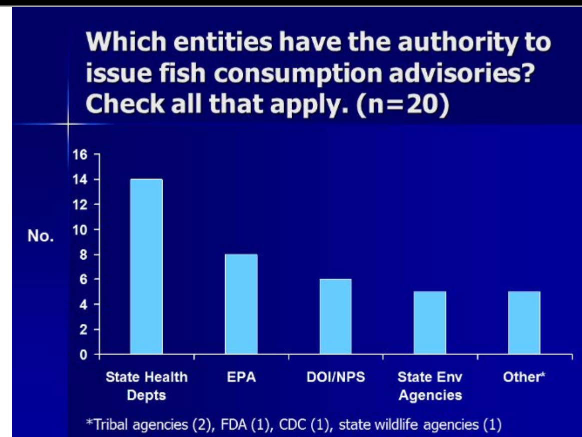
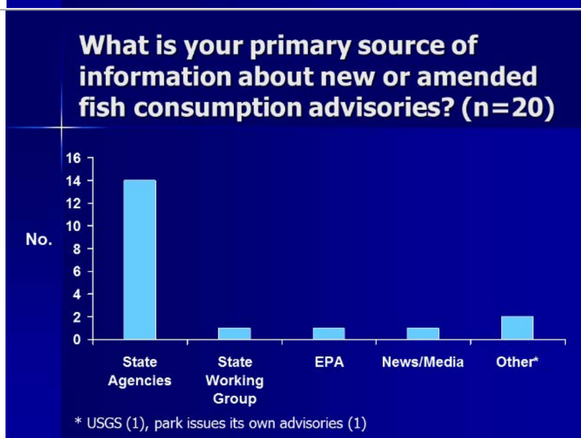
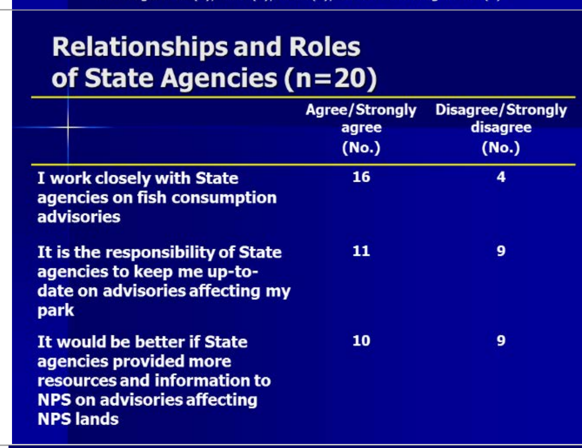
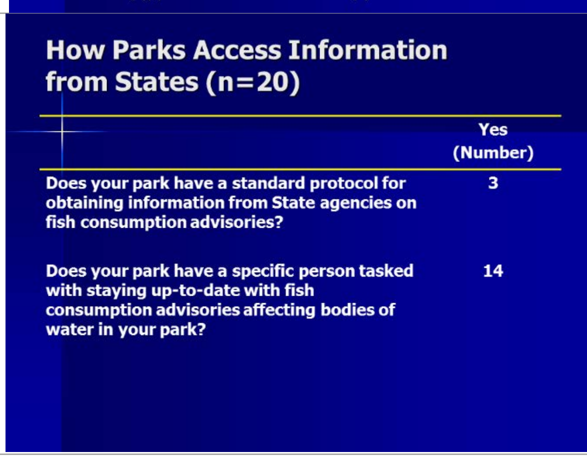




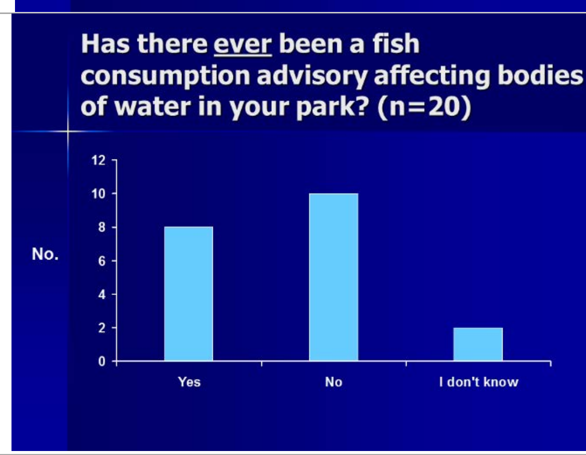



Relationships and Roles of State Agencies (n=20)

	Agree/Strongly agree (No.)	Disagree/Strongly disagree (No.)
I work closely with State agencies on fish consumption advisories	16	4
It is the responsibility of State agencies to keep me up-to-date on advisories affecting my park	11	9
It would be better if State agencies provided more resources and information to NPS on advisories affecting NPS lands	10	9


How Parks Access Information from States (n=20)

	Yes (Number)
Does your park have a standard protocol for obtaining information from State agencies on fish consumption advisories?	3
Does your park have a specific person tasked with staying up-to-date with fish consumption advisories affecting bodies of water in your park?	14



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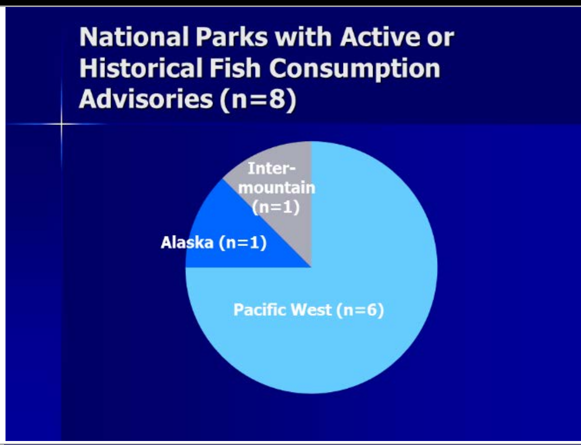
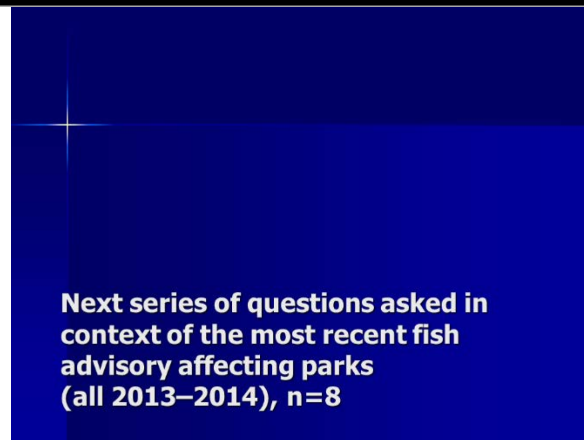
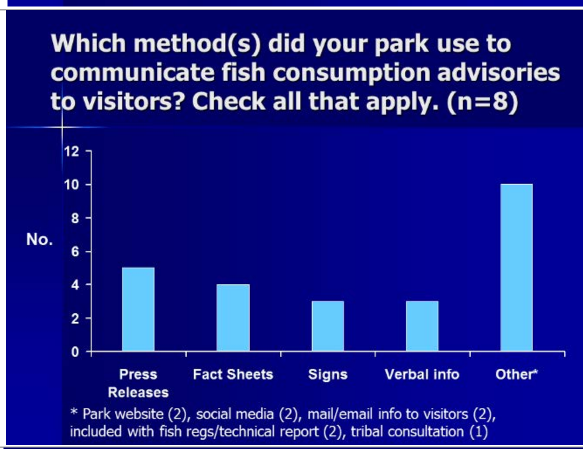
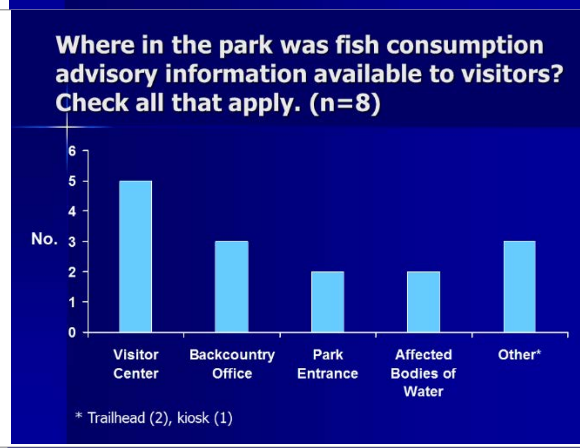
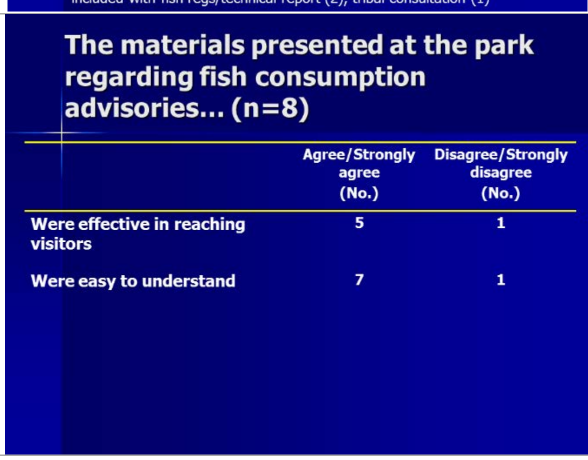




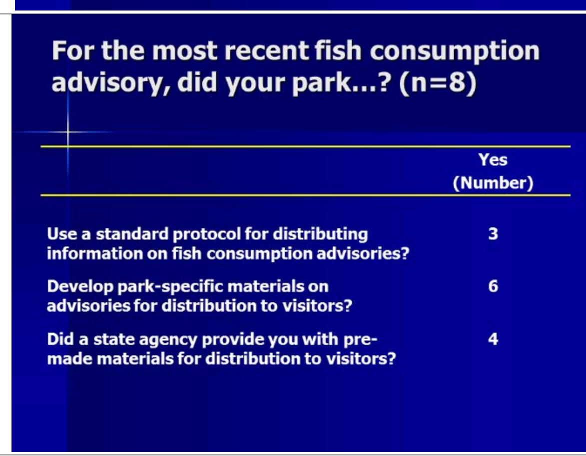






The materials presented at the park regarding fish consumption advisories… (n=8)

	Agree/Strongly agree (No.)	Disagree/Strongly disagree (No.)
Were effective in reaching visitors	5	1
Were easy to understand	7	1



For the most recent fish consumption advisory, did your park…? (n=8)

	Yes (Number)
Use a standard protocol for distributing information on fish consumption advisories?	3
Develop park-specific materials on advisories for distribution to visitors?	6
Did a state agency provide you with pre-made materials for distribution to visitors?	4

SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION
Communication of Fish Advisories Between States and Federal Lands: Results from a Survey of 21

Exclusive Jurisdiction—
Excerpts from Respondent Comments

"As our park is an "exclusive jurisdiction" park, there is considerable confusion about how fish consumption advisories should be declared and how that information should be disseminated to the public."

"As a park with exclusive jurisdiction, we develop our own advisories/brochures on Hg for distribution to the public. We then communicate this information to our state partners so they can include it in the statewide fish consumption guidance brochure."

Exclusive Jurisdiction—
Excerpts from Respondent Comments
(continued)

"The State has no jurisdiction over fish in the park, so studies conducted are NPS and/or other agency funded. However, the State is responsible for issuing fish consumption advisories. We reference the state's websites for further information on fish consumption advisories."

Limitations

- Small sample size
  - May not be representative of all national parks
- Did not survey State agencies, Tribes, or the general public
  - One-sided perspective
- Answers may be biased from recent USGS/NPS study and press release

Conclusions

- States are the primary resource/partner for parks re: fish advisories
- Although parks and States work closely, communication processes can be improved
- Exclusive jurisdiction issues are handled differently by parks and should be specifically addressed
- Targeted outreach to national parks and other federal lands may be warranted

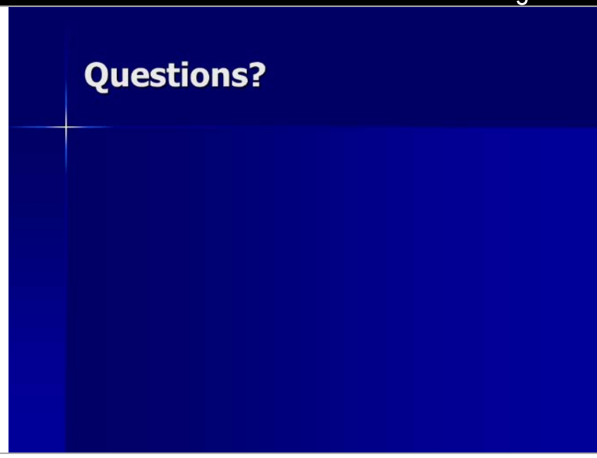
Next Steps

- Continue dialogue between State agencies, national parks, and other federal lands
- Consider working group to address exclusive jurisdiction issues and develop best practices for issuing and sharing information on advisories
- Comprehensive survey of all national parks that allow fishing

Acknowledgments

- NPS Office of Public Health
  - Sean Motl
  - Danielle Buttke
- NPS Air Resources Division
  - Colleen Flanagan Pritz
- NPS Water Resources Division
  - John Wullschleger
- NPS Biological Resource Management Division
  - Kirsten Leong

SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION
Communication of Fish Advisories Between States and Federal Lands: Results from a Survey of 21 Western National Parks – David Wong



Questions and Answers

Q. Regarding the issue of national parks with exclusive jurisdiction, and waters that flow through such national parks, who has responsibility for water quality standards and who has jurisdiction over waters within such national parks? (Mike Ell)

A. The states have primacy for water quality issues everywhere. For fish, the decision about federal or state responsibility is up to the park. For public health issues, the National Park Service treats everything as concurrent jurisdiction. For example, the hantavirus outbreak in Yosemite National Park was addressed by federal and state public health officials. Based on their preliminary survey results, he thinks that national parks are doing things differently for various fish and health issues and that the National Park Service may need to develop guidance.

Q. In your survey, person visits was not addressed in person days. Park visitors do not live there so will probably visit only a few days and not consume that much fish. He recommended that the National Park Service consider communicating with employees who live there and provide them with information about fish advisories and fishing. (Groth)

A. He agreed with those comments.

How EPA Utilizes Fish Advisories as Institutional Controls at Superfund Sites

Steve Ridenour, U.S. Environmental Protection Agency

Biosketch

Steve Ridenour has worked for the U.S. Environmental Protection Agency (EPA) headquarters in the Construction and Post-Construction Management Branch for the Superfund Program since September 2008. His primary responsibilities include institutional controls policy. He is an author on several of EPA's latest guidance efforts: five-year review policy and data sponsorship, and EPA Region 5 post-construction coordination. Mr. Ridenour's experience with fish contaminants includes his work as the Institutional Controls Team Leader and his coordination with the EPA Region 5 office on the technical review of sediment sites addressed under the Superfund program within that region. Mr. Ridenour holds a Bachelor's degree in Economics from Rutgers University and a Master's degree in Public Policy from Johns Hopkins University.

Abstract

This session will discuss how EPA generally relies upon fish advisories implemented at the state or local level as institutional controls (ICs) at some Superfund sites. The session will detail the considerations that the Superfund Program uses in selecting fish advisories as ICs at sites and how EPA can work collaboratively with state and local governments to help implement them. Several examples on the use of fish advisories at Superfund sites will be presented to illustrate the application of such fish advisories.

SESSION 2: FEDERAL, STATE, AND TRIBAL ADVISORY COORDINATION

How EPA Utilizes Fish Advisories as Institutional Controls at Superfund Sites – Steve Ridenour

How EPA Utilizes Fish Advisories as Institutional Controls (ICs) at Superfund Sites

Steve Ridenour, U.S. EPA, Office of Superfund Remediation and Technology Information (OSRTI)

What are ICs?

- EPA Definition: "Non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for exposure to contamination and/or protect the integrity of a response action"
- Limits land and/or resource use by providing information that helps modify or guide human behavior at a site
- Can be used on a short-term or long-term basis

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Four categories of ICs

- Proprietary controls
- Governmental controls
  - Fish/Shellfish bans
- Enforcement / permit tools
- Informational devices
  - Includes fish advisories, among others
  - Provides information or notification that residual contamination remains on site.

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Informational Devices: Fish Advisories

ADVANTAGES
- Very flexible and adaptable to cultural needs
- Easy to layer with other ICs
- Can more widely disseminate information

DISADVANTAGES
- Not enforceable
- People may be unwilling/unable to provide information or change their behavior (e.g., sport and subsistence fishers)
- Difficult to monitor

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Fish Advisory Implementation

- Like all other ICs, EPA does not **directly** implement fish advisories under Superfund but leverages state/local and other existing authorities
  - EPA's Water program compiles a database of fish advisories
  - EPA's Superfund program has an IC registry for construction complete sites
- EPA should coordinate early and often to assess capacity to implement and/or maintain fish advisories
- Some advisories have specific thresholds for issuance but EPA uses own risk assessment process to determine extent of remedy, including fish advisories

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Contaminated Sediment Sites in the Superfund Program

- 72 large contaminated sediment sites with selected remedies or expected ones in the near future
- 54% with unacceptable risks due to the ingestion of fish/shellfish contaminated with PCBs (28), Dioxins/Furans (5), or Mercury (6)
- Remedies include a combination of removals, engineered caps, thin sand covers, and natural sedimentation
- EPA's goal: reduce contaminant levels in surface sediment & fish/shellfish tissue so state public health agencies can relax or remove fish consumption advisories

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Case Study #1: Fox River, Wisconsin

- Proposed to Superfund's National Priorities List (NPL) in July 1998
- Largest sediment site (by volume) in the Superfund program: ~ 39 miles of river and 2,700 square miles of Green Bay
- PCB releases from historical paper mill manufacturing

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Case Study #1: Fox River, Wisconsin (continued)

- The Superfund remedy
  - Dredging, capping, covering of sediments
  - Monitored natural recovery of some areas
  - ICs to prevent ingestion of PCB-contaminated fish above 50 ppb and protect sediment caps.
    - Incorporates fish advisories implemented by Wisconsin Department of Health Services (WDHS) and Wisconsin Department of Natural Resources (WDNR) in 1976
    - MOUs to limit anchoring, dredging, dragging, or construction over sediments caps

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Case Study #2: Palos Verdes Shelf, California

- Part of the Montrose Chemical Superfund site
- Sediment, ocean water, fish, and other ecological receptors at PV Shelf are contaminated from site operations
- Contaminants include DDT and PCBs
- Remedy includes capping, monitored natural recovery, and ICs

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Case Study #2: Palos Verdes Shelf, California (continued)

- IC program to prevent consumption of fish and provide education and outreach, including:
  - Reliance on California Department of Fish and Wildlife (CDFW) commercial catch ban for white croaker from May 1990
  - California's Office of Health and Hazard Assessment (OEHHA) fish advisory, update in June 2009
  - Fish Contamination Education Collaborative (FCEC)
  - Formal agreements with the City of Long Beach, Los Angeles County Environmental Health, and Orange County Healthcare Agency, to evaluate commercial availability of white croaker

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Additional EPA Resources

Institutional Controls: [Institutional Controls]
- ➢ Links to EPA guidance and site-specific IC reports

Sediments: [Technical Guidance]
- ➢ Technical guidance to EPA staff on developing monitoring plans for contaminated sediment sites

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Questions and Answers

Q. At the University of North Carolina Chapel Hill, Institute for the Environment, they are working on programs to communicate risk information from fish advisories that vary among multiple fish species and fish advisories that vary by water body. Has this been considered? (Bawden)

A. The moderator answered by suggesting that many of the panelists could address this more general question, and decided to hold that question until the general Q&A session at the end of this panel.

Q. In New York, they know that fish consumption advisories are not very effective with non-English speaking populations or low-income populations who are catching subsistence fish. How does EPA address this at Superfund sites? (Richter)

A. He mentioned that EPA’s fish/shellfish advisories at Superfund sites are not enforceable. EPA has tried to address this issue and get smarter in issuing fish advisories in different languages to communicate with different populations. The Fox River Superfund Site in Wisconsin is a good example of where studies show that fishing and fish consumption still occurs. The Palos Verdes Shelf Superfund Site in California has a fishing ban, so it is a special example.

Q. What type of evaluation has EPA done on the effectiveness of fish advisories as institutional controls at Superfund sites, especially where fish consumption still occurs? From the states’ perspective, it seems that EPA has not done an overall evaluation of the effectiveness of such institutional controls. (Richter)

A. At the national level, EPA has general guidance, but the specific institutional controls are handled at the state and local level for each Superfund site.

Comment: He emphasized that EPA should be looking at this issue more thoroughly. From the states’ perspective, more specific guidance on developing effective institutional controls with fish advisories at Superfund sites is really needed. (Richter)

General Question and Answer Session

Q. How many Superfund sites have institutional controls with fish advisories? (Kyle)

A. There are 39 Superfund sites with specific fish/shellfish advisories as part of institutional controls. The EPA Fact Sheet available in the back of meeting room lists those 39 sites, which are among the 72 large contaminated sediment sites in the Superfund program. (Ridenour)

Q. For the 72 Superfund sites with contaminated sediments, for how many of them does EPA actually know that people are not fishing at those sites? (Greene)

A. EPA does have evidence that people are still fishing at some of these Superfund sites. EPA is starting to evaluate fish/shellfish advisories more. However, institutional controls have not traditionally been the focus of the Superfund program. EPA knows they have a long way to go with developing institutional controls and making them effective. (Ridenour)

Q. At the Lower Duwamish Waterway Superfund Site in Seattle, there are ethnically diverse populations. The Washington State Department of Health as well as King County have found there are not enough funds during site remediation to communicate with the public about risk during remediation. Also as state and local agencies, they have found more emphasis is needed on monitoring and evaluating the effectiveness of fish advisories at Superfund sites. How can we be part of the risk communication during remediation?(Carr)

A. EPA needs to think about institutional controls earlier in the process before developing the remedy. (Ridenour)

Q. As the EPA Region 10 risk assessor for the Lower Duwamish Waterway Superfund Site, he knows there are many diverse populations. EPA will be looking at perceived risks and benefits along with fish catch and consumption. EPA will be collecting information and using that to shape institutional controls. (Kissinger)

A. Yes, EPA can do scoping at Superfund sites early before developing the remedy and that should be used for developing a fish/shellfish advisory. It is important to spend more effort on monitoring the effectiveness of institutional controls with fish/shellfish advisories. (Ridenour)

Comment: When there is fish consumption and contaminated sediments, the earlier you get involved the better. (Greene)

Q. EPA needs to update the Palos Verdes signage in their presentation, because they actually have a new sign at the Palos Verdes Shelf Superfund Site now. That sign now has more fish species listed as well as mercury. He considers the Palos Verde Shelf Superfund site as a "Cadillac site," with much higher funding than other Superfund sites with contaminated sediments. At Palos Verdes, they have people out on the piers on a daily basis for public outreach handing out materials and answering questions. However, people are still fishing there. These people have learned something about fish contamination and some people throw White Croaker back into the *water. It is difficult to do behavioral surveys to measure whether people are really changing their behavior, because such surveys are hard to do and cost a lot of money. (Brodberg)*

A. Yes, EPA will look into updating that Palos Verdes signage in this presentation. (Ridenour)

Q. She referred back to her earlier question about whether communication of risk information from fish advisories that vary among multiple fish species and fish advisories that vary by water body has been considered. There have been extensive evaluations of fish consumption advisories, but at a local level. However, there have not been any evaluations of outreach efforts. (Bawden)

Q. Are you asking about developing messages for fish consumption advisories?(Greene)

Q. She recapped that her question was—how do you communicate multiple fish consumption advisories by species and location? (Bawden)

A. You can have an advisory for one fish meal per month in this water body and two fish meals per month at another nearby water body. There will always be “lumpers and splitters” with different approaches. “Lumpers” will tend to simplify the language in fish advisories. (Greene)

A. The Saint Regis Mohawk Tribe tested multiple different approaches to communicate fish advisories. Their situation is complex because they are located at the confluence of different water bodies and at the confluence of Quebec, Ontario, and New York State. They also have two different Mohawk tribal governments on different sides of the international border. Dealing with different jurisdictions has been difficult and stalled the process. They have issued their own fish advisory that is similar to what other jurisdictions have issued. (Anthony David)

SECTION II-D SESSION 3: EMERGING ISSUE – HARMFUL ALGAL BLOOMS AND FISH CONSUMPTION

Moderator:
Amy D. Kyle, University of California – Berkley, School of Public Health

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

Presentations
Introduction and Overview: Significance of Cyanotoxins for Human Health
Amy D. Kyle, University of California – Berkeley, School of Public Health

Analytical Methods and Seasonal Variations of Selected Cyanotoxins in Lake, Fish, and Plant Tissue in Nebraska
Dan Snow, University of Nebraska – Lincoln

Considerations for Fish Advisory Programs for Cyanotoxins in Fish
Tom Hornshaw, Illinois Environmental Protection Agency

Cyanotoxin Toxicity: Fish and Human Health Assessment
Lesley D'Anglada, U.S. Environment Protection Agency

Introduction and Overview: Significance of Cyanotoxins for Human Health

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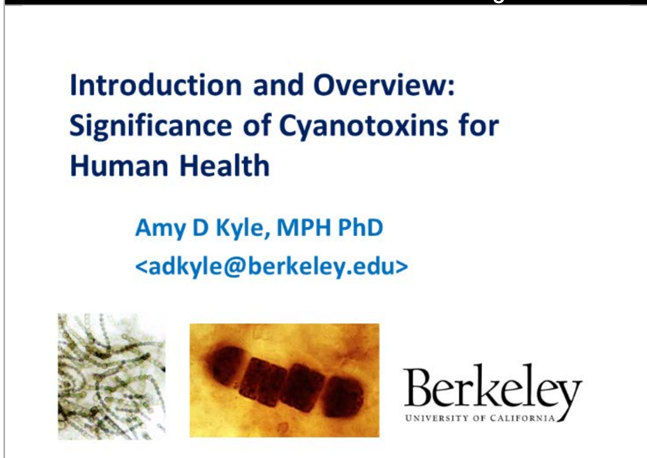
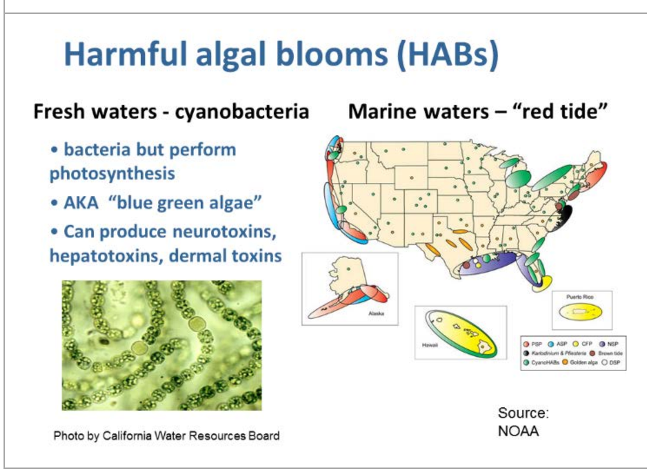
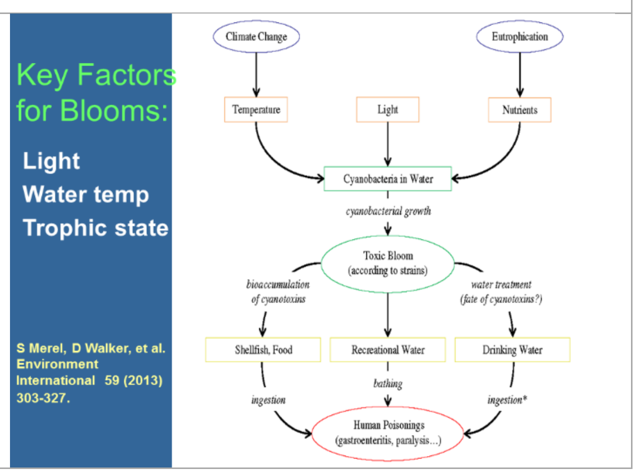
Abstract

This presentation will introduce the session as a whole. It will define harmful algal blooms; focus on cyanotoxins and summarize what is known about where they come from; introduce potential health concerns; review types of approaches to monitor for or predict blooms that can lead to production of the toxins; present a synopsis of data about concentrations reported in fish; and pose a question about whether traditional approaches to monitoring, risk assessment, and advisories for chemicals would be effective for this kind of episodic phenomenon.

SESSION 3: EMERGING ISSUE – HARMFUL ALGAL BLOOMS AND FISH CONSUMPTION
Introduction and Overview: Significance of Cyanotoxins for Human Health – Amy Kyle







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Introduction and Overview: Significance of Cyanotoxins for Human Health – Amy Kyle

Cyanobacteria and their toxins

- Data are complex
- Different species and combinations
- Different toxins and combinations
- Unknown why toxins appear sometimes
- Analytic methods matter

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WHO: Acute Toxicity

Liver Toxicity

Neuro-toxicity

Cyto-toxicity

Cyanotoxins	LD_{50} (i.p. mouse)[b] of pure toxin (µg/kg)	Taxa known to produce the toxin(s)	Mechanism of toxicity
Protein phosphatase blockers (cyclic peptides with the amino acid ADDA)			
Microcystins in general (~60 known congeners)	45–>1000	*Microcystis, Planktothrix, Oscillatoria, Nostoc Anabaena, Anabaenopsis Hapalosiphon*	all block protein phosphatases by covalent binding and cause haemorrhaging of the liver; cumulative damage may occur
Microcystin-LR	60 (25–125)		
Microcystin-YR	70		
Microcystin-RR	300–600		
Nodularin	30–50	*Nodularia spumigena*	
Neurotoxins			
Anatoxin-a (alkaloid)	250	*Anabaena, Oscillatoria, Aphanizomenon, Cylindrospermum*	blocks post-synaptic depolarization
Anatoxin-a(s) (unique organophosphate)	40	known only from two species of *Anabaena*	blocks acetylcholinesterase
Saxitoxins (carbamate alkaloids)	10–30	*Aphanizomenon, Anabaena, Lyngbya, Cylindrospermopsis raciborskii*	block sodium channels
Cytotoxin			
Cylindrospermopsin (alkaloid)	2100 in 1 day 200 in 5–6 days	*Cylindrospermopsis raciborskii*	blocks protein synthesis; substantial cumulative toxicity

[a] derived from Turner et al., 1990; Kuiper-Goodman et al., 1999; Sivonen & Jones, 1999.
[b] LD_{50} = lethal $dose_{50}$ (the dose of a chemical that will, on average, kill 50% of a group of experimental animals); i.p. = intraperitoneal.

Focus on drinking water

EPA CCL List

Table 1. Cyanotoxins on the Contaminant Candidate List (CCL)

Cyanotoxin	Number of known variants or analogues	Primary organ affected	Health Effects[1]	Most common Cyanobacteria producing toxin[2]
Microcystin-LR	80~90	Liver	Abdominal pain Vomiting and diarrhea Liver inflammation and hemorrhage Acute pneumonia Acute dermatitis Kidney damage Potential tumor growth promotion	*Microcystis* *Anabaena* *Planktothrix* *Anabaenopsis* *Aphanizomenon*
Cylindrospermopsin	3	Liver		*Cylindrospermopsis* *Aphanizomenon* *Anabaena* *Lyngbya* *Rhaphidiopsis* *Umezakia*
Anatoxin-a group[3]	2-6	Nervous System	Tingling, burning, numbness, drowsiness, incoherent speech, salivation, respiratory paralysis leading to death	*Anabaena* *Planktothrix* *Aphanizomenon* *Cylindrospermopsis* *Oscillatoria*

[1]Source: *Harmful Algal Research and Response National Environmental Science Strategy (HARRNESS)*
[2] Not all species of the listed genera produce toxin; in addition, listed genera are not equally as important in producing cyanotoxins.
[3]The anatoxin-a group does not include the organophosphate toxin anatoxin-a(S) as it is a separate group. In the US, the most common member is thought to be anatoxin-a, and thus this toxin is listed specifically.

Fish species	Range of microcystin detected (µg/kg)	FW or DW	Extraction protocol
Channel catfish (*Ictalurus punctatus*)	123.1–250.0	FW	Water:methanol:butanol (15:4:1) extraction, C18 cleanup
Tilapia rendalli	3.0–337.0	DW	100% methanol extraction
Goldfish (*Carassius auratus* L.)	50–300 (estimated from their Figure 1)	FW	100% methanol extraction
	500–1960 (estimated from their Figure 2)	DW	Water:methanol:butanol (15:4:1) extraction, C18 and Si cleanup
Yellow perch (*Perca flavescens*)	0.12–4.0	FW	75% methanol and acetic acid extraction
	0.5–7.0	DW	100% methanol extraction
Largemouth bass (*Micropterus salmoides*)	210.0–320.0	FW	Water:methanol:butanol (15:4:1) extraction, C18 cleanup
Nile tilapia (*Oreochromis niloticus*)	45-225 (estimated from their Figure 1b)	FW	Homogenization in methanol, hexane
	0.8–63.4	DW	methanol extraction
Common carp (*Cyprinus carpio*)	46.3	DW	Water:methanol:butanol (15:4:1) extraction, C18 and Si cleanup
	3.3–19.0	FW	50% methanol, hexane
	2.85–138.7	FW	75% methanol, acetic acid
	50–470 (estimated from their Figure 4)	FW	100% methanol extraction
	3.5	FW	5% acetic acid, 0.01M EDTA extraction, charcoal
Black crappie (*Pomoxis nigromaculatus*)	399.0	FW	100% methanol and acidified water, cleanup with C18 cleanup
	1.5–1.9	DW	50% methanol extraction
	1.04–70.43	FW	5% acetic acid, 0.01M EDTA extraction, charcoal cleanup
White crappie (*Pomoxis annularis*)	270.0–320.0	FW	Water:methanol:butanol (15:4:1) extraction, C18 cleanup

Variations in the Microcystin Content of Different Fish Species Collected from a Eutrophic Lake. JR. Schmidt, M Shaskus, JF Estenik, et al. Toxins 2013, 5, 992-1009; doi:10.3390/toxins5050992

Table 5
Comparison of BMAA concentrations determined for various aquatic products in different sample locations.

Locations	Aquatic products			References
	Mollusks	Crustaceans	Fishes	
Baltic Sea	NS	NS	0.0019–1.29	Jonasson et al., 2010
Florida Bay	NS	1361–3042	20–188	Brand et al., 2010
Biscayne Bay	NS	55–6976	34–7351	Brand et al., 2010
Caloosahatchee River	251–305	NS	554–2559	Brand et al., 2010
South Florida	NS	NS	144–1836[a]	Mondo et al., 2012
Mississippi	7–10	NS	NS	Christensen et al., 2012
Kattegat sea	0.006–0.201	NS	NS	Jonasson et al., 2010
Gonghu Bay	0.63–6.72	0.12–8.76	0.07–35.91	This study

[a] Values were calculated as (µg BMAA/g wet weight), and the other values were calculated as (µg BMAA/g dry weight); NS: no samples collected.

Yiying Jiao, Qiankun Chen, Xu Chen, XinWang, Xuewei Liao, Lijuan Jiang, JunWua, Liuyan Yang. Science Total Environment 468–469 (2014) 457–463

462 Y. Jiao et al. / Science of the Total Environment 468–469 (2014) 457–463

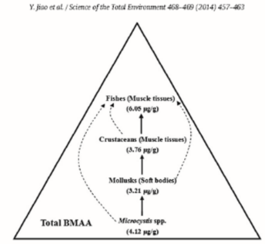

Fig. 4. The occurrence of total BMAA in different trophic levels of aquatic ecosystem in Gonghu Bay during the whole sampling periods. "→" Represents the possible transfer of BMAA; The BMAA concentration is expressed as µg/g dry weight.

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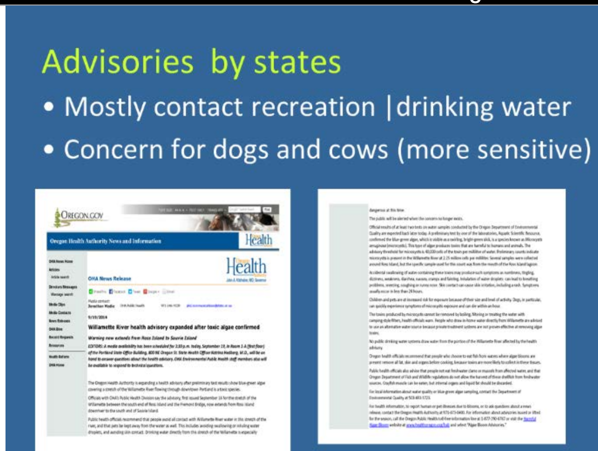
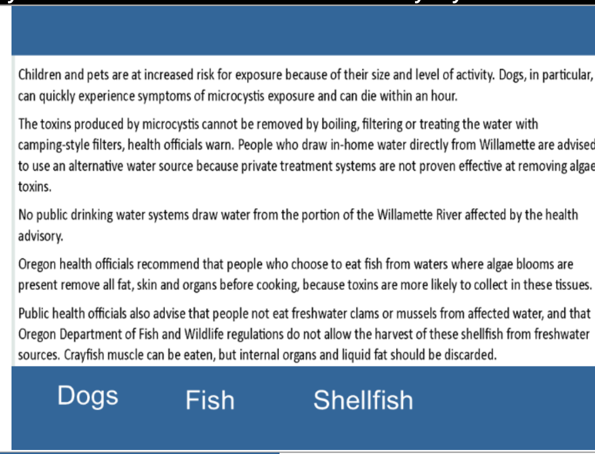
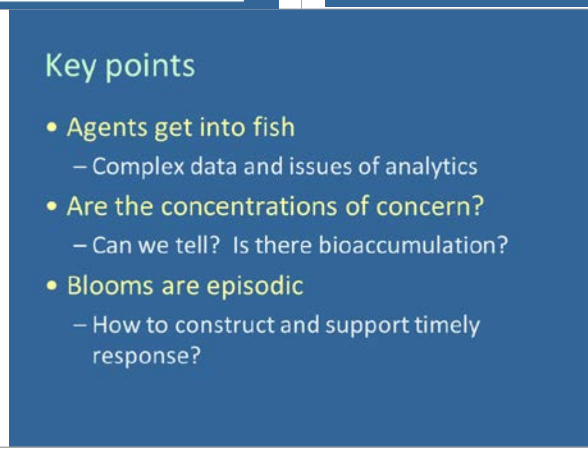
Introduction and Overview: Significance of Cyanotoxins for Human Health – Amy Kyle







Questions and Answers

Note: As the first presenter and moderator for this panel, she announced that she would take no questions about her presentation and moved directly to the next presentation.

Analytical Methods and Seasonal Variations of Selected Cyanotoxins in Lake, Fish, and Plant Tissue in Nebraska

Dan Snow, University of Nebraska – Lincoln

Biosketch

Dr. Daniel Snow is the Director of Laboratory Services at the Water Sciences Laboratory, a part of the Nebraska Water Center and Robert B. Daugherty Water for Food Institute, and a Research Associate Professor in the School of Natural Resources at the University of Nebraska. He holds a Ph.D. from the University of Nebraska, a M.S. degree from Louisiana State University, and a B.S. from Missouri State. Over the past 25 years, his research interests and experience has focused on environmental analytical chemistry and the development of new analytical methods, primarily using chromatography in conjugation with mass spectrometry, for organic and inorganic contaminants in aquatic systems. He also has extensive experience in measurement and use of stable and radioactive isotope tracers in hydrology and geochemistry. Some of his most recent work has examined the occurrence of cyanotoxins in Nebraska lakes and reservoirs, aquatic plants, and fish tissue.

Abstract

Cyanotoxins are naturally-occurring chemicals that have neurotoxic, hepatotoxic, and dermally irritating substances produced by a wide variety of cyanobacteria, or blue-green algae. These compounds can occur in wide range of environmental samples including water, fish, and aquatic and even terrestrial plants. Over the past 10-15 years, awareness of their occurrence in specific environments and compartments has grown through increased monitoring using a wide variety of analytical methods including enzyme-linked immunoassay (ELISA), and more selective instrumental methods ranging from high pressure liquid chromatography (HPLC) with fluorescence, ultraviolet and mass spectrometric detection, and gas chromatography-mass spectrometry detection. Very often selective pre-concentration, extraction, and chemical conversion procedures are required to enhance sensitivity and specificity of any methods, especially in complex plant and animal tissue. Solid phase extraction (SPE) coupled with liquid chromatography and fluorescence detection (HPLC/FD), and liquid chromatography-mass spectrometry (LC/MS/MS) has been used to monitor this occurrence of microcystins and compared to results determined with ELISA monitoring in Nebraska lakes to determine their seasonal variability and help predict where advisories must be posted for recreational use. Many of the reservoirs where microcystins are also regularly found are also appear to be locations likely to produce neurotoxic compounds such as anatoxin-a, as well as the non-protein amino acids β-methylamino-L-alanine (BMAA) and 2,4-diaminobutyric (DABA). The results of these studies suggest that additional research is needed to understand the human health consequences and potential significance of their occurrence.

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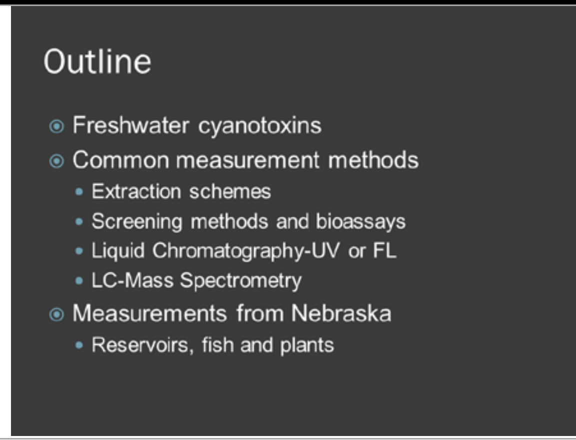
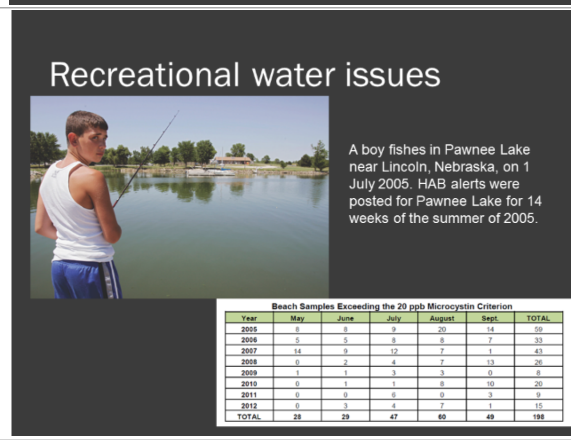
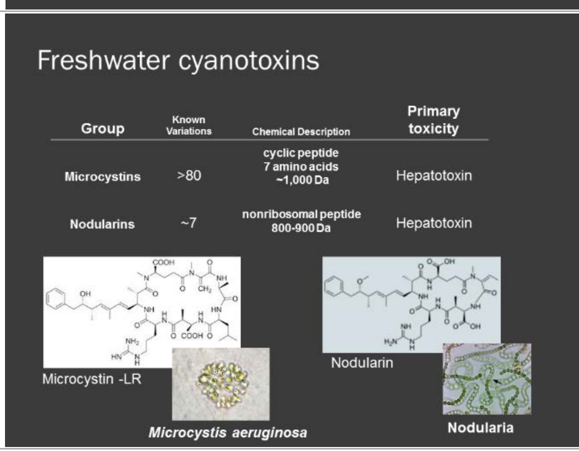
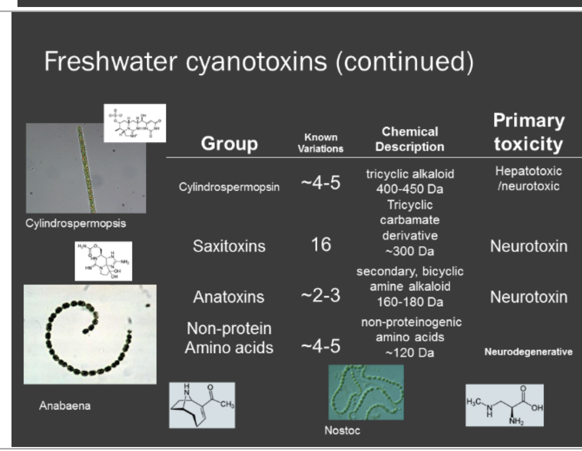
Analytical Methods and Seasonal Variations of Selected Cyanotoxins in Lake, Fish, and Plant Tissue in Nebraska – Dan Snow









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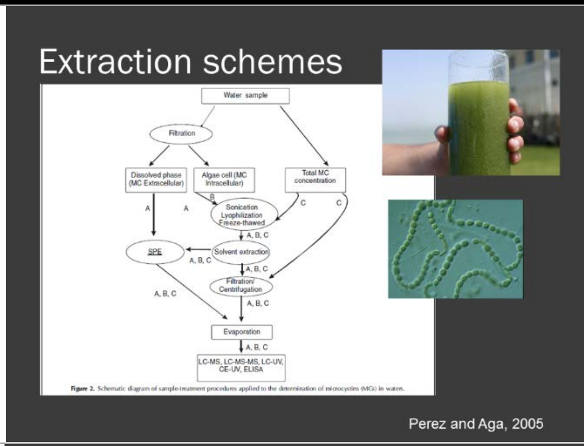
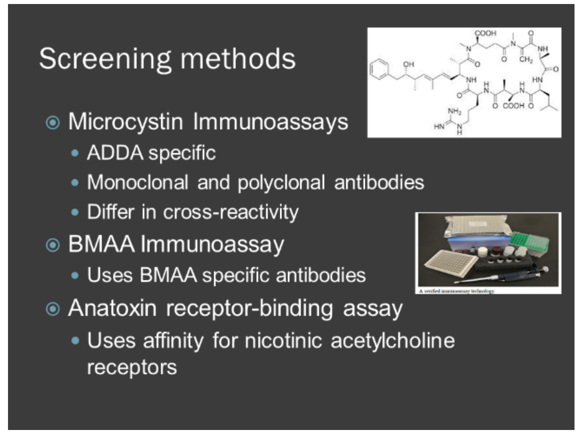
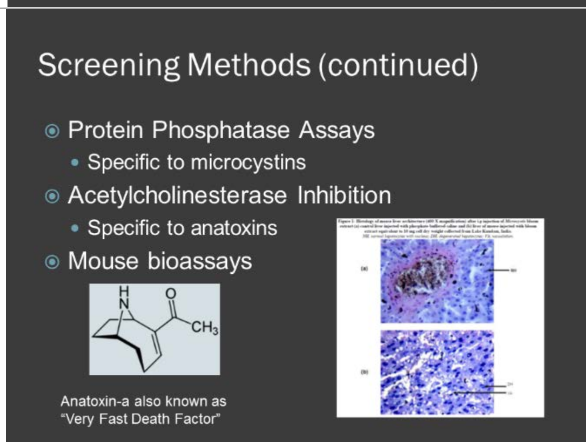
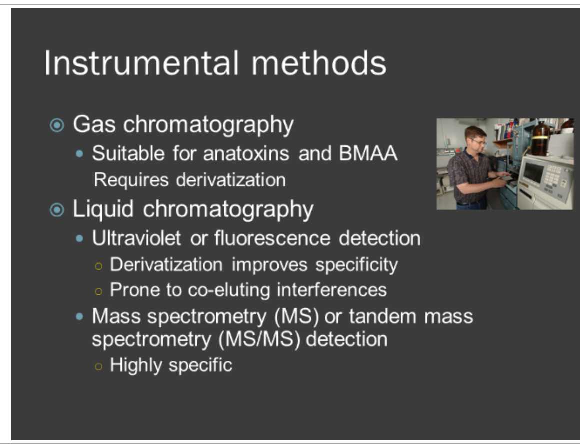
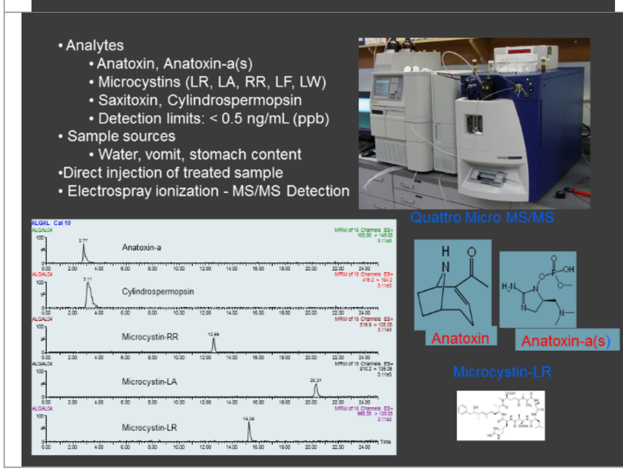
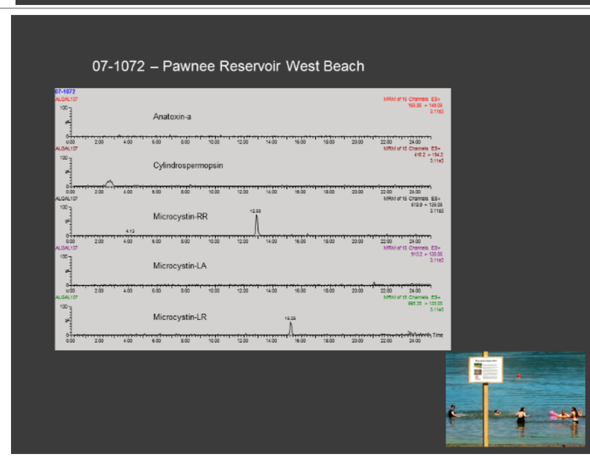




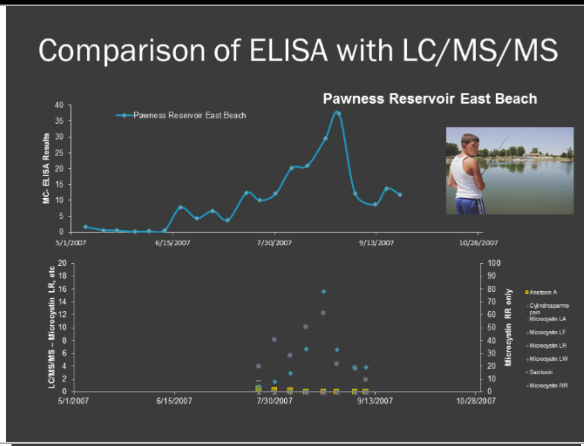


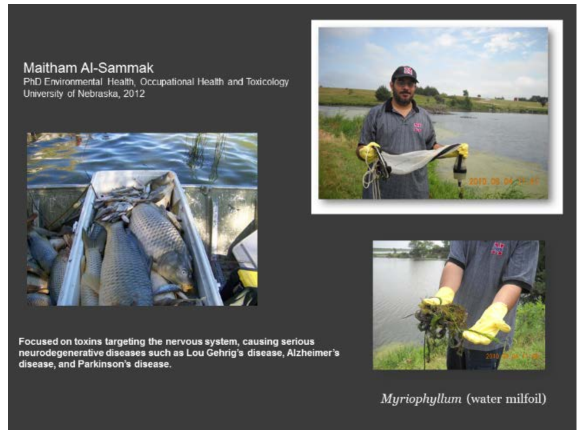


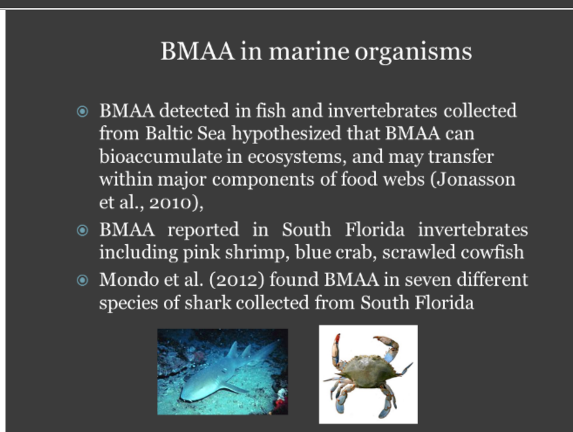


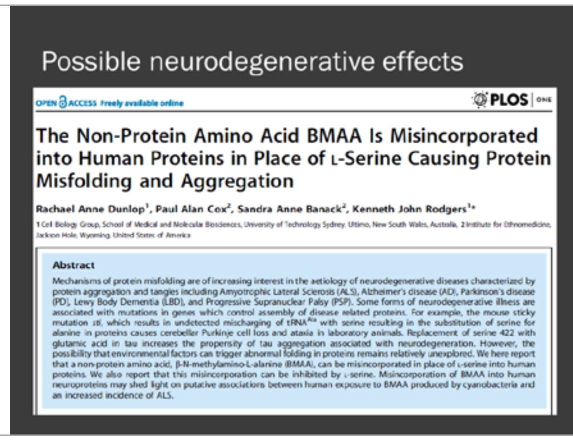


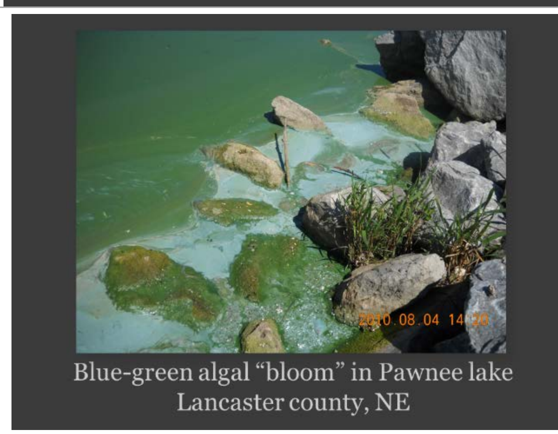
SESSION 3: EMERGING ISSUE – HARMFUL ALGAL BLOOMS AND FISH CONSUMPTION
Analytical Methods and Seasonal Variations of Selected Cyanotoxins in Lake, Fish, and Plant Tissue in Nebraska – Dan Snow







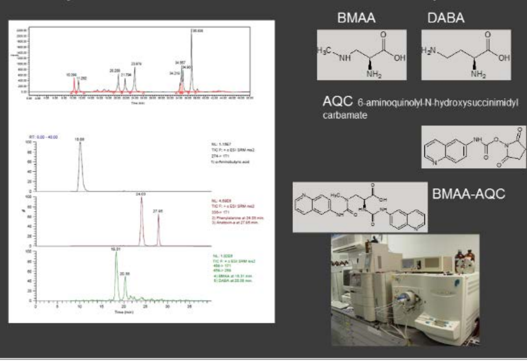




SESSION 3: EMERGING ISSUE – HARMFUL ALGAL BLOOMS AND FISH CONSUMPTION

Analytical Methods and Seasonal Variations of Selected Cyanotoxins in Lake, Fish, and Plant Tissue in Nebraska – Dan Snow

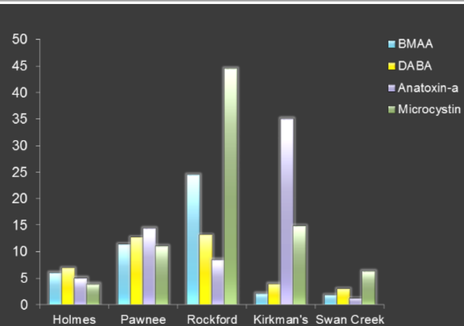
Comparison of HPLC-FL and MS/MS



Lakes and Reservoirs

- A new method was used to extract cyano-neurotoxins from water with detection by LC/MS/MS or HPLC/FL for measurement of BMAA, DABA, and anatoxin-*a*
- Twelve Nebraska lakes and reservoir were sampled
- Two lakes - control group - absence of cyanotoxins consistent with previous monitoring
- BMAA, DABA, and anatoxin-*a* were detected in Nebraska reservoirs in 2009-2010

Waters Oasis MCX solid phase extraction cartridge



BMAA, DABA, anatoxin-*a* levels (μg/L.) compared to microcystin levels in Nebraska lakes in 2009. (microcystin levels from NDEQ website).

Summary

- Water: BMAA and DABA were measured in **13** samples in 2009 and **12** samples in 2010, while anatoxin-*a* was detected in **13** samples in 2009 and **18** samples in 2010.
- Fish: BMAA was found in **22** samples in 2009 and **9** samples in 2010, while DABA was detected in **19** samples in 2009 and **7** samples in 2010. Anatoxin-*a* was not detected in any fish samples.
- Plants: BMAA, DABA, and anatoxin-*a* were detected in **15** samples in 2009 and **15** samples in 2010.

Table 7. Summary of samples with positives and undetected (ND) levels of cyanotoxins from a total of 387 samples collected between 2009 and 2010.

Samples	2009	2010	Total positive (% of total)	ND
Reservoir water	13	18	31 (46.3)	36
Fish	24	9	33 (13.3)	215
Aquatic plant	15	15	30(41.7)	42
Total samples collected in 2009–2010 = 387			94	293

Freshwater Cyanotoxins

- Variety of methods used for measurement
- Microcystins regularly monitored using ELISA screen
- Seasonal occurrence – peak in mid to late summer
- Recent research suggests neurotoxic metabolites also occur in water, plants and fish tissue

References

- *Al-Sammak, M.*, K. Hoagland, D. Cassada, D. D. Snow. 2014. Co-occurrence of the cyanotoxins BMAA, DABA and Anatoxin-a in Nebraska reservoirs, fish, and aquatic plants. Toxins, 6 (2), 488-508. doi:10.3390/toxins6020488. ISSN 2072-6651http://www.mdpi.com/journal/toxins. Published on-line: 28 January 2014.
- *Al-Sammak, M. A.*, Snow, D., Hoagland, K., and Cassada, D. 2013. Methods for Detection of Neurodegenerative Cyanotoxins BMAA, DABA, and Anatoxin-a in Environmental Samples. Toxicon, 76(0): 316-325. http://dx.doi.org/10.1016/j.toxicon.2013.10.015 .
- Efting, A.; Snow, D.; Fritz, S. 2011. Cyanobacteria and microcystin in the Nebraska (USA) Sand Hills Lakes before and after modern agriculture. Journal of Paleolimnology 46, (1), 17-27.
- Yang, Y.; Park, Y.; Cassada, D. A.; Snow, D. D.; Rogers, D. G.; Lee, J., 2011. In vitro and in vivo safety assessment of edible blue-green algae, Nostoc commune var. sphaeroides Kützing and Spirulina plantensis. Food and Chemical Toxicology 49, (7), 1560-1564.

Questions and Answers

Q. Did your study look at fish tissue or whole fish? (Richardson)

A. Fish tissue.

Considerations for Fish Advisory Programs for Cyanotoxins in Fish

Tom Hornshaw, Illinois Environmental Protection Agency

Biosketch

Dr. Tom Hornshaw is the manager of the Toxicity Assessment Unit of the Illinois Environmental Protection Agency, joining the IEPA in 1985. In addition to directing the IEPA toxicologists, he provides toxicological expertise for human and environmental health risk assessments; acceptable levels of chemicals in soil, water, air, and fish; and development of rules and regulations. He is the Agency's representative to the Great Lakes Consortium for Fish Consumption Advisories, and is the Chair of the multi-agency Illinois Fish Contaminant Monitoring Program. Dr. Hornshaw obtained B.S. and M.S. degrees in Fisheries Biology from Michigan State University, and he holds a dual Ph.D., also from Michigan State, in Animal Science and Environmental Toxicology.

Abstract

Harmful Algal Blooms (HABs) are becoming more frequent in Illinois lakes, and detrimental effects on human and environmental health are possible due to exposure to cyanotoxins. This presentation will briefly discuss the IEPA’s experience with HABs, and our efforts to establish a HAB Program. It will also provide recommendations for users of lakes experiencing a HAB about the safety of eating fish and other activities such as swimming, boating, skiing, and watering a garden.

SESSION 3: EMERGING ISSUE – HARMFUL ALGAL BLOOMS AND FISH CONSUMPTION
Considerations for Fish Advisory Programs for Cyanotoxins in Fish – Tom Hornshaw

CONSIDERATIONS FOR FISH ADVISORY PROGRAMS FOR CYANOTOXINS IN FISH

Thomas C. Hornshaw, Ph.D
Manager, Toxicity Assessment Unit
Illinois EPA

WHO GUIDANCE VALUES FOR RECREATIONAL EXPOSURES TO CYANOBACTERIA & MC

- Low risk: <20,000 cells/ml or <10 ug/l
- Moderate risk: 20,000-100,000 cells/ml or 10-20 ug/l
- High risk: 100,000-10,000,000 cells/ml or 20-2,000 ug/l
- Very high risk: >10,000,000 cells/ml or >2,000 ug/l

2005, OUR INTRODUCTION TO HABS

- Otter L. bloom introduces us to algal toxins
- Samples sent to phycologist, finds 305,356 cells/ml, primarily Cylindro
- Lake Assn. gets results, asks for advice
- We advise caution, Assn. cancels regatta (later toxin analysis finds no toxins)
- Other sites sampled, 5 >100,000 cells/ml, 1 >1 M cells/ml, MC max = 8.0 ug/l

2005-10 MC SUMMARY

- 2005: 12 samples, 0.09-8.00 ug/l, avg=1.78 ug/l
- 2006: 10 samples, 0.15-8.20 ug/l, avg=2.35 ug/l
- 2007: 165 samples, 0.12-10.77 ug/l, avg=0.75 ug/l
- 2008: 179 samples, 0.15-17.47 ug/l, avg= 0.64 ug/l
- No 2009 samples
- 2010 Clinton L. false alarm – dog dies & girl gets sick, DNR issues advisory, but no bloom & MC range <0.2-1.6 ug/l; death & sickness found to be heat-related

2011 – MICROCYSTIN TEST KITS

- IEPA began using *"Abraxis Microcystin Dipstick for Recreational Water"* Test Kits.
- Quick results in ranges of 0, 0-1.0, 1.0-2.5, 2.5-5.0, and 5.0-10.0 ug/L Microcystin.
- One-year shelf life, ~$24/test
- **A very useful tool!** So far whenever we've had laboratory Microcystin analyzed where we've also used a test kit, test kit results were corroborated.
- 2011 MC results again low concern, and then…

1-Lake Le-Aqua-Na, July 10, 2012

2-Lake Le-Aqua-Na, July 10, 2012

2012 MC HIGHLIGHTS

- L. Le-Aqua-Na: Scum, test kit >10 ug/l, MC=48 ug/l; DNR closes lake
- Candlewick L.: Lake Assn. sample=14,800 ug/l; Assn. closes lake
- Westlake: Lake Assn. sample=31,500 ug/l; Assn. closes lake
- USGS gets involved; 12 sites sampled, range <0.1-4,800 ug/l
- And then the questions began…

CAN I…?

- Eat the fish?
- Swim in the water?
- Ski on the water?
- Water my vegetables?

EAT THE FISH?

- Poor database for uptake into fish, very few commercial labs do fish MC analysis
- Used data from 3 studies with measured MC concs. in water & fish to calculate BAFs (7 species total)
- BAF range 0.6-18.4 (ex., L. Erie water=1.3 ug/l, yellow perch=5.0 ug/kg, BAF=5.0/1.3=3.85)
- Then used Ohio "Do not eat" level of 28 ug/kg in filets as target to back-calculate water conc. corresponding to 28 ug/kg

EAT THE FISH? (contd.)

- Water conc. X BAF=28 ug/kg
- For BAF=0.6, water conc.=46.7 ug/l
- For BAF=18.4, water conc.=1.52 ug/l
- Since WHO Guidance (20 ug/l) is in middle of water conc. range it was chosen as water conc. for "Do not eat" advice
- Wait 2 weeks after scum/bloom is gone before eating fish (Adamovsky et al., 2007)

INITIAL MC BAF DATA

- Poste et al., 2011: L. Ontario (0.9 ug/l) & L. Erie (1.3 ug/l) & filets (ug/kg) from 4 species
- FW drum: Ont. filets=0.8, BAF=0.89; Erie filets=2.4, BAF=1.85
- Wh. perch: Ont. filets=4.5, BAF=5.0; Erie filets=5.6, BAF=4.31
- Y. perch: Ont. filets=3.1, BAF=3.44; Erie filets=5.0, BAF=3.85
- Walleye: Ont. filets=2.1, BAF=2.33; Erie filets=23.9, BAF=18.4

SESSION 3: EMERGING ISSUE – HARMFUL ALGAL BLOOMS AND FISH CONSUMPTION
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BAF DATA, (continued 1)

- Adamovsky et al., 2007: 9-wk pond study (avg MC=17 ug/l) with common & silver carp
- Common carp avg=9.8 ug/kg, BAF=0.58, max=29 ug/kg, BAF=1.7
- Silver carp avg=10.6 ug/kg, BAF=0.62, max=19 ug/kg, BAF=1.1
- Depuration study: MC <DL after 1 wk in silver carp & 2 wk in common carp (also cites studies with half-lives of 8 d for snails and 3-4.8 d for clams)

BAF DATA, (continued 2)

- Ohio EPA: Grand Lake St. Mary black crappies
- 2011 samples: water conc. range 5.6-34.2 ug/l, crappie max=65.4 ug/kg, BAF range 1.91-11.6
- 2012 samples: water conc. range 30-45 ug/l, crappie max=25.7 ug/kg, BAF range 0.57-0.86
- Note: L. Ontario crappie max=1.9ug/kg, water=0.9 ug/l, BAF=2.11

ADDITIONAL MC BAF DATA

- Barry et al., 2011: carp BAF=14 (Mexican lake with persistent bloom)
- Papadimitriou et al., 2012: carp BAF=3.7 (Aug) and 5.9 (Nov) (eutrophic Greek lake)
- Amrani et al., 2014: carp BAF~11.3 and eel BAF~1.1 (adjusted for dry wgt.; Algerian lake)
- Singh and Asthana, 2014: carp BAF=0.16, catfish >150 g BAF=1.54, and catfish <150 g BAF=1.96 (Indian lake)
- Note: Carp BAF range (5 studies) 0.16-14, 2 OMs

ADDITIONAL MC DEPURATION DATA

- Smith & Haney 2006: 50% decrease in sunfish muscle after 15 days
- Dyble et al., 2011: 99% decrease in juvenile y. perch muscle after 16 hours (single dose)
- Lance et al., 2014: 58% decrease in stickleback muscle after 5 days

SWIM IN THE WATER?

- Even low MC concs. can cause sensitive people to have allergic response
- Increasing conc.=increasing symptoms (eye/nose irrit., rash/hives, blisters)
- Follow WHO Guidance of 20 ug/l to protect against symptoms
- Don't swim when scum/bloom present
- Wait 2 weeks after scum/bloom is gone

SKI ON THE WATER?

- Water sprays can produce toxin-containing aerosols if water conc. is high
- Inhaling &/or swallowing aerosols can cause headaches, nausea, sore throat, and respiratory problems
- Eye & nose irritation possible
- Don't boat, water ski, tube, etc. when scum/bloom is present
- Wait 2 weeks after scum/bloom is gone

WATER MY VEGETABLES?

- Few studies on uptake into vegetables
- Should be OK to water soil, studies suggest minimal uptake into plants
- If edible portions are recently watered they should be thoroughly washed
- Don't water recently planted vegetables or plants, MC shown to affect root & shoot growth (Pflugmacher et al., 2007)

UNCERTAINTIES!

- Guidance primarily for acute effects, long-term effects?
- Guidance for MC only, other toxins?
- Poor correlation between cell counts and toxin concs.
- BAF based on limited data, several variables contribute (species, age, diet, water body/habitat characteristics, metabolic capability)
- Wait 2 weeks recommendation based on limited data

Did Cell Count and Microcystin Expected Relationships Exist in 2012 ?

Kinda, Sorta, Not Really!

Collection Date	Lake/ Location	Result (Microcystin ug/L)	WHO Rec. Advisory Level	*Result (Total Cyano-bacteria cells/mL)*	*WHO Rec. Advisory Level*
8/29/12	Candlewick (RPV-99)	4,800	Very High	*84,573,082*	*Very High*
8/29/12	Westlake (RPZK-98)	1,700	High	*302,526*	*High*
9/4/12	Camp Walter Scott Beach (RCS-99)	1,500	High	*3,528,833*	*High*
8/30/12	Patriot's Park Lake (ROY-99)	9.8	Low	*572,012*	*High*
8/29/12	Le-Aqua-Na (RPA-99)	6.7	Low	*1,178,963*	*High*
9/4/12	Wonder Lake (RTZC-99)	0.88	Low	*467,627*	*High*

2005-12 LESSONS LEARNED & QUESTIONS

- Hot, dry summers cause lots of algae problems!!
- Lots of blue greens ***does not always*** equal lots of algal toxins.
- ***"Think twice before you lyse."*** Blue green algae management for PWS vs. recreational uses can be polar opposites!
- ***Better safe than sorry!*** Otter Lake Water Commission did the right "public safety" thing in canceling the regatta.
- ***Who is responsible*** for advisories? IDPH? IEPA? Lake Owner?
- ***Who's out there*** looking at this stuff in Illinois?
- ***Big Lag Time*** – The time between collection, algal identification and enumeration, toxin analyses, and issuance of an advisory/closure is lengthy.

POST-FALL 2012

January 16, 2013, meeting to share information, listen to experts, share experiences, seek input for the future. 70-80 in attendance:

- Gregg Good, IEPA, Summary of HAB Issue
- Dave McMillan, IEPA, PWS Issues
- Joe Rush, JadEco, Homeowner Education and Recent Experiences
- Tom Hornshaw, IEPA, HAB Health Risks (fish, veggies, aerosols)
- Val Beasley, U of I VetMed, Pets and Livestock
- Keith Loftin, USGS National HAB Expert
- Cyndi Wagner, IDEM HAB Coordinator
- Open Discussion

2013 - BIRTH OF THE HAB PROGRAM

- ***Public Safety Goal*** (as opposed to Research)
  - Provide HAB Education
  - Monitoring/Analysis – Accurate & Fast Results (~6-7 days)
  - Provide Results for Local Decision-Making
- ***Decision to "KISS"*** – Keep it Simple Stupid!
  - Just Microcystin, no other Toxins right now
  - Just Toxin Analysis, no ID/Enumeration of Algae right now
- ***Secured a Laboratory*** – Iowa DNR ELISA Testing
- ***Secured Funding*** – Illinois Partners for Conservation
- ***Test Kits Purchased*** – IEPA SWS and VLMP Coordinator Staff
- ***Other IEPA Section Lookout*** - Public Water Supply and Field Operations Staff Notified
- ***SOPs Developed*** - for Microcystin Sampling and Shipment
- ***"HAB Report Form" Developed*** - for Submittal to Determine need for IEPA/VLMP Coordinator Personal Investigation

SESSION 3: EMERGING ISSUE – HARMFUL ALGAL BLOOMS AND FISH CONSUMPTION
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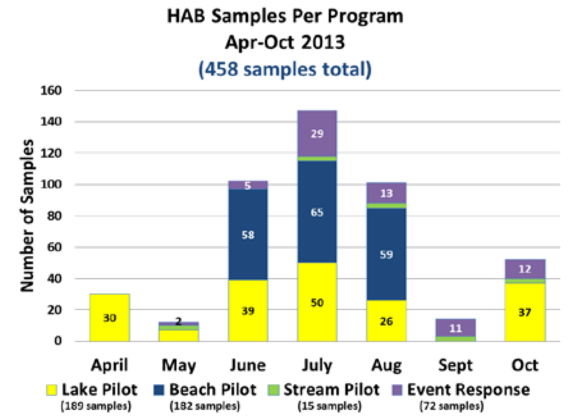
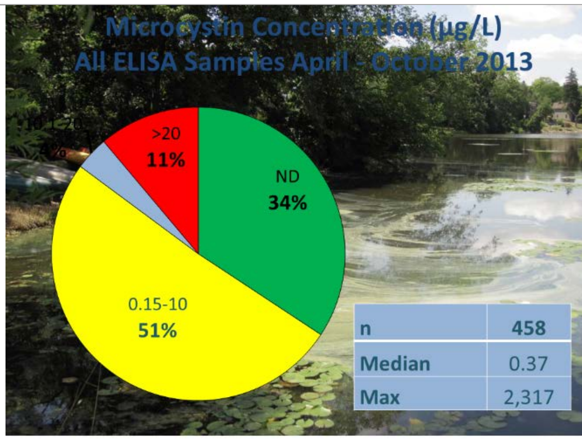
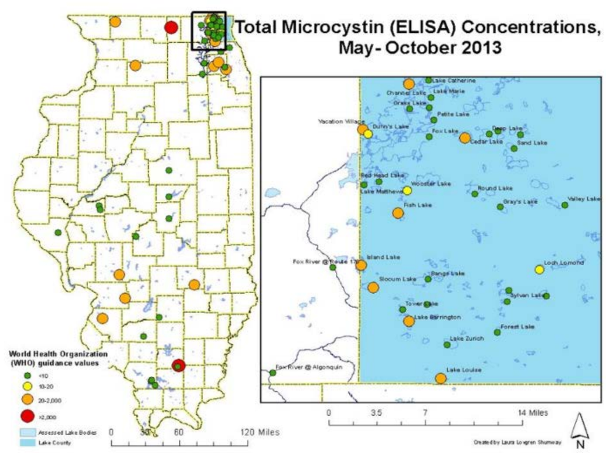
2013 HAB PROGRAM (contd)

- ***We Nailed Down a Monitoring Design***
  - Routine Pilot Survey
    - 10 of 45 IEPA Ambient Monitoring Program Lakes
    - 30 of 100+ Lake County Health Dept. - Beaches
    - 3 IEPA Ambient Stream Stations on the Fox River
  - Event Response
    - Blooms noticed at other IEPA Ambient Lakes
    - Citizenry Reporting of Bloom Conditions
- ***We Developed a HAB Website*** – Fact Sheet, Presentations, Educational Materials, Report Forms, SOPs, etc.







FINAL THOUGHTS

- 20 ug/l guidance value is very conservative? No fish kills or human or animal symptoms yet
- Variability seen in BAFs between & among species, but all 10 species' BAFs <20, so there's better confidence in choosing 20 ug/l
- Nutrients can play big role in fueling blooms, but how to keep N & P on the farm?

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SESSION 3: EMERGING ISSUE – HARMFUL ALGAL BLOOMS AND FISH CONSUMPTION
Considerations for Fish Advisory Programs for Cyanotoxins in Fish – Tom Hornshaw

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Dyble J et al., 2011. A kinetic study of accumulation and elimination of Microcystin-LR in yellow perch (*Perca flavescens*) tissue and implications for human fish consumption. Mar. Drugs 9: 2553-2571.

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REFERENCES 003

Papadimitriou T et al., 2012. Assessment of microcystin distribution and biomagnification in tissues of aquatic food web compartments from a shallow lake and evaluation of potential risks to public health. Ecotoxicology 21: 1155-1166.

Pflugmacher S et al., 2007. Effects on growth and physiological parameters in wheat (*Triticum aestivum* L.) grown in soil and irrigated with cyanobacterial toxin contaminated water. Environ. Toxicol. Chem. 26: 2710-2716.

Poste AE et al., 2011. Evaluating microcystin exposure risk through fish consumption. Environ. Sci. Technol. 45: 5806-5811.

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Singh S and Asthana RK, 2014. Assessment of microcystin concentration in carp and catfish: a case study from Lakshmikund Pond, Varanasi, India. Bull. Environ. Contam. Toxicol. 92: 687-692.

Smith JL and Haney JF, 2006. Foodweb transfer, accumulation, and depuration of microcystins, a cyanobacterial toxin, in pumpkinseed sunfish (*Lepomis gibbosus*). Toxicon 48: 580-589.

Illinois EPA HAB website: Illinois EPA HAB website.

Questions and Answers

Note: There were no questions because the moderator moved along to the next speaker on this panel.

Cyanotoxin Toxicity: Fish and Human Health Assessment

Lesley V. D'Anglada, U.S. Environmental Protection Agency

Biosketch

Dr. Lesley V. D'Anglada is a microbiologist at the U.S. Environmental Protection Agency (EPA), Office of Science and Technology (OST), Office of Water in Washington, DC. Over the last nine years, Dr. D'Anglada has provided technical guidance on microbial contamination to other offices in the Agency, to personnel from other government agencies, and to non-governmental groups. She is the lead in coordinating with EPA Regions and other federal partners on the issues related to cyanobacterial Harmful Algal Blooms (HABs) and has organized webinars, served in expert panels, written papers, and is currently editing a special edition of Toxins on HABs and public health. She is leading the efforts for the development of Drinking Water Health Advisories and Human Health Ambient Water Quality Criteria for cyanotoxins. In addition, she is the EPA/World Health Organization (WHO) Microbial Subcommittee Member providing advice and recommendations on potential public health risks associated with pathogens in drinking water, and a former Adjunct Professor of Environmental Health at George Mason University in Virginia. Dr. D'Anglada received her B.S. in Industrial Microbiology, her M.S. in Environmental Health, and her Doctorate in Public Health with a concentration in Environmental Health from the University of Puerto Rico.

Abstract

Cyanotoxins in surface water may constitute a human and animal health risk and have adverse effects on aquatic life and water quality. In the United States, cyanobacterial HABs seem to have dramatically increased in recent decades and most of the states are now experiencing them in their freshwaters. OST has compiled field and laboratory studies conducted worldwide on the levels of three cyanotoxins (microcystin-LR, cylindrospermopsin, and anatoxin-a) found in tissues of aquatic species on fish, shellfish, and crustaceans. The studies showed wide ranges of cyanotoxins concentrations in fish tissues and organs as well as among trophic levels. Several studies have shown higher concentrations in fish livers compared with edible fish tissue. OST has also compiled and reviewed the toxicity of these three cyanotoxins in humans ranging from acute toxicity, hepatoxicity, developmental, and growth studies, as well as reproductive toxicity. Only a few recent studies have been published on the presence and effects of cyanotoxins, especially on the microcystin LR congener. OST will use these data for the development of Drinking Water Health Advisories and Human Health Ambient Water Quality Criteria for cyanotoxins.

Cyanotoxin Toxicity: Fish and Human Health Assessment

Lesley V. D'Anglada, Dr.PH
US Environmental Protection Agency
Office of Water/Office of Science and Technology

2014 National Forum on Contaminants in Fish
September 22, Alexandria VA

1

Presentation Overview

- Describe public health guidelines in place
- Discuss the toxicity assessment done for the three cyanotoxins listed in CCL
- Present an overview of the literature review done on cyanotoxins levels detected in fish
- Opportunity for Questions

2

Overview of Harmful Algal Blooms

- The prevalence and duration of Harmful algal blooms (HABs) in freshwater is rapidly expanding in the U.S. and worldwide.
- Some algal blooms can produce toxins at levels that may be of concern for human health and ecological impact.
- HABs have caused economic losses to the fishing and recreation industries while increasing costs for managing and treating potable water supplies.




Guidelines and Regulations for Recreational and Drinking Water

- No federal regulations or guidelines for cyanobacteria or cyanotoxins in recreational and drinking water in the U.S.
- Candidate Contaminant List (CCL):
  - CCL 1 and CCL 2: Cyanobacteria (blue-green algae), other freshwater algae, and their toxins
  - CCL 3 (2009): Cyanotoxins (anatoxin-a, microcystin-LR, and cylindrospermopsin)
- Regulatory Determination:
  - RD 1 and RD 2: No Regulatory Decision - not sufficient information
  - RD 3 - to be published
  - WHO Guidelines:
    - Drinking Water: **1 µg/L** for microcystin-LR
    - Recreational Water Risk:
      - Low: <20,000 cyanobacterial cells/mL; 10 µg/L MC-LR
      - Moderate: 20,000-100,000 cyano cells/mL; 10-20 µg/L MC-LR
      - High: >100,000 cyanobacterial cells/mL; >20 µg/L MC-LR

Guidance values for drinking water have been adopted by 3 states

State	Drinking Water Guidance/Action Level
Minnesota	Microcystin-LR: 0.04 µg/L
Ohio	Microcystin: 1 µg/L Tox Eq Anatoxin-a: 20 µg/L Cylindrospermopsin: 1 µg/L Saxitoxin: 0.2 µg/L
Oregon	Microcystin: 1 µg/L Tox Eq Anatoxin-a: 3 µg/L Cylindrospermopsin: 1 µg/L Saxitoxin: 3 µg/L

- Guidance values for recreational waters have been adopted by many states...

State	Recreational Water Guidance/Action Level
California	Microcystin: 0.8 µg/L; Anatoxin-a: 90 µg/L; Cylindrospermopsin: 4 µg/L
Connecticut	-Visual Rank Category 1: Visible Material is not likely cyanobacteria or water is generally clear. -Visual Rank Category 2: Cyanobacteria present in low numbers. -Visual Rank Category 3: Cyanobacteria present in high numbers.
Illinois	Microcystin-LR concentration results approach or exceed 10 µg/L
Indiana	Level 1: very low/no risk < 4 µg/L microcystin-LR Level 2: low to moderate risk 4 to 20 µg/L microcystin-LR Level 3: serious risk > 20 µg/L microcystin-LR Warning Level: Cylindrospermopsin: 5 ppb
Iowa	Microcystin ≥ 20 µg/L
Kansas	Health advisory: >4 µg/L to <20 µg/L for microcystin or > 20,000 cell/mL to <100,000 cell/mL cyanobacteria cell counts Health Warning: > 20 µg/L or > 100,000 cell/mL cyanobacterial cell counts and visible scum present
Kentucky (Louisville District)	Advisory: >20,000 cells/mL of cyanobacteria cell counts; Caution: > 100,000 cells/mL of cyanobacteria cell counts
Massachusetts	14 µg/L for microcystin-LR and ≥ 70,000 cells/mL for cyanobacteria cell counts
Nebraska	Microcystin ≥ 20 µg/L
New Hampshire	>50% of cell counts from toxigenic cyanobacteria
North Carolina	Visible discoloration of the water or a surface scum may be considered for microcystin testing
Ohio	Microcystin-LR: PHA: 6 µg/L; NCA: 20 µg/L; Anatoxin-a: PHA: 80 µg/L; NCA: 300 µg/L Saxitoxin: PHA: 0.8 µg/L; NCA: 3 µg/L; Cylindrospermopsin: PHA: 5 µg/L; NCA: 20 µg/L
Oklahoma	100,000 cell/mL of cyanobacteria cell counts and > 20µg/L for microcystin
Oregon	Option 1: Visible scum and cell count or toxicity Option 2: Toxigenic species >100,000 cells/mL Option 3: Microcystis or Planktothrix >40,000 cells/mL Option 4: Microcystin : 10 µg/L ; Anatoxin-a: 20 µg/L; Cylindrospermopsin: 6µg/L; Saxitoxin: 100 µg/L
Rhode Island	Visible cyanobacteria scum or mat and/or cyanobacteria cell count > 70,000 cells/mL and/or ≥14 µg/L of microcystin-LR
Texas	> 100,000 cell/mL of cyanobacteria cell counts and >20µg/L microcystin
Vermont	4,000 cells/mL cyanobacteria cell counts or ≥ 6µg/L microcystin-LR and the visible presence of cyanobacterial scum Anatoxin-a ≥10 µg/L
Virginia	Microcystin provisional action level: 6µg/L
Washington	Microcystin-LR: 6 µg/L; Anatoxin-a: 1 µg/L; Cylindrospermopsin: 4.5 µg/L; Saxitoxin: 75 µg/L
Wisconsin	> 100,000 cells/mL or scum layer

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Drinking Water Health Advisory for Cyanotoxins Development

Drinking Water Health Advisories (HA) for Cyanotoxins: Microcystin-LR, Anatoxin-a, and Cylindrospermopsin

- Joint collaboration with Health Canada to develop science basis for HAs.
- Informal technical guidance for unregulated drinking water contaminants to assist federal, state and local officials, and managers of public or community water systems in protecting public health.
- HA are **non-regulatory** concentrations at which adverse health effects are not anticipated to occur over specific exposure durations:
  - One-day, 10-day, lifetime, and carcinogenic effect
- Status:
  - External Peer Review of the Health Effects Support Document for Cyanobacterial Toxins – *Currently*
  - Draft final HA to include:
    - Quantification of Toxicological Effects
    - Analytical Methods
    - Treatment Techniques
  - Publication – End 2014/Early 2015

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Cyanotoxins Toxicity Assessment

- Microcystin-LR
- Cylindrospermopsin
- Anatoxin-a

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Preliminary Human Health Assessment on Microcystin

Toxicity Assessment Summary:

- The toxicological database is almost exclusively limited to data on the MC-LR congener.
- Case reports confirm target organs, but lack of dose information makes the human data not useful.
- Acute and sub-chronic toxicity studies confirm the liver, kidney and testes as target organs.
- Chronic toxicity studies have not observed clinical signs of toxicity.
- Reproductive and developmental toxicity studies showed decreased in sperm counts and a reduction in sperm motility after 3 and 6 months with severity increasing with longer duration of exposure.

Some of the Research Gaps Identified:

- None of the available studies are considered adequate for carcinogenicity assessment of microcystins.
- Very limited information is available on the toxicity via inhalation exposure.
- Limited information on the relative potencies of other microcystin congeners when compared to MC-LR is
- Information on the potential health effects from exposure to mixtures of cyanotoxins.

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Preliminary Human Health Assessment on Cylindrospermopsin

Toxicity Assessment Summary:

- Based on acute and sub-chronic studies done in mice, liver and kidneys appear to be the primary target organs for cylindrospermopsin toxicity.
- There are no chronic exposure studies on cylindrospermopsin.
- There are few studies on the genotoxicity of cylindrospermopsin, and there is some evidence of potential damage to DNA in mouse liver or causes mutations.

Some of the Research Gaps Identified:

- The chronic toxicity of cylindrospermopsin is unknown.
- None of the available studies are considered adequate for carcinogenicity assessment of cylindrospermopsin.
- No information on acute or chronic inhalation toxicity of cylindrospermopsin was identified.

Preliminary Human Health Assessment on Anatoxin-a

Toxicity Assessment Summary:

- The main known toxic effect of anatoxin-a is acute neurotoxicity.
- There are no cancer, genotoxicity, acute or chronic exposure studies on anatoxin-a, thus there is inadequate information to assess carcinogenic potential.
- Not enough information on sensitive endpoints and associated dose-response relationships to develop an RfD.

Some of the Research Gaps Identified:

- No acute oral studies using purified anatoxins could be found.
- No chronic oral studies have been performed.
- There is no information on carcinogenicity in humans or animals or on possible carcinogenic processes.
- No information regarding mutagenicity or genotoxicity of anatoxin-a was identified.

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Next Steps DW Health Advisories

- Quantification of Dose-Response (One-day, 10-day, lifetime, and carcinogenic effect)
  - RfD for microcystin-LR
  - RfD for cylindrospermopsin

$$RfD = \frac{NOAEL(LOAEL)}{UF}$$

- External Peer Review
- Development of DW HA
  - Health Advisory Value
  - Analytical Methods
  - Treatment Techniques

$$HA = \frac{RfD \times BW}{UF \times DW}$$

- Internal Review
- Publication – Spring 2015

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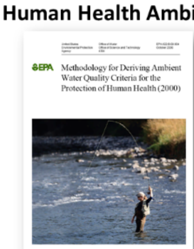
And then....

Human Health Ambient Water Quality Criteria Development



- Under section 304(a)of the CWA, EPA develops numeric values limiting the amount of chemicals present in our nation's waters to protect public health, aquatic life and recreational uses.
- These criteria are **not rules** and States may adopt the criteria that EPA publishes, modify EPA's criteria to reflect site-specific conditions, or adopt different criteria based on other scientifically-defensible methods.

Guidance document available at Guidance Document
Technical support documents:
- **Risk Assessment** Risk Assessment
- **National Bioaccumulation Factors** National Bioaccumulation Factors
- **Site-specific Bioaccumulation Factors** Site-specific Bioaccumulation Factors

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Water Quality Criteria Development

Hazard Assessment

Toxicity
- Toxic effects and dose-response properties
- Risk Specific Doses for linear carcinogens
- Point of Departure (POD)/Uncertainty Factor (UF) for nonlinear carcinogens
- Reference dose (RfD) for non carcinogens

Exposure
- Relative Source Contribution (RSC)
- Exposure parameters: body weight (BW) drinking water intake (DI) and Fish Intake (FI)

Bioaccumulation factors (BAFs)
- Site-specific BAFs or National BAFs
- Use of site-specific BAFs encouraged
- Trophic level data on accumulation of chemical in fish or shellfish

For consumption of water and organisms:

$$AWQC\ (\mu g/L) = \frac{RfD\ (mg/kg\text{-}d) \times RSC \times BW\ (kg) \times 1000\ \mu g/mg^{\dagger}}{DI\ (L/d) + \sum_{i=2}^{4}(FCR_i\ (kg/d) \times BAF_i\ (L/kg))}$$

For consumption of organisms only:

$$AWQC\ (\mu g/L) = \frac{RfD\ (mg/kg\text{-}d) \times RSC \times BW\ (kg) \times 1000\ (\mu g/mg)^{\dagger}}{\sum_{i=2}^{4}(FCR_i\ (kg/d) \times BAF_i\ (L/kg))}$$

Where:
AWQC = ambient water quality criteria
RfD = reference dose
RSC = relative source contribution
BW = body weight
DI = drinking water intake
$\sum_{i=2}^{4}$ = summation of values for aquatic trophic levels (TL) where the letter "i" stands for the trophic levels to be considered, starting with TL 2 and proceeding to TL 4
FCR_i = fish consumption rate for aquatic trophic levels 2, 3, and 4
BAF_i = bioaccumulation factor for aquatic trophic levels 2, 3, and 4

Evaluation of Potential Bioaccumulation of Cyanotoxins in Fish

- Microcystin-LR
- Cylindrospermopsin
- Anatoxin-a

Steps for deriving BAFs for cyanotoxins:
- Collect and review all relevant bioaccumulation data for the cyanotoxins for review for adequacy.
- Calculate individual toxin-specific BAF for each trophic level.

BAF Derivation equation used by EPA in the 2000 Human Health Methodology

$$BAF = \frac{C_t}{C_w}$$

where:
C_t = total concentration of the chemical in wet tissues
C_w = total concentration of chemical in water

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Trophic Level	Species/tissue		Concentration of Microcystins	Reference
2	Shrimp	Whole	0.051-0.114 µg/g ww	Ibelings and Chorus, 2007
		Muscle	0.004-0.006 µg/g ww	Zimba et al., 2006
		Hepatopancreas	**55 µg/g ww**	
	Crayfish	Whole	0.4 - 2.9 µg/g dw	Vasconcelos et al., 2001
	Tilapia rendalli and Oreochromis niloticus)	Muscle	0.002-0.337 µg/g ww	Magalhães et al., 2001
		Liver	0.091- 31.1 µg/g ww	Mohamed et al., 2003
		Viscera	**0-71.6 µg/g ww**	Soares et al., 2004
3	Carp (Cyprinus carpio)	Muscle	0.05 - 0.157 µg/g fresh ww	Li et al., 2004
		Liver	**0.094-0.807 µg/g ww**	Kohoutek et al, 2010
		Hepatopancreas	0.123 - 0.261 µg/g ww	Papadimitriou et al., 2010
				Berry et al, 2011
	Silver carp (Hypophthalmichthys sp.)	Muscle	1.77 - 1.81 µg/g dw	Xie et al., 2005
		Liver	7.77 µg/g dw	
		Intestine	**22 µg/g dw**	
	Crab	Muscle	0.103 – 0.4 µg/g ww	Mahalhães et al., 2003
	Silverside fish (Odontesthes bonariensis)		(average/maximum)	Cazenave et al., 2005
		Muscle	0.05/0.34 µg/g ww	(MC-RR)
		Liver	**0.16/1.01 µg/g ww**	
		Gill	0.03/0.10 µg/g ww	
	Yellow perch (Perca flavescens)	Muscle	0.00012-0.004 µg/g ww	Wilson et al., 2008
		Liver	**0.017-1.182 µg/g ww**	
4	Catfish (Ictalurus punctatus)	Muscle	0.21 µg/g ww	Zimba et al., 2001
		Liver	**0.123 – 0.250 µg/g ww**	
	Largemouth black bass (Micropterus salmoides)	**Muscle**	**0.32 µg/g**	NDEQ, 2011
		Liver	0.21 µg/g	
	White crappie (Pomoxis annularis)	**Muscle**	**0.32 µg/g**	
		Liver	0.27 µg/g	

*Trophic level assignments based on the Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000)
* Exposure routes from feeding on MC's scums in tanks or natural routes in lake.

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Preliminary Summary of CYL Concentrations in Fish

Trophic Level	Species/tissue		Concentration of Microcystins	Reference
2	Crayfish	Muscle tissue	0.9 µg/g freeze dried tissue	Saker and Eaglesham, 1999
		Hepatopancreas	**4.3 µg/g freeze dried tissue**	
3	Rainbow fish	Viscera	1.2 µg/g freeze dried tissue	Saker and Eaglesham, 1999

*Trophic level assignments based on the Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000)
* Exposure routes from feeding on MC's scums in tanks or natural routes in lake.

Preliminary Summary of Anatoxin-a Concentrations in Fish

Trophic Level	Species/tissue		Concentration of Microcystins	Reference
3	Carp (Cyprinus carpio)	Whole	0.005 – 0.073 µg/g fresh ww	Osswald et al., 2007

*Trophic level assignments based on the Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000)
* Exposure routes from feeding on MC's scums in tanks or natural routes in lake.

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Findings…so far

- MC's levels in edible fish and shellfish are highly variable depending on trophic level, bloom conditions, and potential for depuration: (Ibelings and Havens, 2008, Zhang et al, 2009)
  - Concentrations are higher in liver > gut > kidneys and gonads > muscle tissue
  - Concentrations are higher >phytoplanktivorous > omnivorous > carnivorous fish
- Different aquatic animals may have different metabolism routes and accumulation pattern of MCs.
- Exposure to high levels of cell-bound toxin are more of a concern for accumulation in fish than when compared with dissolved toxin (Kinnear, 2010 and GWA Nyakairu, 2010).

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Findings…so far (continued)

- Microcystin concentrations in fish tends to be higher in lakes where microcystin concentrations in water are also high (Poste et al, 2012)
- Rather than biomagnification, biodilution seems to occur in the foodweb with toxins being subject to degradation and excretion at every level (Ibelings and Havens, 2008).
- One of research needs identified is the need to quantify the total toxicity in fish caused by MCs variants and other secondary metabolites.

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Next Steps

- Finalize DWHA's
  - Quantification of HA values
  - Incorporate Analytical Methods and Treatment Techniques
- Literature Search and Development of Human Health Ambient Water Quality Criteria for Cyanotoxins (in progress)

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Questions?

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Questions and Answers

Q. *When will the document currently under development be released? Also what type of advisory for cyanotoxins will it include? Will it be for drinking water or ambient water? (Hoffman-Contois)*

A. EPA wants to release the document as soon as possible, hopefully in the spring of 2015. They are currently consulting experts to ensure the accuracy of the document. EPA will notify the states as soon as it is released. The document will only include a drinking water health advisory. EPA does not know yet whether it will be acute, chronic, or sub-chronic values.

Q. *How would you implement a water quality standard if there is no point or nonpoint source? Is there a precedent for this? (Mike Ell)*

A. Yes, there is no point or nonpoint source, although EPA knows nutrient discharges play an important role in HABs. It may take more time to analyze the toxicity of cyanotoxins for ambient water quality, versus a drinking water health advisory.

General Question and Answer Session

Q. *Where he grew up, there were many ponds that were green with scums, especially during the summer. How often does pond scum include toxins? Also in a pond without a bloom and with no scums, how likely is it that toxins could occur? (Gochfeld)*

A. He has seen one paper that reported if there was no evidence of a bloom, it was doubtful that you would find evidence of toxins. He thinks that toxicity could occur only for a short time after a bloom collapses. (Hornshaw)

A. He is not sure whether blooms are more frequent now. He thinks there have always been cyanotoxins, but maybe concentrations are higher now. There have been reports of livestock deaths—especially cows—for over 100 years. (Snow)

Q. *We need leadership in this area. We need more comparability of data. Tom Hornshaw mentioned a study with 28 ug/kg in fish fillets. He has looked at the WHO Guidance values. He asked Tom Hornshaw whether the Illinois EPA has a water concentration number where they start to worry about people eating fish? (Ginsberg)*

A. Although 20 ug/l was the water concentration number used by the Illinois EPA, it was in the middle of the range they were seeing, so it could have been a higher or lower number. In Ohio, the level of 28 ug/kg in fillets was based on just one study. The person from Ohio is no longer in that position, but he could try to look up more about that Ohio study. The WHO Guidance values were based on acute exposure. (Hornshaw)

Q. *She was looking at CDC's work on recreational waters that documents around 800 public health outbreaks from cyanotoxins. The states do not have the resources to deal with this. Because of lack of information, CDC put a Fellow into the public health departments of each of the eight Great Lakes states to help identify outbreaks and send clearer messages of the health impacts to physicians. She expects with more physicians educated, there will be more reports of outbreaks. (Fisher)*

A. There were no responses or comments from any of the panelists.

Q. *Could Tom Hornshaw or Dan Snow speak on how to collect samples from one part of a lake to represent the whole water body? (Celona)*

A. Their approach requires taking three different samples within the bloom within one foot of the water surface. This will help ensure there will be variability in those samples. (Hornshaw)

A. In his presentation on Pawnee Lake, he only showed data for one side of the lake, but the other side of the lake had different data. Cyanotoxins can be very different in different parts of a lake. Because these are seasonal contaminants, the more data we have the better we can predict the impacts. (Snow)

Q. *Do you have any recommendations for where to collect the data? (Celona)*

A. Collect data at swimming beaches just below the surface of the water. (Snow)

A. Collect three samples within the bloom, no more than one foot below the surface of the water. (Hornshaw)

Q. Jackie Fisher had mentioned EPA support for HABs. In Wisconsin, there are reports of problems with blooms, but no reports of people getting sick from eating fish. Also there are no reports of problems from people swimming or animal fatalities in Wisconsin. Although there were no deaths or illnesses yet, they recommend that people do not fish where there are blooms. It would be worth finding out if there are any reports of anyone with gastrointestinal illness from HABs. (Anderson)

A. In Illinois, there are no reports yet of human illness or dog deaths from HABs. (Hornshaw)

Q. Resources are a constraint and it is difficult to get samples. A lot of blooms blow across the water by wind, and it can be difficult to get out to the site before the bloom moves. It will take a lot of work to issue guidance on fish related to HABs. In Wisconsin, they are taking a precautionary approach. There can be a major economic impact from cancelling events or closing beaches and people may question why. (Anderson)

A. There were no responses or comments from any of the panelists.

SECTION II-E SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY

Introduction

Moderator:
Alan Stern, New Jersey Department of Environmental Protection

Biosketch
Dr. Alan H. Stern is lead for toxicology and human health risk assessment in the Office of Science of the New Jersey Department of Environmental Protection. He received a B.S. in Biology from the State University of New York at Stony Brook, an M.S. in Cellular and Molecular Biology from Brandeis University, and a Doctorate in Public Health from the Columbia University School of Public Health. He is a Diplomate of the American Board of Toxicology and served as a member of the National Research Council/National Academy of Sciences Committee on the Toxicology of Methylmercury. Dr. Stern's areas of expertise include human health risk assessment and exposure assessment, including probabilistic approaches. He has pursued an abiding interest in the risk assessment for mercury in general and methylmercury in particular, having published several papers relating to the derivation and interpretation of the methylmercury reference dose. He is also very involved in the consumption advisory process in the State of New Jersey.

Presentations
PFOA-PFOS Health Effects: Draft Office of Water Health Assessments
Joyce Donohue, U.S. Environmental Protection Agency

EPA's Dioxin Reassessment and Toxicity-Equivalence Factors for Dioxin-Like Compounds
Jeff Swartout, U.S. Environmental Protection Agency

EPA's Reassessment of the RfD for PCBs: Key Issues to Be Addressed
Geniece Lehmann, U.S. Environmental Protection Agency

Co-occurrence of PCBs and Mercury in Fish Tissue: Is There a Case for Additivity Based on Common Developmental Endpoints?
Vince Cogliano, U.S. Environmental Protection Agency

National Time Trends in Environmental Exposures and Fish Consumption in U.S. Women of Reproductive Age (NHANES 1999-2012)
Rebecca Birch, Westat

Implications of Recent Epidemiological Evidence on Effects of Methylmercury for Fish Consumption Advice
Ned Groth, Gelfond Fund

Neurodevelopment Effects of Methylmercury
Glenn Rice, U.S. Environmental Protection Agency

Epidemiological Evidence of Fish Consumption, Methylmercury Exposure, and Risk of Cardiovascular Diseases in Adults
Jyrki Virtanen, University of Eastern Finland

Status of IRIS Update for Organic and Inorganic Mercury
Vince Cogliano, U.S. Environmental Protection Agency

PFOA-PFOS Health Effects: Draft Office of Water Health Assessments

Joyce Donohue, U.S. Environmental Protection Agency

Biosketch

Dr. Joyce Morrissey Donohue, R.D., is a Senior Health Scientist in the Health and Ecological Criteria Division in the Office of Science and Technology, Office of Water, at the U.S. Environmental Protection Agency (EPA). Ms. Donohue has a background in biochemistry and nutrition with over 20 years of experience in dealing with the toxicological properties of contaminants in drinking water. During her career, she has authored toxicological profiles of chemicals for EPA, NSF International, U.S. Department of Agriculture, the Agency for Toxic Substances and Disease Registry, and the Department of the Army. She has taught courses in chemistry, biochemistry, nutrition, and nutrition sciences at Virginia Tech and Northern Virginia Community College as an adjunct Associate Professor.

Abstract

Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) are environmentally persistent fluorocarbon compounds. Human exposures result from their use in packaging materials for foods, as stain repellants on upholstery and carpets as well as from discharges to the environment (manufacturing and waste disposal). Epidemiology data suggest the possibility for human health adverse effects and animal studies demonstrate dose-response for a variety of toxicity endpoints. The Office of Water released short-term provisional health advisories for both compounds in 2009. Draft Health Effects Documents were completed in 2013 and externally peer reviewed at a public meeting in August 2014. The draft documents will be revised to accommodate peer review comments and update the research. The resultant reference doses will be used to establish Lifetime Health Advisories for drinking water. They can also be applied in the derivation of guidelines for other exposure media.

SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY

PFOA-PFOS Health Effects: Draft Office of Water Health Assessments – Joyce Donohue

PFOA -PFOS Health Effects

Draft OW Health Assessments

September 23, 2014

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Background

- Widely distributed in the environment
  - Food (fish an important dietary source)
  - Drinking water
  - Indoor air (particulate matter and dust)
- Identified as a drinking water contaminant near sites of discharge
- Provisional Health Advisories (HA) issued by OW in 2009
  - PFOA 0.4 ng/L; PFOS 0.2 ng/L
  - Based on a 10 kg child; 20% from 1L drinking water
  - Short term exposure
- OW Commitment to complete a quantitative heath risk assessment and develop a lifetime HA value

2

Chemical Characteristics

- Minimal solubility in water
  - Hydrophobic and oleophobic
- Resemble the fatty acid octanoic acid
  - PFOA has a carboxylate functional group and PFOS a sulfonate functional group; sulfonate more acidic
  - partial negative charge on the fluorine atoms
  - Bind to positive surfaces
- Not metabolized
- Multiple options for binding to proteins and other biopolymers
  - Serum albumin
  - Fatty acid binding protein
  - Cell surface receptors such as PPAR-α, CAR, PXR, FXR, T3

3

Epidemiology

Effect	PFOA	PFOS
Increased total cholesterol	↑ (3/4) studies	↑ 3/5 studies
Indicators of liver damage	+ (4/5) studies	↑ no data
Low birth weight, growth or development	↑ (2/5) studies	↑ 4/6 studies
Thyroid effects	+ 1/10 studies	+ 1/4 studies
Suppression of immune response*	+ 1/4 studies	+ 1/4 studies
Diabetes	No association	No data
Reproductive hormones	1/4	No data
Cancer	Some association 4/6 studies	Associations not significant

↑positive association; + had an apparent significant effect on the parameter measured

*some association for children with asthma

Reverse causation may account some population based associations

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C8 Studies (PFOA)

- Research Program established under a Class Action Settlement with DuPont
  - Drinking water contamination (DuPont Plant)
  - West Virginia and parts of Ohio
- Probable links established:
  - Kidney and testicular cancer
  - Thyroid disease
  - Ulcerative colitis
  - Elevated cholesterol
  - Pregnancy-induced hypertension and pre-eclampsia

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PFOA Animal Studies

- Rats, mice and monkeys
- Common denominator ↑ liver weight
  - Hallmark of exposure
  - Peer Reviewers questioned whether this was a good Point of Departure (POD) for the Reference Dose (RfD)
- Co-occurring effects
  - Liver hypertrophy, necrosis, decreased cholesterol,
  - Developmental delays (eye-opening, mammary gland),
  - Decreased spleen weight, IgM, increased IgG
  - Accelerated puberty
- NOAELs: Range 0.06 –1.6 mg/kg/day
  - Many key studies lacked NOAELS
- LOAELS: Range 0.65 to 5 mg/kg/day

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SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY
PFOA-PFOS Health Effects: Draft Office of Water Health Assessments – Joyce Donohue

PFOS Animal Studies

- Rats, monkeys, mice
  - Effects on pup survival in early life
  - Developmental delays
  - Increased liver weight in wild type, PPARα null, and PPARα humanized mice
  - Thyroid hormone increases
  - Limited data for immunological effects
- Co-occurring effects
  - Developmental (growth, survival, neurobehavioral)and liver
- NOAELs: Range 0.008 to 1 mg/kg/day
- LOAELs: Range 0.072 to 5 mg/kg/day

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Complex Toxicokinetics

- Saturable renal reuptake of PFOA/ PFOS from urine before excretion
  - A portion of the PFOA/PFOS removed by the kidneys is reabsorbed by kidney tubules causing the long half-live in humans.
  - Published and EPA PK models account for the renal resorption
- Distinctly different species half lives and times to steady state
  - Years for humans
  - Hours/days for rats, mice and monkeys
- EPA Pharmacokinetic Model based on serum measurements from animal studies (Wambaugh, 2013)
  - Supported calculation of a human equivalent dose based on first order human clearance estimates

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Role of PK Model in RfD Derivation

- Normalized serum concentrations across the animal species accounting for
  - species differences in saturable resorption
  - dosing duration
  - experimental NOAELs and LOAELs
- Facilitated calculation of the human equivalent dose (HED) for use in RfD derivation
  - HED = Average serum mg/L x human clearance
- RfD = HED ÷ Uncertainty Factor
  - NOAEL UF = 30 (10 intraspecies; 3 pharmacodynamic interspecies)
  - LOAEL UF = 300 (same as NOAEL = 10 for use of a LOAEL)

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Reference Dose Outcomes

- PFOA
  - Draft RfD = 0.00002 mg/kg/day
  - Critical Effects increased liver weight (10%), hepatic hypertrophy, increased kidney weight, reduced fetal ossification, accelerated puberty
  - Equivalent to a draft Lifetime HA of 0.1 ng/L for a 70 Kg adult and 20% RSC
    - Peer Reviewers suggested a exposure duration adjustment might be needed
- PFOS
  - Draft RfD = 0.00003 mg/kg/day
  - Critical Effects: increased liver weight (10%), developmental neurotoxicity (increased motor activity and decreased habituation)
  - Equivalent to a draft Lifetime HA of 0.2 ng/L for a 70 Kg adult and 20% RSC
    - Peer Reviewers suggested a exposure duration adjustment might be needed

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Cancer Findings

- PFOA - Suggestive Evidence
  - Positive association for kidney and testicular cancers (epidemiology studies)
  - Animals studies: liver, testicular, and pancreatic tumors
    - Only one species evaluated (rat)
    - Dose-response only for testicular tumors (Leydig cell)
      - Cancer Slope Factor = 0.07 per mg/kg/day (>RfD of 0.00002 mg/kg/day)
- PFOA – Suggestive Evidence
  - Liver adenomas
  - No data for quantification
- Peer Reviewers agreed with the Cancer classifications

11

Next Steps

- Address peer review comments
  - Peer Review comments received on September X
- Update the literature supporting the HAs
  - Over 100 publications collected after the preparation of the peer review draft
- Settle the duration adjustment issue
- Complete the clearance process for document release

12

Questions and Answers

Note: There were no questions because the moderator asked that any questions be held until the general Q&A session at the end of this panel.

EPA's Dioxin Reassessment and Toxicity-Equivalence Factors for Dioxin-Like Compounds

Jeff Swartout, U.S. Environmental Protection Agency

Biosketch

Mr. Swartout received his B.S. in Biology from Elmhurst College, Elmhurst, Illinois. He has had extensive graduate training in developmental biology and toxicology at the University of Cincinnati, where he was a Ph.D. candidate. He has served as a toxicologist for the U.S. Environmental Protection Agency (EPA), National Center for Environmental Assessment (NCEA) for 29 years. Jeff specializes in quantitative uncertainty analysis with an emphasis on dose-response modeling for both chemicals and pathogens. He was the co-lead for the most recent dioxin assessment, which culminated with the publication on EPA's Integrated Risk Information System (IRIS) in 2012 of the first dioxin reference dose (RfD). He was also one of the principal authors of the Mercury Study Report to Congress, in which he authored a section on the bioaccumulation of mercury in fish. Mr. Swartout has authored or co-authored several publications addressing quantitative uncertainty in the RfD, exposure model uncertainty, toxicokinetics, and pathogen dose-response modeling. Mr. Swartout is currently a member of the Chemical Risk Assessment Branch in NCEA-Cincinnati, serving on the Cumulative Risk Assessment Team. His current research is focused on dose-additivity for mixtures.

Abstract

EPA has derived an oral RfD for 2,3,7,8-tetrachlorodibenzodioxin (TCDD) of 0.7 pg/kg-day, which was posted as final on IRIS in 2012. The RfD is based on two epidemiologic studies of the Seveso, Italy, population following an acute exposure to TCDD. The critical effects were increased levels of thyroid-stimulating hormone in newborns exposed to TCDD in utero and decreased sperm concentrations in men exposed as boys. The RfD derivation was complicated by the unusual nature of the exposure profile, which was an initial high peak exposure declining over time to background levels. Background exposure to dioxin-like compounds (DLCs), which could have contributed to the observed effects, further complicated the exposure modeling. In its TCDD RfD uncertainty analysis, EPA estimated the contribution of DLCs using a toxicity-equivalence factor (TEF) approach for several background exposure scenarios and found about a 3-fold range of uncertainty above and below the RfD. With respect to DLCs, EPA has adopted the 2005 World Health Organization (WHO) Toxicity Equivalence Factor (TEF) approach for estimating the health impact of combined DLC exposures. TEFs can used to compute the total TCDD toxicity equivalent dose in various exposure media, including fish. The WHO TEFs were derived by professional judgment considering varied sources of in vivo and in vitro data and are not central tendency estimates. The application of TEFs is subject to a number of assumptions concerning applicable endpoints, dose-response shape, and mode of action. Because of these broad uncertainties, EPA recommends the application of a sensitivity analysis for major dioxin hazard assessments involving TEFs, an example of which will be presented.

SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY
EPA's Dioxin Reassessment and Toxicity-Equivalence Factors for Dioxin-like Compounds – Jeff Swartout

EPA's Dioxin (2,3,7,8-tetrachlorodibenzo-*p*-dioxin) Reassessment and Toxicity-Equivalence Factors for Dioxin-Like Compounds

Jeff Swartout and Glenn Rice,
Office of Research and Development,
National Center for Environmental Assessment, U.S. Environmental Protection Agency;
Linda Teuschler, LK Teuschler & Associates

National Forum on Contaminants in Fish
Alexandria, Virginia
September 23, 2014

The views expressed in this presentation are those of the authors and do not necessarily reflect the views and policies of the U.S. Environmental Protection Agency

Our EPA TCDD RfD* Team

- Jeff Swartout (U.S. EPA)
- Glenn Rice (U.S. EPA)
- Linda Teuschler (U.S. EPA, retired)
- Belinda Hawkins (U.S. EPA)
- Janet Hess-Wilson (DOD, formerly U.S. EPA)
- Scott Wesselkamper (U.S. EPA)
- Michael Wright (U.S. EPA)
- Hisham El-Masri (U.S. EPA)

*This presentation covers only the 2,3,7,8-tetrachloro-dibenzodioxin (TCDD) RfD assessment published on IRIS (U.S. EPA, 2012)

1

Reference Dose (RfD)

RfD = POD / UF

Where:

POD = Point of departure either a no-observed-adverse-effect level (NOAEL), a lowest-observed-adverse-effect level (LOAEL) or a benchmark dose ($BMDL_x$). Typically, observed in epidemiology study or animal bioassay

UF = Uncertainty factor(s) applied to account for the extrapolation required from the characteristics of the experimental regimen to the assumed human scenario

2

Selected Epidemiologic Studies

- Studies from two epidemiologic cohorts passed selection criteria
  - Seveso cohort
    - Baccarelli et al, 2008 (increased neonatal TSH)
    - Mocarelli et al, 2008 (decreased sperm counts)
    - Alaluusua et al, 2004 (developmental dental defects)
    - Eskenazi et al, 2002 (increased length of menstrual period)
  - Ranch Hand cohort
    - Michalek and Pavuk, 2008 (diabetes)
      - Measurements made too long after exposure to quantify confidently
- Main source of uncertainty is exposure profile characterization
  - High short-term initial pulse followed by low-level background exposure
  - Determination of effective dose
    - internal dose metric
      - whole blood TCDD concentration from Emond PBPK model
    - identification of critical exposure windows
    - consideration of peak exposure

3

Mocarelli et al. 2008 Overview

- Decreased sperm counts in men who were exposed to TCDD as boys aged 1 – 9
  - Mean sperm concentration and motile sperm concentration reduced 20% and 11%, respectively, in the 1st-quartile exposure group (68 ppt in serum)
  - No dose-related effect of TCDD on sperm counts for men who were 10-17 years old when exposed.
  - Critical exposure window of first 10 years of life identified
  - No TCDD-free reference group
- LOAEL of 0.020 ng/kg-day determined
  - Average of peak and window-specific mean exposures
  - 20% decrease in exposed population mean is biologically significant
  - Emond human PBPK model applied to measured serum concentrations
  - Mean modeled exposure across critical window of 0.008 ng/kg-day
  - Peak exposure equivalent to 0.032 ng/kg-day

4

Baccarelli et al. 2008 Overview

- Increased levels of TSH in newborns exposed to TCDD in utero, 10 to 20 years following initial peak maternal exposure
  - Gestational exposure levels relatively constant
- TSH levels greater than 5 µU/ml considered to be indicative of potential thyroid or neurological functional impairment
  - No overt functional impairment
  - WHO trigger for medical follow-up
- Multivariate regression model of maternal serum TCDD levels and neonatal TSH links exposure and effect
  - Maternal serum TCDD of 235 ppt associated with neonatal TSH levels greater than 5 mU/ml defined as the LOAEL
- A corresponding continuous 30-year daily oral TCDD intake of 0.020 ng/kg-day was determined using the Emond human gestational PBPK model (Emond, et al., 2004)

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SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY
EPA's Dioxin Reassessment and Toxicity-Equivalence Factors for Dioxin-like Compounds – Jeff Swartout

Basis and Derivation of the Draft TCDD RfD

Principal study detail		
Study	POD (ng/kg-day)	Critical effects
Mocarelli et al. (2008)	0.020 (LOAEL)	Decreased sperm count (20%) and motility (11%) in men exposed to TCDD during childhood
Baccarelli et al. (2008)	0.020 (LOAEL)	Elevated TSH (> 5 μU/mL) in neonates
RfD derivation		
POD	0.020 ng/kg-day (2.0E−8 mg/kg-day)	
UF	30 (UF_L = 10, UF_H = 3)	
RfD	7 × 10^{-10} (7E-10) mg/kg-day	

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Uncertainty in the TCDD RfD: Sensitivity Analysis

- Sensitivity analysis of co-principal studies
  - Evaluated several key kinetic variables and background DLC exposures
  - Alternative PODs ranged 3-4 fold in either direction
  - Background DLC exposure most significant variable
    - DLCs act like TCDD in eliciting AhR-mediated effects
      - Considered to be dose-additive
    - POD estimates were 10% to 30% higher than RfD POD
    - DLC quantification too uncertain to apply to RfD
- Potentially sensitive effects in other studies excluded from RfD POD consideration
  - Exposure too uncertain; LOAELs unclear; DLCs an issue at low doses
  - Sperm effects in men who were breast fed as infants (Mocarelli et al., 2011)
  - UF_H of 3 applied to cover uncertainty in sensitive populations

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Use of Reference Doses by EPA's Regulatory Programs and Other Decision-Makers

- Reference Dose has no "real-world" impact until combined with other information (human exposure, available treatment technology, etc.) to inform decisions
- Typically considered in context with a hazard quotient
- Dioxins typically occur as mixtures. Use Toxicity Equivalence Factors (TEF) to estimate risks

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Hazard Quotient

$$HQ = E/RfD$$

HQ = Hazard quotient
E = Exposure to a substance (mg/kg-day)
RfD = Reference Dose (mg/kg-day)

Hazard quotient: The ratio of the exposure to a substance and its health reference value (e.g., RfD). Typically used as a screening tool. If Hazard Quotient <1, then adverse health effects are not expected to occur. If Hazard Quotient >1, then likelihood of adverse health effects is explored further. The Hazard Quotient cannot be translated to a probability that adverse health effects may occur.

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TEF Formula

$$TEQ = \sum_{i=1}^{k} (I_i \times TEF_i)$$

I — i^{th} individual DLC exposures (mg/kg-day)
TEF — Toxicity Equivalence Factor for ith DLC (unitless)
TEQ — TCDD toxicity equivalence (mg/kg-day)

TEQ is sum of the products of each i^{th} DLC Intake and its TEF for i = (1, 2,…k) DLCs.

HQ_{DLC} = TEQ/RfD

EPA (U.S. EPA, 2010) has adopted the WHO 2005 TEFs for Dioxin-Like Compounds (van den Berg, et al., 2006)

DLC = dioxin-like compound

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Top Five DLCs in Food and Recommended TEFs

Congener	2005 TEF
Polychlorinated dibenzo-*p*-dioxins (PCDDs)	
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
1,2,3,6,7,8-HxCDD	0.1
Polychlorinated dibenzofurans (PCDFs)	
2,3,4,7,8-PeCDF	0.3
Polychlorinated biphenyls (PCBs)	
3,3',4,4',5-PeCB (126)	0.1

- TEFs are derived primarily from oral-exposure study data and may not apply to internal concentrations
- TEFs are not central-tendency estimates
- 12 dioxin-like PCBs

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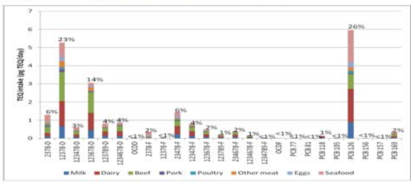
Dioxin intake from food (Parvez, et al., 2013)

- Analysis of data on DLC concentrations in 8 food categories to estimate total TEQ intake in average daily U.S. diet (source: Lorber et al., 2009, 2010)
  - 3 DLCs estimated to provide 63% of total TEQ intake
    - 1,2,3,7,8-PeCDD (23%)
    - 1,2,3,6,7,8-HxCDD (14%)
    - PCB-126 (26%)
  - 2,3,7,8-TCDD & 2,3,4,7,8-PeCDF provide another 6% each



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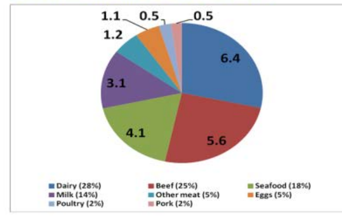
Food Category Contributions to Total Dietary TEQ (Parvez, et al., 2013)

- Seafood consumption provides 18% of total TEQ
  - DLC levels in commercial seafood recently updated by FDA
  - Relationship to fresh-water/marine fish-only consumption uncertain (specific data not available)



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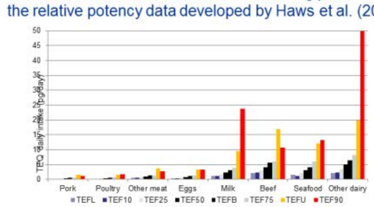
Sensitivity Analysis of Dioxin in Food (Parvez, et al., 2013)

- Alternative TEF values were estimated using percentile values from the relative potency data developed by Haws et al. (2006).



- For seafood: $TEQ_{10} = 1.2$, $TEQ_{25} = 2.0$, $TEQ_{50} = 3.2$, $TEQ_{75} = 6.0$, $TEQ_{90} = 13$ (pg/day)
- The average total dietary TEQ intake was 23 pg/day, with plausible bounds of 8 and 105 pg/day.

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Summary

- RfD = 7 x 10^{-10} mg/kg-day
  - Based on developmental endpoints from 2 epidemiologic studies
    - increased neonatal TSH (Baccarelli et al, 2008)
    - decreased sperm counts (Mocarelli et al., 2008)
  - Sensitivity analysis of key variables suggests 3-fold range in either direction
- WHO 2005 DLC TEFs adopted by EPA
  - Few significant changes from 1998
  - For use in dose-additive HQ
  - Sensitivity analysis recommended for major assessments
- U.S. dietary intake of total TEQ estimated by Parvez, et al. (2013)
  - 63% provided by 3 DLCs
  - 18% of total intake from seafood
    - Median daily intake = 3.2 pg/day
    - Sensitivity analysis suggests 11-fold range of uncertainty
    - Relationship to fresh-water/marine fish-only consumption uncertain

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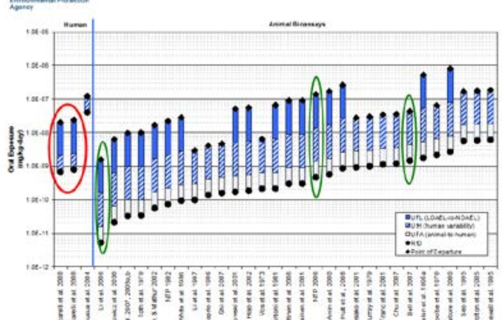
Candidate RfD Array



Questions and Answers

Q. Given the low reference dose and relatively small contribution of fish to exposure, what are the implications for fish advisories? (Stern)

A. EPA's Office of Water uses a 20% contribution from water for a health advisory. They attribute 20% of the toxic equivalency to fish.

Q. In New Jersey, where such contaminants are pervasive, the approach they took was that if they strictly applied the reference dose, the result would be no fish consumption. Instead, they limited fish meals to two meals per week. (Stern)

A. He cannot answer, because that sounds like a policy issue.

EPA's Reassessment of the RfD for PCBs: Key Issues to Be Addressed

Geniece Lehmann, U.S. Environmental Protection Agency

Biosketch

Dr. Geniece Lehmann received her Ph.D. in Toxicology from the University of Rochester. At present, she works as a toxicologist for the U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) where she evaluates quantitative and qualitative risk information on health effects that may result from exposure to environmental contaminants. Since 2009, Dr. Lehmann has served as the IRIS technical lead for assessment of polychlorinated biphenyls (PCBs). As such, she has explored and evaluated available options for assessing health risk from PCB exposure and presented on this topic at several national and international meetings. She has also co-chaired sessions at national meetings on the importance of the breastfeeding exposure pathway for risk assessment of persistent organic pollutants, such as those found in fish.

Abstract

PCBs were produced commercially in the United States from 1929-1977 for use in a wide variety of applications. Unfortunately, the unique chemical properties of PCBs that made them so useful (e.g., thermal stability, resistance to acids and bases, low water solubility) also contributed to their resistance to degradation, bioaccumulation in food chains, and toxicity. Although the commercial manufacture of PCBs was banned in the United States in 1979, even today, PCBs can be found in marine and fresh water fish, and fish consumption constitutes a major source of human exposure to these chemicals. Currently, there are two IRIS reference doses (RfDs) available for use in assessing human health risk associated with consumption of PCB-contaminated fish. The RfD for the commercial PCB mixture Aroclor 1016 (70 ng/kg-day) was established in 1993, and is based on a study that observed reduced birth weight in infant rhesus monkeys exposed during gestation. The RfD for Aroclor 1254 (20 ng/kg-day) was established in 1994, and is based on a study that observed immunotoxicity in adult female rhesus monkeys exposed for about five years. The value of the Aroclor 1254 RfD is identical to that of the Agency for Toxic Substances and Disease Registry's chronic minimal risk level (MRL) for PCBs (established in 2000) and the World Health Organization's tolerable daily intake for PCBs (established in 2003); all three of these reference values are based on the same study and health endpoints. However, PCB research over the past two decades has provided some new information to consider: studies of PCB-exposed humans have revealed previously unrecognized health effects; studies have been conducted in animals exposed to more environmentally relevant PCB mixtures; and there is new information regarding risk estimation for breastfeeding infants, a population that may be especially vulnerable to PCB-induced neurobehavioral effects. This presentation will provide an overview of the advances in knowledge to be considered in future EPA assessments of the health risks associated with dietary PCB exposure.

SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY

EPA's Reassessment of the RfD for PCBs: Key Issues to Be Addressed – Geniece Lehmann

EPA's Reassessment of the RfD for PCBs: Key Issues to Be Addressed

Geniece M. Lehmann, Ph.D.

National Forum on Contaminants in Fish

September 23, 2014

Alexandria, VA

1

Topics to Cover

- Review current IRIS non-cancer reference values for PCBs
- Why is a reassessment needed?
- Provide overview of the enhanced IRIS draft development process
- Identify key issues
- How might these issues impact future assessments?

The views expressed in this presentation are those of the author and do not necessarily reflect the views or policies of the U.S. EPA.

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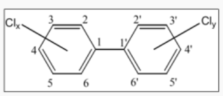
Polychlorinated Biphenyls (PCBs)

U.S. Manufacture and Production:
- Manufactured from 1929 to 1977
- Peak production in 1970 (85,000,000 lbs)

Some Uses:
- Dielectric fluid in transformers
- Oil used in motors and hydraulic systems
- Electrical devices/appliances containing PCB capacitors
- Fluorescent light ballast capacitors
- Adhesives and tapes
- Oil-based paints
- Plasticizer in caulk and window glazing

Humans are exposed to PCBs as diverse mixtures of congeners.



Congeners vary in structure, stability, toxicity and MOA: these properties are determined by chlorine number and position

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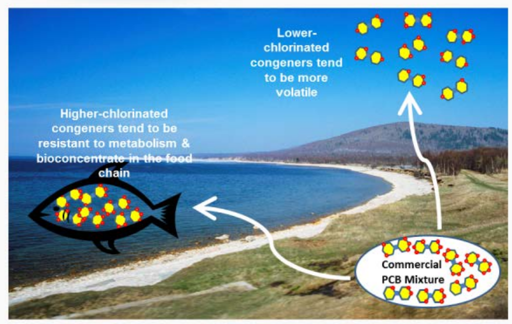

Current IRIS Reference Values for PCBs

- **RfD:** an estimate (with uncertainty spanning perhaps an order of magnitude) of oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime
- RfDs for PCB mixtures
  - Aroclor 1016
    - **70 ng/kg-day**
    - Posted to IRIS in 1993
    - Reduced birth weight observed in rhesus monkeys exposed during gestation
  - Aroclor 1254
    - **20 ng/kg-day**
    - Posted to IRIS in 1994
    - Immunotoxicity in adult rhesus monkeys exposed for 55 months
  - NO RfD for general PCB mixtures

5

Why Reassess?

- "New" human health effects to consider
- Data are available for PCB mixtures found in the environment.
- New approaches may be applied to protect breastfeeding infants.

6

EPA's Reassessment of the RfD for PCBs: Key Issues to Be Addressed – Geniece Lehmann

IRIS Draft Development

- Planning and scoping
- Public meeting on problem formulation
- Literature search and critical study selection
- Evidence table development
- Public meeting on literature search & evidence tables
- Draft assessment preparation
  - Hazard Identification
  - Rationale for selection of studies used for dose-response assessment
  - Toxicity value derivation

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Example of Problem Formulation for PCBs 1

Outcome	Human (in vivo) Studies	Animal (in vivo) Studies
Reproductive	+++ (female); ++ (male)	+++ (female); ++ (male)
Developmental	+++++	++++
Neurological	+++++++++	++++
Hepatic	++	+++
Gastrointestinal	+	+
Endocrine	++++ (thyroid)	+++ (thyroid); + (adrenal)
Metabolic Disease	+++	-
Respiratory	+	+
Cardiovascular	+	-
Immunologic	+++	++++
Dermal	++	++
Ocular	+	++

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Example of Problem Formulation for PCBs 2

Outcome	Human (in vivo) Studies	Animal (in vivo) Studies	Novel Aspects of Animal Studies
Reproductive	+++ (female); ++ (male)	+++ (female); ++ (male)	● = observed effects at or below the POD used for the current IRIS Aroclor 1254 RfD
Developmental	+++++	++++	
Neurological	+++++++++	++++ ●	
Hepatic	++	+++ ●	
Gastrointestinal	+	+	
Endocrine	++++ (thyroid)	+++ (thyroid); + (adrenal)	
Metabolic Disease	+++	-	
Respiratory	+	+	
Cardiovascular	+	-	
Immunologic	+++	++++ ●	
Dermal	++	++ ●	
Ocular	+	++ ●●	

Why Reassess? A

- "New" human health effects to consider
- Data are available for PCB mixtures found in the environment.
- New approaches may be applied to protect breastfeeding infants.

10

Current IRIS Reference Values for PCBs 2

- **RfD:** an estimate (with uncertainty spanning perhaps an order of magnitude) of oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime
- RfDs for PCB mixtures
  - Aroclor 1016
    - **70 ng/kg-day**
    - Posted to IRIS in 1993
    - Reduced birth weight observed in rhesus monkeys exposed during gestation
  - Aroclor 1254
    - **20 ng/kg-day**
    - Posted to IRIS in 1994
    - Immunotoxicity in adult rhesus monkeys exposed for 55 months
  - **NO RfD for general PCB mixtures**

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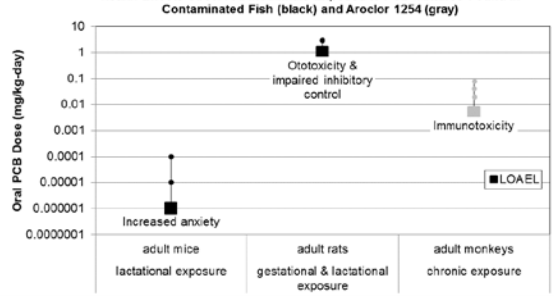
Example of Problem Formulation for PCBs 3

Outcome	Human (in vivo) Studies	Animal (in vivo) Studies	Novel Aspects of Animal Studies
Reproductive	+++ (female); ++ (male)	+++ (female); ++ (male) ●● ●●●	● = observed effects at or below the POD used for the current IRIS Aroclor 1254 RfD
Developmental	+++++	++++ ●●●●	
Neurological	+++++++++	++++ ●●●●●● ●●●●●	● = administered a mixture of PCB congeners selected to mimic the profile found in human milk, other biological matrices (except fish), or contaminated soil
Hepatic	++	+++ ●●	
Gastrointestinal	+	+	
Endocrine	++++ (thyroid)	+++ (thyroid); + (adrenal) ●●	
Metabolic Disease	+++	-	
Respiratory	+	+	
Cardiovascular	+	-	● = administered a mixture of PCB congeners selected to mimic the profile found in contaminated fish
Immunologic	+++	++++ ●●	
Dermal	++	++ ●	
Ocular	+	++ ●●	

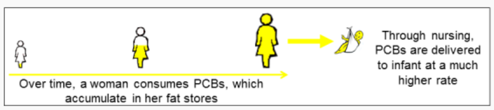
PCB Mixture Mimicking…	Health Effects Observed in Exposed Animals
Contaminated soil	*Adult mice exposed during development* ↓ plasma T_4, ↓ thymocyte number, & ↑ thymocyte proliferative response
Human milk	*Juvenile monkeys exposed during infancy* ↓ inhibitory control *Neonatal rats* ↑ liver & brain weights, & ↓ body weight ↓ aromatase activity in hypothalamus-preoptic area (*males*) *Weanling female rats* ↓ serum estradiol & ↓ uterine weight *Juvenile rats exposed during development* Altered timing of puberty onset *Adult rats, subchronic exposure* ↑ liver weight, ↓ thyroid weight, & ↓ litter size *Adult rats exposed during development* ↓ bone size ↓ testes weights, ↓ serum testosterone, & ↓ sexual dimorphism (*males*)
Contaminated fish	*Adult rodents exposed during development* ↑ anxiety Ototoxicity & ↓ inhibitory control



Elnar et al. (2012). Neurodevelopmental and behavioral toxicity via lactational exposure to the sum of six indicator non-dioxin-like-polychlorinated biphenyls (6 NDL-PCBs) in mice. *Toxicology* 299: 44-54.
Powers et al. (2009). Developmental exposure to PCBs, MeHg, or both: Long-term effects on auditory function. *Environ Health Perspect* 117: 1101-1107.
Sable et al. (2009). Developmental exposure to PCBs and/or MeHg: Effects on a differential reinforcement of low rates (DRL) operant task before and after amphetamine drug challenge. *Neurotoxicol Teratol* 31: 149-158.
Tryphonas et al. (1991). Effect of chronic exposure of PCB (Aroclor 1254) on specific and nonspecific immune parameters in the rhesus (*Macaca mulatta*) monkey. *Fundam Appl Toxicol* 16: 773-786.

Why Reassess? B

- "New" human health effects to consider
- Data are available for PCB mixtures found in the environment.
- New approaches may be applied to protect breastfeeding infants.



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PCB Lactational Dose Magnification (Example)

Average daily maternal dose: **1 ng/kg-day**

1) **Elimination rate (pre-breastfeeding)**: $k_{elim} = \frac{\ln(2)}{t_{1/2}} = 0.00027\ (\text{days})^{-1}$ ***assuming $t_{1/2}$ = 2,555 days***

2) **Elimination rate (during breastfeeding)**: $k_{elac} = k_{elim} + \frac{IR_{milk} \times f_f \times f_{mbm}}{f_{fm} \times BW_{mat}} = 0.0021\ (\text{days})^{-1}$

3) **Average PCB concentration in milk fat**:

$$C_{milk\ fat,avg} = \frac{DAI_{mat} \times f_f}{k_{elim} \times f_{fm}} \times \left[\frac{k_{elim}}{k_{elac}} + \frac{1}{k_{elac} \times t_{bf}}\left(1 - e^{-k_{elim} t_{pn}} - \frac{k_{elim}}{k_{elac}}\right)\left(1 - e^{-k_{elac} t_{bf}}\right)\right] = 7{,}560\ \text{ng/kg-lipid}$$

4) **Average daily infant dose from milk fat**: $ADD_{inf} = \frac{C_{milk\ fat} \times f_{mbm} \times CR_{milk} \times ED_{inf}}{BW_{inf} \times AT}$ = **38 ng/kg-day**

If $t_{1/2}$ ranges from 730 to 23,725 days, possible ADD_{inf} values range from 12 to 91 ng/kg-day.

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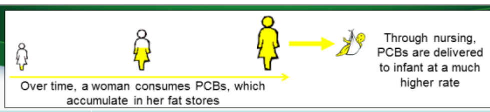
Oregon DEQ. (2010). Human health risk assessment guidance. Portland, OR: Oregon Department of Environmental Quality. Available at http://www.deq.state.or.us/lq/pubs/docs/cu/HumanHealthRiskAssessmentGuidance.pdf.



PCB Mixture Mimicking…	Health Effects Observed in Exposed Animals
Contaminated soil	*Adult mice* ***exposed during development*** ↓ plasma T_4, ↓ thymocyte number, & ↑ thymocyte proliferative response
Human milk	*Juvenile monkeys* ***exposed during infancy*** ↓ inhibitory control ***Neonatal rats*** ↑ liver & brain weights, & ↓ body weight ↓ aromatase activity in hypothalamus-preoptic area (*males*) ***Weanling female rats*** ↓ serum estradiol & ↓ uterine weight *Juvenile rats* ***exposed during development*** Altered timing of puberty onset *Adult rats* ***exposed during development*** ↓ bone size ↓ testes weights, ↓ serum testosterone, & ↓ sexual dimorphism (*males*)
Contaminated fish	*Adult rodents* ***exposed during development*** ↑ anxiety Ototoxicity & ↓ inhibitory control

Health Benefits of Breastfeeding

"…a history of breastfeeding was associated with a reduction in the risk of acute otitis media, non-specific gastroenteritis, severe lower respiratory tract infections, atopic dermatitis, asthma (young children), obesity, type 1 and 2 diabetes, childhood leukemia, sudden infant death syndrome (SIDS), and necrotizing enterocolitis."

- AHRQ. (2007). Breastfeeding and Maternal and Infant Health Outcomes in Developed Countries. Rockville, MD: ***Agency for Healthcare Research and Quality****. Available at Breastfeeding and Maternal and Infant Health Outcomes in Developed Countries.*

"Extensive research using improved epidemiologic methods and modern laboratory techniques documents diverse and compelling advantages for infants, mothers, families, and society from breastfeeding and use of human milk for infant feeding. These advantages include health, nutritional, immunologic, developmental, psychologic, social, economic, and environmental benefits."

- ***American Academy of Pediatrics****. (2005). Breastfeeding and the Use of Human Milk. Pediatrics 115: 496-506.*

"WHO can now say with full confidence that breastfeeding reduces child mortality and has health benefits that extend into adulthood."

- WHO. (2007). Fourth WHO-Coordinated Survey of Human Milk for Persistent Organic Pollutants in Cooperation with UNEP. Guidelines for Developing a National Protocol. Geneva, Switzerland: ***World Health Organization****. Available at Guidelines for Developing a National Protocol.*

EPA's Reassessment of the RfD for PCBs: Key Issues to Be Addressed – Geniece Lehmann

Infant Risk Adjustment Factor

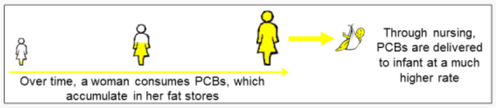
$$\text{Hazard Quotient} = \frac{\text{Calculated Exposure}}{\text{Acceptable Exposure}}$$

$IRAF = HQ_{infant} / HQ_{mother}$

$HQ_{infant} = HQ_{mother} \times IRAF$

Calculated Infant Risk Adjustment Factors

Chemical	IRAF
DDT/DDD/DDE	2
Dioxins	2
PCBs	25



Oregon DEQ. (2010). Human health risk assessment guidance. Portland, OR: Oregon Department of Environmental Quality. Available at http://www.deq.state.or.us/lq/pubs/docs/cu/HumanHealthRiskAssessmentGuidance.pdf.

Why Reassess? C

- "New" human health effects to consider
- Data are available for PCB mixtures found in the environment.
- New approaches may be applied to protect breastfeeding infants.

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Possible Impacts on Future Assessments

- "New" human health effects to consider
  - Future reference values may be derived for additional health effects.
    - Neurodevelopmental effects?
    - Effects on thyroid hormone homeostasis?
    - Metabolic and/or cardiovascular effects?
- Data are available for PCB mixtures found in the environment.
  - Future reference values might be based on environmental PCB mixtures rather than Aroclor mixtures.
- New approaches may be applied to protect breastfeeding infants.

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Summary

- PCB reassessment is indicated by the availability of:
  - More recent data on health effects
  - Data on environmental PCB mixtures
  - New approaches to limit exposure in breastfed infants
    - Risk assessors in Oregon are already using some of these approaches in conjunction with currently available reference values.
- IRIS PCB assessment is in the early stages of the new draft development process.
- Once draft development begins, we would expect to complete the assessment in about 3 years.

Contact Information
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Questions and Answers

Q. Is outreach to physicians about breastfeeding included in the plan? We should get the word out to protect people. (Murphy)

A. This has not been discussed yet, but they will probably reach out to EPA program offices about that early in the process.

Q. It is good to see that EPA is looking at pathways and focusing on body burden, but generally you do not issue fish advisories based on gender. However, we may need to consider thinking about fish advisories targeted to young girls and maybe to young boys. (Ginsberg)

A. EPA has not completely analyzed the data for this reassessment of the reference dose for PCBs, but so far the data indicates the most sensitive endpoints will be to protect from exposure to breast milk and protect women who are breastfeeding. Men do not breastfeed, so will not be affected by that endpoint. EPA is using human and animal data for this reassessment.

Q. Is there any point in treating dioxin-like PCBs differently? (Stern)

A. Dioxin-like PCBs can act by non-dioxin mechanisms. Dioxin-like PCBs will be included in EPA’s reassessment of the reference dose for PCBs, but they also have other effects. Dioxin-like PCBs also will be covered in EPA’s dioxin reassessment.

Co-occurrence of PCBs and Mercury in Fish Tissue: Is There a Case for Additivity Based on Common Development Endpoints?

Vince Cogliano, U.S. Environmental Protection Agency

Biosketch

Dr. Vince Cogliano serves as acting director of the Integrated Risk Information System (IRIS) at the U.S. Environmental Protection Agency in Washington DC. IRIS develops scientific reviews of the health hazards of chemicals in the environment. Previously, Dr. Cogliano served at the International Agency for Research on Cancer (IARC), which is part of the World Health Organization, in Lyon, France, as head of the IARC Monographs programme. The IARC Monographs are a series of scientific reviews that identify environmental factors that can increase the risk of human cancer. Dr. Cogliano received his Ph.D. from Cornell University. Dr. Cogliano's professional interests include qualitative and quantitative health risk assessment and its application to the protection of public health.

Abstract

Not provided.

SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY
Co-occurrence of PCBs and Mercury in Fish Tissue: Is There a Case for Additivity Based on Common Development Endpoints? – Vince Cogliano

Co-Occurrence of PCBs and Mercury in Fish Tissue

Is There a Case for Additivity Based on Common Developmental Endpoints?

Vincent Cogliano
IRIS Program Director (interim)
National Center for Environmental Assessment
Office of Research and Development
U.S. Environmental Protection Agency

The views expressed here do not necessarily represent the views or policies of the U.S. Environmental Protection Agency

Overview

NRC advice on cumulative risk assessment

IRIS initiatives to facilitate cumulative risk assessment

The case for additivity of PCBs and mercury

2

Advice from the National Research Council

"For cumulative risk assessment, the committee strongly recommends that EPA group chemicals that cause common adverse outcomes and not focus exclusively on structural similarity or on similar mechanisms of action."

"Focusing primarily on physiologic consequences rather than structural or mechanistic similarity is a critical and achievable next step in cumulative risk assessment and is more directly relevant to relating chemical exposures to human diseases and disorders."

NRC 2008, *Phthalates and Cumulative Risk Assessment*, pp 9-10

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Advice from the National Research Council (continued)

"To cite another example, EPA could evaluate combined exposures to lead, methylmercury, and polychlorinated biphenyls because all contribute to cumulative risk of cognitive deficits consistent with IQ reduction in children, although the deficits are produced by different mechanisms of action. Cumulative risk assessment based on common adverse outcomes is a feasible and physiologically relevant approach to the evaluation of the multiplicity of human exposures and directly reflects EPA's mission to protect human health."

NRC 2008, *Phthalates and Cumulative Risk Assessment*, pp 11-12

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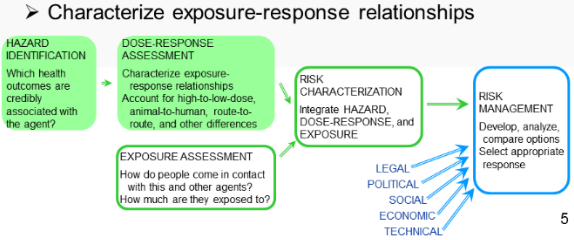
About IRIS

IRIS assessments systematically and critically review the publicly-available peer-reviewed studies to

- Identify adverse health outcomes
- Characterize exposure-response relationships



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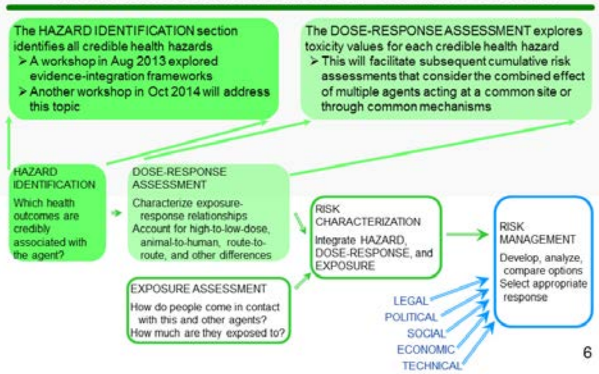
The Enhanced IRIS Means New Scientific Content



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Example of Toxicity Values for Multiple Health Outcomes – Benzo[a]pyrene (draft)

Table ES-1. Organ/system-specific RfDs and proposed overall RfD for benzo[a]pyrene

Effect	Basis	RfD (mg/kg-d)	Confidence
Developmental	Neurobehavioral changes Gavage neurodevelopmental study in rats (PND 5-11) (Chen, 2012, [link])	3×10^{-4}	MEDIUM
Reproductive	Decreased ovary weight Gavage subchronic (60 d) reproductive toxicity study in rats (Xu, 2010, [link])	4×10^{-4}	MEDIUM
Immunological	Decreased thymus weight and serum IgM Gavage subchronic (35 d) study in rats (De Jong, 1999, [link])	2×10^{-3}	LOW
Proposed Overall RfD	**Developmental toxicity**	3×10^{-4}	**MEDIUM**

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The Enhanced IRIS Was Recently Reviewed by the National Research Council

"Overall, the committee finds that substantial improvements in the IRIS process have been made, and it is clear that EPA has embraced and is acting on the recommendations in the NRC formaldehyde report. The NRC formaldehyde committee recognized that its suggested changes would take several years and an extensive effort by EPA staff to implement. Substantial progress, however, has been made in a short time, and the present committee's recommendations should be seen as building on the progress that EPA has already made." [p 9]

Review of EPA's Integrated Risk Information System (IRIS) Process

" . . . the IRIS program has moved forward steadily in planning for and implementing changes in each element of the assessment process. The committee is confident that there is an institutional commitment to completing the revisions of the process . . ." [p 135]

NRC 2014, *Review of EPA's Integrated Risk Information System (IRIS) Process*

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How to Cumulate Risks of Multiple Agents?

Models of joint action

- Response addition (independent action)
- Dose addition
- Synergistic or antagonistic interaction

"The committee concludes that the answer should be based on empirical data that directly test any proposed method."

NRC 2008, *Phthalates and Cumulative Risk Assessment*, p 9

PHTHALATES AND CUMULATIVE RISK ASSESSMENT

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Advice from a 1998 Workshop

Participating agencies: DHHS, NIEHS, CDC, FDA, EPA, NOAA, OSTP, OMB, ATSDR

Epidemiology panel: " . . . the most likely explanation is that both (mercury and PCBs) . . . affect these three outcomes . . ."

Neurobehavioral panel: "PCB exposure might act as an effect modifier, increasing the susceptibility to MeHg."

ATSDR 1999, *Toxicological Profile for Mercury*, pp 258-259

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Subsequent Advice from ATSDR

"Therefore, at sites where methylmercury is present in combination with other known or suspected neurodevelopmental toxicants, such as lead or polychlorinated biphenyls (PCBs), and in which exposure is primarily episodic in nature, the health assessor might consider using a value below the chronic oral MRL for methylmercury as a starting point for determination of further site investigation."

ATSDR 1999, *Toxicological Profile for Mercury*, p A-19

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

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Review of Newer Studies

Question

- Do PCBs and mercury have a joint effect on neurobehavioral development in humans or in animals?

Protocol for answering the question

- Literature survey of studies pertinent to the question
  - ATSDR Tox Profile (1999)
  - ATSDR Addendum (2013)
  - PubMed search for "mercury" and "PCB" and "neurotoxic"
- Make tables of pertinent study methods and results

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SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY
Co-occurrence of PCBs and Mercury in Fish Tissue: Is There a Case for Additivity Based on Common Development Endpoints? – Vince Cogliano

Epidemiologic Studies Pertinent to a PCB-Mercury Interaction

Study	Finding
Grandjean et al 2001 Faroe Islands	PCB association found for highest tertile Hg
Stewart et al 2003 Oswego NY	MeHg associations were found for higher prenatal PCBs
Saint-Amour 2006 Nunavik	No significant interaction on neurobehavioral parameters
Grandjean et al 2012 Faroe Islands	Joint action not investigated

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Experimental Animal Studies Pertinent to a PCB-Mercury Interaction

Study	Finding
Bemis & Seegal 1999 Rat brain	Simultaneous PCB+MeHg exposure decreased tissue dopamine and increased media dopamine beyond changes from PCBs alone; no effects from MeHg alone
Roegge et al 2004 Female Long-Evans rat	Demonstrates possibility of additive neurotoxic effects of PCBs and MeHg
Fischer et al 2008 Neonatal male NMRI mouse	Interaction of low doses of MeHg+PCB-153 enhances developmental neurotoxicity
Cheng et al 2009 Mouse	PCBs may augment the neurobehavioral deficits caused by increased Hg
Cauli et al 2013 Rat	MeHg+PCB-126/153 induce different effects than the individual compounds

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Summary

There is some evidence of additivity or interaction between PCBs and mercury

The NRC has strongly recommended that the EPA group chemicals based on common adverse outcome

New IRIS assessments will facilitate subsequent cumulative assessments based on common outcomes

Effect modification by PCBs is worth considering in future dose-response assessments of mercury

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Questions and Answers

Q. *You get dozens of outcome measures with neurobehavioral effects in humans from mercury and PCBs. You might look at one PCB that will give one effect and another PCB will give a different outcome. We also get different effects from mercury exposure from fish. (Groth)*

A. Because some fish are higher in Omega 3, consuming different fish will have different Omega 3 health benefits. Because Omega 3 will be different in each exposure scenario, you will probably want separate analyses of risks and benefits for each scenario. He does not understand yet how IRIS is going to approach this difficult analysis. We know there are beneficial effects of breastfeeding and fish consumption that are difficult to separate.

Q. *The biochemical effects of mercury are similar to PCBs. Selenium enzymes have an effect and should be considered in analyses, because they would modify effects of mercury and PCBs. (Ralston)*

A. There was no response or comment, and the moderator moved along to the next question.

Q. *Early studies showed sea birds with developmental effects from interaction of mercury and PCBs. Have recent studies shown any link? He is surprised that the data are so sparse. (Gochfeld)*

A. He was also surprised there were so few studies and very sparse data on the interaction of mercury and PCBs. However, you find this interaction only with high mercury or high PCB levels. This is an effect that needs to be evaluated. The synergism may occur, but not at low or moderate levels. We need to understand more about complex interaction effects of mercury and PCBs, and also about the interaction with benefits like Omega 3.

Q. *She does research on women and children with PCB, lead, and mercury exposure from the National Health and Nutrition Examination Survey (NHANES) data. She has looked at some animal studies on mercury and PCB interaction, but fewer studies are available on mercury and lead. Her research shows that children breastfed get a lot of PCBs from the mother's body, and the first born may get most of it. (Marcella Thompson)*

A. We should consider factors such as birth order, but previous data have not been collected that way. He wished such data had been collected.

National Time Trends in Environmental Exposures and Fish Consumption in U.S. Women of Reproductive Age (NHANES 1999-2012)

Rebecca Birch, Westat

Biosketch

Rebecca Jeffries Birch has been investigating biomarkers of environmental exposure using data from the National Health and Nutrition Examination Survey (NHANES) for 10 years. Much of her work has involved mercury and fish consumption. Ms. Birch is currently working on a project investigating time trends in serum perfluorooctanesulfonic acid (PFOS) concentrations and its relationship to fish consumption. She has also investigated the relationships between health outcomes and environmental chemicals to which people in the United States may be exposed through consumption of fish, such as polychlorinated biphenyls (PCBs) and pesticides and their effect on thyroid hormones. Recently, Ms. Birch completed a project estimating fish consumption rates for the U.S. population and various subpopulations. Ms. Birch is currently employed at Westat as an Epidemiologist.

Abstract

Consumption of finfish and shellfish is the primary exposure pathway of methylmercury (MeHg) in the United States and is an important pathway of exposure to other environmental contaminants, such as perfluorooctane sulfonate (PFOS) and PCBs. Regulations and fish advisories may contribute to decreased exposure to mercury over time. This presentation discusses a study of blood mercury concentrations and fish consumption in NHANES data and presents preliminary findings from further analyses. We combined fish tissue mercury concentration data and 1999-2010 NHANES blood mercury concentration and fish consumption data to investigate trends in blood mercury concentrations, fish consumption, and mercury intake in women of reproductive age. Using regression analysis, we found NHANES 1999-2000 to have higher blood MeHg concentrations than the mean of the later years ($p<.0001$) and a positive quadratic trend since 2000 ($p=0.004$). No trend was observed in fish consumption amount or mercury intake. A decreasing trend was found in the ratio of mercury intake to fish consumed ($p=0.04$), consistent with women shifting their consumption to fish with lower mercury concentrations.

SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY
National Time Trends in Environmental Exposures and Fish Consumption in U.S. Women of Reproductive Age (NHANES 1999-2012) – Rebecca Birch

NATIONAL TIME TRENDS IN ENVIRONMENTAL EXPOSURES AND FISH CONSUMPTION IN U.S. WOMEN OF REPRODUCTIVE AGE (NHANES 1999-2012)

NATIONAL FORUM ON CONTAMINANTS IN FISH

SEPTEMBER 23, 2014

Rebecca Jeffries Birch, Westat

Jeff Bigler, USEPA

John Rogers, Westat

PROJECT OBJECTIVES

- Investigate national time trends in environmental exposures among women of childbearing age
- Investigate the relationship between environmental exposures and fish consumption
- Exposures of interest:
  - Metals
  - Persistent organic pollutants

NHANES

- National Health and Nutrition Examination Survey (NHANES)
  - A continuing survey designed to collect data on the health and nutritional status of the U.S. population
  - Data are collected from a statistically representative sample of the U.S. population (approximately 5,000 persons/year)
  - CDC releases the NHANES data every two years
  - Regional data may be accessed through the NCHS Research Data Center through a proposal process

NHANES: DIETARY DATA

- 24-hour recall
  - Amount of each food and drink item in the previous 24 hours.
  - Each food is associated with a food code that links to recipe databases
- Fish screener (30-day frequency of consumption)
  - Participants are asked to report the number of times in the past 30 days that they consumed fish
    - 8 specific shellfish types and "unknown" and "other" shellfish
    - 18 specific finfish types and "breaded fish products," "unknown," and "other" finfish

NHANES: ENVIRONMENTAL EXPOSURE DATA

- Blood
  - **Mercury (inorganic, total, and for 2011-2012 organic)**
  - Cadmium
  - Lead
- Serum
  - Phenols
  - **Polychlorinated biphenyls (PCBs)**
  - **Polybrominated diphenyl ethers (PBDEs)**
  - **Polyfluorinated compounds (e.g., PFOS and PFOA)**
  - Phthalates
- Urine
  - Pesticides
  - Polyaromatic hydrocarbons
  - Heavy metals

MERCURY & FISH CONSUMPTION

National Time Trends 1999-2010

SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY
National Time Trends in Environmental Exposures and Fish Consumption in U.S. Women of Reproductive Age (NHANES 1999-2012) – Rebecca Birch

PURPOSE OF STUDY

- Assess national time trends
  - Blood mercury concentrations
  - Fish consumption
  - Hg intake
- Assess the relationship between blood mercury concentrations and mercury intake through fish consumption
- NHANES 1999-2010
- 10,087 women of childbearing age (16 to 49 years) with all data elements of interest

DATA PROCESSING METHODOLOGY OVERVIEW

- Data Elements Required for Analysis
  - Blood MeHg concentration
  - 30-day Hg intake from fish consumption
    - Mean mercury concentration in fish tissue, by species (non-NHANES data)
    - Fish meal size
    - 30-day fish consumption (g)
    - Body weight (kg)
  - Demographics
  - NHANES year
  - Analytic weights and sample design variables

DATA PROCESSING METHODOLOGY: ESTIMATED 30-DAY HG INTAKE (MG/KG)

- Calculate 30-day Hg intake for each species reported consumed

Est. 30-day Hg intake$_{species}$ =

Mean Meal Size$_{species}$*30-day Frequency$_{species}$*FTHg$_{species}$

- Sum estimates over all species reported consumed
- Divide by body weight

FISH TISSUE HG DATA

Est. 30-day Hg intake$_{species}$ =

Mean Meal Size$_{species}$*30-day Frequency$_{species}$*FTHg$_{species}$

- Obtained non-NHANES data on fish tissue Hg concentrations
  - States
  - U.S. FDA
  - Studies published in the peer-reviewed literature
- We estimated the geometric mean concentration for each species using regression modeling
- To the extent it could be tested, there were no consistent time trends

ESTIMATING FISH MEAL SIZE

Est. 30-day Hg intake$_{species}$ =

Mean Meal Size$_{species}$*30-day Frequency$_{species}$*FTHg$_{species}$

- Calculated the grams of fish consumed by species and participant using 24-hour recall data and recipe files
- Modeled the quantity of raw fish consumed from the 24-hour file as a function of
  - Number of times fish was consumed in the last 30 days
  - Race/ethnicity
  - Age
  - Income
  - NHANES release
- The prediction equation was used to assign a meal size to each participant/species pair

30-DAY FREQUENCY OF CONSUMPTION

Est. 30-day Hg intake$_{species}$ =

Mean Meal Size$_{species}$*30-day Frequency$_{species}$*FTHg$_{species}$

- Reports of species-specific frequency of consumption
- Reconcile species between 24-hr recall and fish screener

SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY
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ESTIMATING 30-DAY MERCURY INTAKE AND FISH CONSUMPTION

Est. 30-day Hg $intake_{species}$ =

Mean Meal $Size_{species}$*30-day $Frequency_{species}$*$FTHg_{species}$

- Sum up all species-specific estimates for each participant
- Divide by bodyweight to get µg HG/kg bw

Est. 30-day Fish $Consumption_{species}$ =

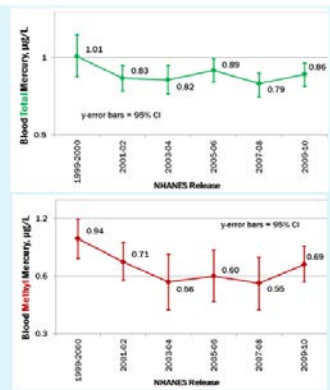
Mean Meal $Size_{species}$*30-day $Frequency_{species}$

DATA PROCESSING: BLOOD MERCURY

- No direct analysis of blood for MeHg in 1999-2010 NHANES
- Assumption MeHg = THg – Ihg
- Detection limit issues
  - 80% IHG
  - 11% THg
- Multiple Imputation

STATISTICAL METHODOLOGY: BLOOD MERCURY

- Weighted analyses using the recommended statistical weights
- SAS MIANALYZE
- Non-linear regression to model the relationship between blood mercury and mercury intake from fish
- Logistic regression to predict the probability that blood mercury exceeds 5.8 µg/L



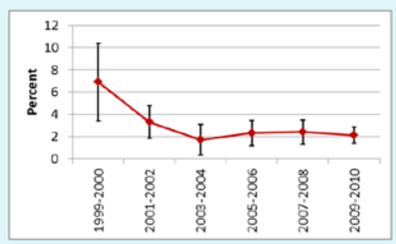
RESULTS

GEOMETRIC MEAN BLOOD HG ACROSS TIME, UNADJUSTED

	Parameter	Std error	p-Value	Relative Ratio
Intercept	0.44	0.07	0.008	
Hg/Wt Slope	1.05	0.08	<.0001	
Bodyweight	-0.09	0.05	0.077	
Age, Overall			<.0001	
Linear in ln(age)	0.34	0.05	<.0001	
Quadratic in ln(age)	-0.28	0.13	0.037	
Income, Overall			<.0001	
0 to 20K	-0.16	0.04	<.0001	0.85
20 to 45K	-0.07	0.03	0.037	0.93
45 to 75K	0.00	0.03	0.966	1.00
>75K	0.25	0.04	<.0001	1.29
MultiHH	-0.01	0.07	0.903	0.99
Refuse/DK	0.07	0.09	0.418	1.08
Over 20K	-0.09	0.08	0.29	0.92
Race, Overall			<.0001	
Non-Hispanic Black	0.14	0.04	<.0001	1.15
Mexican American	-0.27	0.04	<.0001	0.76
Other Hispanic	0.04	0.05	0.452	1.04
Other Race and Multi-racial	0.33	0.05	<.0001	1.39
Non-Hispanic White	-0.24	0.04	<.0001	0.79
NHANES Year, Overall			<.0001	
1999-2000 different from post-2000	0.47	0.09	<.0001	
Linear trend after 1999-2000	-0.01	0.01	0.711	
Quadratic trend after 1999-2000	0.05	0.02	0.004	
1999-2000 diff. from post-2000 quadratic trend	0.11	0.11	0.348	

RESULTS

Non-linear model predicting blood methyl-mercury



NHANES Release	N	% with MeHg >5.8 µg/L (95% CI)
1999-2000	1,637	6.9 (3.41,10.4)
2001-2002	1,780	3.3 (1.85,4.75)
2003-2004	1,599	1.7 (0.33,3.07)
2005-2006	1,792	2.3 (1.16,3.44)
2007-2008	1,493	2.4 (1.30,3.50)
2009-2010	1,786	2.1 (1.37,2.83)

RESULTS

PERCENT OF WOMEN WITH BLOOD MEHG OVER 5.8 MG/L, UNADJUSTED

National Time Trends in Environmental Exposures and Fish Consumption in U.S. Women of Reproductive Age (NHANES 1999-2012) – Rebecca Birch

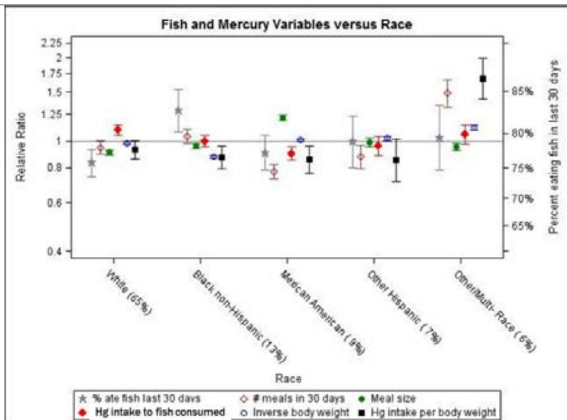
	Parameter	Std error	p-Value	Odds Ratio
Intercept	-3.8	0.23	<.0001	
Transformed Hg intake	1.42	0.13	<.0001	
Bodyweight	-0.61	0.35	0.0878	
Age, Overall			0.002	
Linear in ln(age)	0.92	0.31	0.004	
Quadratic in ln(age)	-1.91	0.98	0.055	
Income, Overall			<.0001	
0 to 20K	-0.99	0.33	0.004	0.37
20 to 45K	0.00	0.21	0.997	1.00
45 to 75K	0.04	0.25	0.866	1.04
>75K	0.56	0.21	0.009	1.75
MultiHH	-0.2	0.35	0.563	0.82
Refuse/DK	0.67	0.49	0.174	1.96
Over 20K	-0.09	0.61	0.888	0.92
Race, Overall			<.0001	
Non-Hispanic Black	0.37	0.14	0.012	1.45
Mexican American	-1.39	0.24	<.0001	0.25
Other Hispanic	-0.33	0.49	0.503	0.72
Other Race and Multi-racial	1.34	0.24	<.0001	3.82
Non-Hispanic White	0.01	0.22	0.966	1.01
NHANES Year, Overall			<.0001	
1999-2000 different from post-2000	1.43	0.29	<.0001	
Linear trend after 1999-2000	-0.09	0.07	0.245	
Quadratic trend after 1999-2000	0.05	0.07	0.451	
1999-2000 diff. from post-2000 quadratic trend	0.81	0.6	0.182	

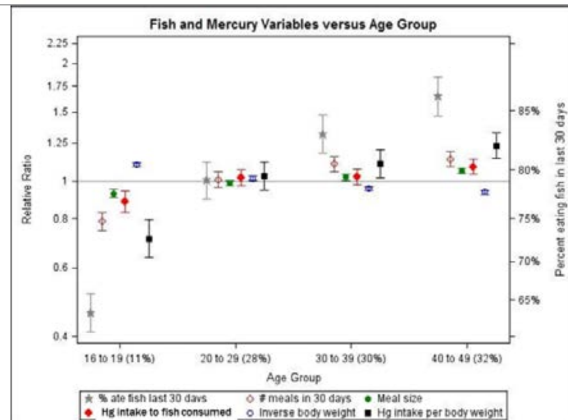
RESULTS

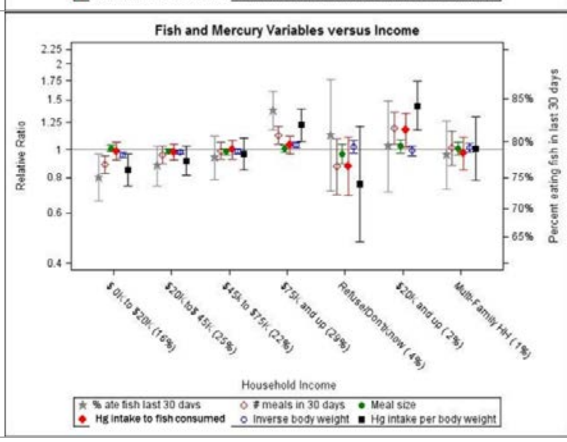
Logistic model predicting the probability of blood methyl-mercury over 5.8 µg/L

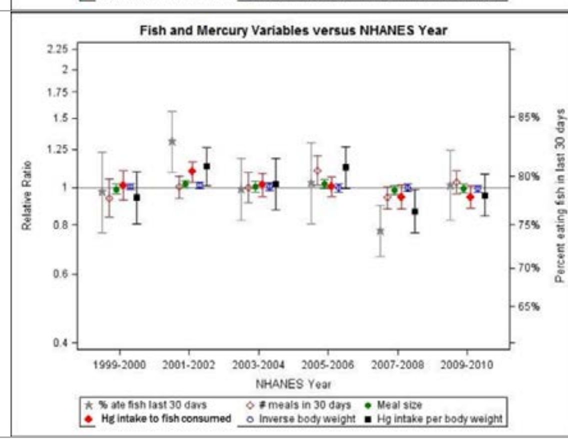
STATISTICAL METHODOLOGY FOR TRENDS IN HG INTAKE AND FISH CONSUMPTION

- The mercury intake per bodyweight can be expressed as the product of:
  - 1) frequency of fish consumption
  - 2) mean meal size
  - 3) fish tissue mercury concentration (Ratio of Hg intake to fish consumed)
  - 4) inverse bodyweight
- Linear regression to evaluate changes over time in these variables adjusting for demographic factors









SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY
National Time Trends in Environmental Exposures and Fish Consumption in U.S. Women of Reproductive Age (NHANES 1999-2012) – Rebecca Birch

CONCLUSIONS

- Mean blood Hg and % over 5.8 µg/L in 1999-2000 was found to be significantly higher than the mean of the subsequent releases (2001-2010)
- There was a significant relationship between mercury intake from fish consumption and blood mercury
- The analysis showed few changes in fish consumption and mercury intake over the study period
- Limitations
  - Fish tissue mercury
  - Dietary data collection

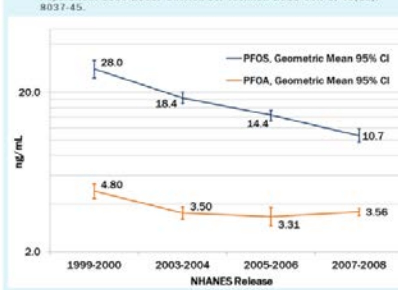
CONTINUING WORK ON MERCURY

- 2011-2012 NHANES includes MeHg in blood
  - Provides for direct analysis of women's MeHg concentrations
  - Allows for a way to determine best imputation methodology of MeHg in other years
- Include region and coastal analyses (See Mahaffey et *al*., 2009)

LOOKING FORWARD: POTENTIAL NEW ANALYSES

PFOS & PFOA, PCBs, PBDEs

Data from: Kato K, Wong L-Y, Jia LT, Kuklenyik Z, Calafat AM. *Trends in Exposure to Polyfluoroalkyl chemicals in the U.S. Population: 1999-2008.* Environ Sci Technol. 2011 Oct. 1. 45(19): 8037-45.



Future analyses would look at the relationship of PFOS and PFOA with fish consumption.

PFOS & PFOA NATIONAL TIME TRENDS FROM CDC

Women aged 12 and older, unadjusted geometric means

PCBS AND PBDES: NATIONAL TIME TRENDS FROM CDC

- Sjödin et al., analyzed NHANES data on PBDEs and PCBs for years, 2003-2008.
  - Found decreases in arithmetic means of several PCB congeners from 2003/04 to 2007/08
  - Similarly, found decreases in the arithmetic mean of serum concentrations of 4 PBDEs in NHANES 2007/08 compared to 2003/04; however, most confidence intervals of the arithmetic means overlapped
- Future analyses would investigate the relationship between PCBs and PBDEs with fish consumption
- More complex than mercury analysis due to the types of exposures and the multiple congeners

Sjödin A, Jones RS, Caudill SP, Wong L-Y, Turner WE, Calafat AM. *Polybrominated Diphenyl Ethers, Polychlorinated Biphenyls, and Persistent Pesticides in Serum from the National Health and Nutrition Examination Survey: 2003-2008.* Environ Sci Technol. 2014. 48(1): 753-60.

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Questions and Answers

Note: There were no questions because the moderator moved directly into the general Q&A session at the end of this panel.

General Question and Answer Session

Q. This question was for Rebecca Birch. She has read Ms. Birch's time trends document and has an issue with the idea that women are choosing lower mercury fish. She thinks this data do not show that women are actually choosing lower mercury fish. Instead, women may be just eating lower mercury fish without specifically choosing them. (Susan Buchanan)

A. The data suggest that women are switching to lower mercury fish, but this does not take into account fish advisories. Using the National Health and Nutrition Examination Survey (NHANES) data is not the best way to look at this. (Birch)

Q. This question was for Rebecca Birch. Are there enough pregnant women in the NHANES data set? (Lowery)

A. No. (Birch)

Q. The data shows that the number of women who eat fish with high mercury levels has declined in recent years. Perhaps people are choosing salmon instead of tuna, and making a trade-off to get more Omega 3 benefits from eating salmon. Are there any regional data sets available, such as for New York? Could you check salmon Omega 3 levels versus other fish species? (Gochfeld)

A. She does not know much about local NHANES data sets. It is difficult to find high fish consumers with the NHANES data. (Birch)

Q. EPA's draft reference dose for PFOA would have this reference dose three times lower than the reference dose that Minnesota uses now. Based on IRIS changes, we will probably find that consuming fish will look much worse previously than it does now. Looking at the benefits of fish consumption will be important, not just looking at the toxicity effects. As a question specifically for Joyce Donohue, will the reference dose go up or down for PFOS? (McCann)

A. EPA has looked at the peer review results. Now there are 100 new studies that need to be reviewed by EPA. It would be premature to make any statement. (Donohue)

Q. She wanted to add a cautionary note. Based on individual studies with consumers, they are choosing fish not only based on health benefits but on availability and cost. Fish high in mercury are getting more expensive. Other new fish species, such as tilapia and swai, are now available at a lower cost and are lower mercury fish. (Burger)

Q. Has consumption of canned albacore tuna decreased? (Stern)

A. No, but the amount of albacore tuna in the can has decreased. (Burger)

Q. What are the larger changes planned for EPA's IRIS program? We have been very focused on risk assessment, but IRIS is also important in informing people about data on local areas and stressors. We should look across different agents in a more quantitative assessment. (Kyle)

A. As we are able to focus research more on epidemiological studies that may include modifiers for specific endpoints, we may be able to add more information about modifiers and other factors. The value in doing endpoint-specific assessments is that we may be able to identify some of the environmental causes of diseases such as diabetes. We could look at non-chemical stressors in analyses. EPA will look at epidemiological studies for effect modifiers and co-factors. (Cogliano)

Implications of Recent Epidemiological Evidence on Effects of Methylmercury for Fish Consumption Advice

Ned Groth, Gelfond Fund

Biosketch

Dr. Edward (Ned) Groth III was born in Somerville, New Jersey. He received an A.B. in Biology from Princeton University in 1966 and a Ph.D. in Biological Sciences from Stanford University in 1973. His dissertation was titled "Two Issues of Science and Public Policy: Fluoridation of Community Water Supplies and Air Pollution Control in the San Francisco Bay Area." His thesis research under the direction of Professor Paul Ehrlich concerned the interplay between scientific, political, and other factors in environmental and public health policymaking. Dr. Groth did post-doctoral research on the environmental impacts of population growth at the California Institute of Technology, from 1973 to 1974. From 1975 to 1979, he was on the staff of the Environmental Studies Board of the National Research Council, at the U.S. National Academy of Sciences (NAS), in Washington, DC, where he worked on an evaluation of environmental research needs, helped develop multi-disciplinary approaches for assessing risks and control options for pollutants, and directed a study on lead in the human environment.

In 1979, Dr. Groth joined Consumers Union (CU) of United States, the publisher of Consumer Reports magazine, an independent consumer testing and publishing organization, as Director of Public Service Projects. Until his retirement in 2004, Dr. Groth gave the organization's technical and editorial staff scientific advice on a wide array of health and environmental risk issues related to consumer products. His central interests were food safety, toxic chemicals, risk assessment, and risk communication. He participated, as a consumer advocate, in public debates and dialogues with government agencies on myriad health and safety issues. Dr. Groth was also active in the global work carried out by Consumers International, of which CU is a founding member, on similar issues, particularly international food safety standards. Dr. Groth is the author of numerous papers and technical reports and a co-author of several books. He has served on many expert committees and advisory boards, including the Committee on Agricultural Biotechnology, Health and the Environment of the U.S. National Research Council; the Food Forum of the U.S. National Academy of Sciences; a Joint Expert Consultation on Risk Communication in Food Safety for the World Health Organization (WHO) and Food and Agriculture Organization (FAO) of the United Nations; and a WHO/FAO Expert Consultation on Science and Ethics in Food Safety. He has traveled widely in recent years to advise the WHO and FAO, member governments, and national consumer organizations on such issues as methylmercury in fish, the application of risk analysis to food safety, risk communication, and public participation in food safety decision-making.

Abstract

In June 2014, the U.S. Environmental Protection Agency (EPA) and the U.S. Food and Drug Administration (FDA) issued a draft of updated fish consumption advice that is essentially unchanged from the agencies' 2004 advice; it places somewhat more emphasis on promoting fish consumption by pregnant women to obtain nutritional benefits, and places no more emphasis than before on reducing or avoiding methylmercury exposure. But epidemiological research on the effects of methylmercury exposure on neurodevelopment and cognitive functions has expanded greatly and seen many methodological advances since 2004. More than a dozen studies in 10 countries have confirmed the adverse neurodevelopmental effects of methylmercury. The lowest observed adverse effect level (LOAEL) in at least eight recent studies is an order of magnitude lower than the

recognized LOAEL in 2004. The number of neurodevelopmental outcomes associated with prenatal methylmercury exposure has expanded substantially, and effects on cognition have now been associated with elevated postnatal exposure in both children and adults. The basis for EPA/FDA's draft updated advice is a risk-benefit modeling assessment done by FDA. The advice needs to be much more solidly grounded in empirical epidemiological evidence and the advice needs to be changed and improved from the current draft version.

SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY
Implications of Recent Epidemiological Evidence on Effects of Methylmercury for Fish Consumption Advice – Ned Groth

Implications of Recent Epidemiological Evidence on Effects of Methylmercury for Fish Consumption Advice

Presented at the 2014 EPA Fish Forum
Alexandria, VA, Sept 22-24
Edward Groth III, PhD
Groth Consulting Services
Pelham, NY USA

2004 EPA/FDA Advice:

- Targets: Pregnant women (WCBA) & young children.
- Benefits of fish consumption: WCBA and kids should eat up to 12 oz of seafood per week.
- Generic advice: Choose a variety of low-mercury fish.
- Specific advice:

1. Avoid swordfish, shark, king mackerel and Gulf tilefish.
2. Eat up to 6 ounces/week of canned albacore tuna.
3. Lower-mercury choices include shrimp, canned light tuna, salmon, pollock, and catfish.

2014 (Draft) EPA/FDA Advice

- Targets: Pregnant women (WCBA) & young children.
- Benefits of fish consumption: WCBA and kids should eat **at least 8 to 12** oz of seafood per week.
- Generic advice: Choose a variety of low-mercury fish.
- Specific advice:

1. Avoid swordfish, shark, king mackerel and Gulf tilefish.
2. Eat up to 6 ounces/week of canned albacore tuna.
3. Lower-mercury choices include shrimp, canned light tuna, salmon, pollock, catfish, **tilapia and cod**.

What's changed?

- The advice now specifies a minimum beneficial intake of 8 oz of seafood per week and an optimal beneficial range (based on research in the past decade showing benefits of maternal fish intake during pregnancy for neurodevelopment).
- Two more "lower-mercury" items with large market shares have been added to the "safer choices" list.

What *hasn't* changed

- The new advice (and EPA/FDA's presentation of it to the media) suggests we have learned nothing new in the past decade about methylmercury's effects.
- The new advice (like the old) seems very tolerant of methylmercury exposure.
- While the four fish on the "do not eat" list account for less than 1 percent of the US market, the two varieties of canned tuna—both recommended for consumption by pregnant women and kids—own 12.5 percent of the market and provide **37.25** percent of all methylmercury inputs, far and away the largest sources of exposure.

My Impressions of This Advice

- It focuses on promoting seafood consumption, not on reducing methylmercury exposure. [My opinion: Good advice can and should do both.]
- It specifically promotes increased consumption by pregnant women and young children of the 2 largest sources of methylmercury exposure (i.e., canned tuna). Per capita consumption now averages ~0.8 oz/week, or just 7 to 13 % of recommended amounts.
- It seems completely insensitive to recent research on adverse effects of methylmercury.

Effects of Methylmercury: What We Knew a Decade Ago

- In 2004, it was taken as a given that the Reference Dose (RfD, a dietary intake of 0.1 μg/kg-bw/day) and the associated blood mercury level of 5.8 μg/L and hair mercury level of 1 ppm, defined "acceptable" or "safe" exposure to methylmercury.
- The RfD was based on a 1997 study in the Faroes that associated significant decrements in cognitive ability with prenatal MeHg exposures at an average umbilical cord blood level of 58 μg/L. By incorporating a 10X Uncertainty Factor, EPA set the RfD at 5.8 μg/L.

Effects of Methylmercury: What We've Learned Since 2004

- Associations between prenatal MeHg exposure and adverse effects on cognitive development have been confirmed in more than a dozen studies.
- The LOAEL for neurodevelopmental effects has been lowered by an order of magnitude, and today is around 5 μg/L in blood and 1 ppm in hair.
- The range of neurodevelopmental effects associated with prenatal MeHg exposure has expanded.
- Cognitive deficits have also been associated with children's postnatal exposure and with the high-end of "normal" fish consumption in adults.

My Conclusions:

- The RfD, adopted in 2001 based on 1997 evidence, no longer protects public health, because multiple recent studies have associated adverse effects with exposures around or even below the RfD.
- Advice that tolerates exposures up to the RfD or (as the draft 2014 advice does) *actively promotes exposure that exceeds the RfD* (6 oz of albacore tuna contain 143 % of the RfD for a 60-kg woman) cannot protect or advance public health.
- Advice should give far more weight to epidemiological evidence – which I'll review for you now.

Overview of Recent Research

- More than a dozen studies on neurodevelopmental effects in ~10 countries since 2004.
- Major advances in controls for mutually confounding effects of seafood consumption and methylmercury exposure on cognitive endpoints.
- For example: Beneficial effects of maternal fish intake have now been observed in the Seychelles and Faroes studies (among others).
- With adjustment for beneficial effects, adverse effects in the Faroes are larger, and previously masked adverse effects have been observed in the Seychelles, making these once-inconsistent studies more concordant.

Summaries of Individual Recent Studies*

* See me afterward for complete references and/or copies of individual studies.

1. Oken et al. (2005, 2008); Boston, USA

- Evaluated 135 children's cognitive performance at age 6 months and 341 children's performance at age 3 years.
- Mean maternal hair Hg 0.55 ppm, 90^{th} percentile 1.2 ppm (2005 paper; similar in 2008 group).
- Fish consumption > 2 meals/week associated with significant improvements in cognitive functions.
- Mercury exposure > 90^{th} percentile associated with significant decrements in cognitive functions.
- Net adverse effects in a significant subpopulation.
- Outcome differences as large as 28 percent.

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2. Jedrychowski et al. (2006, 2007), Krakow, Poland

- Examined children at ages 1, 2 and 3 years.
- Associated substantial developmental delays in 1-year-olds with above-average blood mercury.
- Cord blood mercury in the "developmentally delayed" group averaged 1.05 μg/L (vs. 0.85 μg/L in "normal" group); i.e., substantially lower than in USA.
- High-Hg group scored 16.6 points lower on BSID-PDI and 10 points lower on BSID-MDI.
- No differences were associated with mercury exposure at ages 2 and 3 years.
- No control for confounding by fish benefits.

3. Lederman et al. (2008), NYC

- Examined 280 children at ages 1, 2, 3 and 4 years in a multi-ethnic population.
- Study included a substantial minority (102 subjects or 36%) of Asian-Americans with high-fish diets and far above average methylmercury exposure.
- Cord blood in Asian children averaged 14.95 μg/L; in non-Asians, it average 3.73 μg/L.
- Substantial decrements in BSID-PDI and on verbal, performance and full IQ at ages 3 and 4 years were associated with methylmercury exposure.
- Maternal fish consumption associated with improved performance on the same outcome measures.

4. Lam et al. (2013), Hong Kong

- Assessed 608 children at age 8 years on a large number of cognitive functions.
- Associated significant decrements in performance on several outcomes with elevated MeHg in cord blood.
- Defined "elevated" MeHg exposure as cord blood > 5.8 μg/L (i.e., US Reference Level).
- 81 percent of population had cord blood > 5.8 μg/L.
- I.e., adverse effects occurred in 81 % of population.
- Unable to measure beneficial effects of maternal fish consumption or adjust for mutual confounding.

5. Suzuki et al. (2010), Tohoku, Japan

- Examined 498 newborns (3 days old) using a standard neonatal behavioral assessment screen (NBAS).
- Elevated maternal hair mercury was associated with decreased performance on the NBAS motor scale.
- This population had an average maternal hair Hg level of 2.22 ppm—i.e., higher than in the US, but lower than in the Faroes or Seychelles.
- Subsequent testing at ages 30 and 42 months failed to associate any performance differences with mercury exposure; some were associated with PCBs.

6. Wu et al. (2014), Zhoushan, China

- Examined 418 newborns at age 3 days, using an NBAS similar to that used by Suzuki et al.
- The mean maternal blood Hg level was 5.68 μg/L and cord blood mean was 7.92 μg/L; 56 percent of mothers exceeded the US Reference Dose (5.8 μg/L).
- Blood mercury level was strongly correlated with the mothers' fish consumption.
- Methylmercury exposure was inversely associated with the total NBAS score and with the active and passive muscle tone components of the motor score.
- Did not assess benefits of fish consumption or adjust for confounding.

7. Sagiv et al. (2012), New Bedford, MA, USA

- Examined 421 8-year-olds for ADHD risk.
- Associated increase in ADHD-related behaviors with elevated prenatal methylmercury exposure.
- Maternal mean hair Hg was 0.62 ppm.
- Maternal hair Hg > 1 ppm was associated with a 40% increase in risk of "inattentive" behavior and a 70% increase in risk of "hyperactive/impulsive" behavior.
- Above-average maternal fish consumption during pregnancy reduced ADHD risk by 60%.
- If replicated, this study expands the list of possible adverse developmental outcomes associated with Hg.

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8. Boucher et al. (2012), Nunavik, Canada

- Examined 279 11-year-old Inuit children for ADHD.
- Maternal diet is high-fish and also includes marine mammals; i.e., more similar to Faroes than to USA.
- Elevated cord-blood Hg (>11.4 µg/L) was associated with a 4-fold increase in risk of being diagnosed with ADHD.
- This study provides evidence that analogous effects (i.e., increased ADHD risk) are associated with both very high and "high-normal" exposures to MeHg.

9. Freire et al. (2010), Granada, Spain

- Examined 75 4-year-old children.
- Associated significant decrements in general cognition, memory and verbal performance with elevated MeHg exposure.
- Population's mean hair Hg was 1.81 ppm, median was 1.04 ppm.
- Decreased performance was associated with hair Hg > 1.0 ppm; i.e., occurred in >50% of study subjects.
- Mercury exposure was determined to come from the children's own fish consumption (i.e., not prenatal).

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- Mercury exposure was determined to come from the children's own fish consumption (i.e., not prenatal).

10. Murata et al. (2004), Faroes

- Tested 878 14-year-olds using an objective measure of brain function, auditory evoked potentials.
- Latency increased (i.e., signal transmission was delayed) in subjects with hair Hg > 1 ppm.
- This difference was associated with the children's own recent (post-natal) mercury exposure, not with their prenatal exposure.

11. Myers et al. (2009), Seychelles
12. Davidson et al (2010), Seychelles

- Myers et al. associated deficits in four measures of risk-taking, fine motor coordination and IQ with elevated MeHg exposure in 9-year-olds.
- Davidson et al. associated lower performance on an end-of-year scholastic test with higher MeHg exposure in 9-year-olds.
- Effects were small, most were gender-specific, and all were largely offset by benefits of fish consumption.
- Fish intake and mercury exposure in this population are very high (hair Hg averaged 6.09 ppm).
- Nevertheless, more effects associated with childhood fish consumption.

13. Ng et al. (2013), Taiwan

- Assessed cognitive development of 168 children from birth to age 2 years.
- Focused on a subset (N = 26) with a genetic variant associated with poor neural repair function.
- Associated MeHg exposure with large decrements in cognitive performance in carriers of that allele.
- This genetic trait that enhances vulnerability to toxic effects of methylmercury (through age 2) was present in 15.5 % of the studied population.

14. Julvez et al. (2013), Avon, UK

- Examined data from a subset of the ALSPAC cohort.
- Other papers from the ALSPAC study have shown the benefits of maternal fish consumption in pregnancy and failed to associate any outcome differences with the population's methylmercury exposure.
- Julvez et al. examined data for children found to have one or more of about 40 genetic variants thought to be associated with increased risk of MeHg toxicity.
- Four specific alleles were associated with IQ deficits in individuals with higher MeHg exposure.
- Study was too small to be definitive, → more research.

15. Masley et al. (2012), Florida, USA

- Examined 384 middle-aged adults using a multi-test screen for cognitive functions.
- Population was very health-conscious and ate a lot of fish. Mean blood Hg level was 7.2 µg/L.
- Blood Hg > 5 µg/L and < 15 µg/L was associated with improved cognitive performance relative to blood Hg < 5 µg/L (i.e., shows beneficial effects of fish intake).
- Blood Hg > 15 µg/L was associated with significant (~5%) decrements in executive and other functions.
- Eleven percent of this population had blood Hg > 15 µg/L, and 2.6% had levels > 25 µg/L.

Some Conclusions

1. **Eight recent studies have associated adverse neurodevelopmental effects with methylmercury exposures around or below the RfD**:

- **Oken et al**. (Several outcomes @ hair Hg ≥ 1.2 ppm)
- **Jedrychowski et al**. (lower BSID @ cord blood Hg 1.05 µg/L)
- **Lederman et al**. (-2.5 IQ points per doubling cord blood Hg)
- **Lam et al**. (Several outcomes @ cord blood Hg > 5.8 µg/L)
- **Wu et al**. (Neonatal motor scores, 56% of mothers > 5.8 µg/L)
- **Sagiv et al**. (40-70% increased risk of ADHD-related behaviors @ maternal hair Hg > 1 ppm.)
- **Murata et al**. (brain signal delays @ child hair Hg > 1 ppm)
- **Freire et al**. (decrements in general cognition, memory, verbal and performance IQ @ child hair Hg > 1 ppm)

Conclusions, Continued

2. **Recent research has:**

- Lowered the LOAEL by an order of magnitude from what was recognized a decade ago.
- Expanded the list of functions apparently affected by prenatal or postnatal methylmercury exposure.
- Begun to associate adverse effects with MeHg exposure and postnatal fish consumption in children.
- Begun to document adverse cognitive effects of MeHg in adults with far above-average fish consumption.
- Begun to link the risk of adverse effects with specific genetic variants that enhance susceptibility.
- Emphasis on "begun" in all these latter cases.

Implications for Advice, I

- Epidemiological research during the past decade has advanced our understanding of methylmercury risks enormously.
- Yet the (draft) 2014 EPA/FDA fish consumption advice is essentially unchanged from the 2004 version.
- Conclusion: The draft new advice is not well grounded in understanding of epidemiological evidence.
- In fact, the draft advice is based almost entirely on a benefit/risk assessment model developed by FDA.
- A model—while quite useful—is not "reality."
- The advice needs to take greater account of empirical evidence, which has grown enormously since 2004.

Implications for Advice, II

- Based on empirical evidence, I believe the advice for pregnant women and young children should be much more precautionary:

1. It should place as much emphasis on reducing and avoiding methylmercury exposure as it now does on ensuring nutritionally optimal seafood consumption.
2. Reducing MeHg exposure can best be accomplished by guiding consumers to seafood choices that are actually low-mercury, i.e., items with < 0.07 ppm Hg.
3. There are about 25 popular choices in that category, *but no form of canned tuna is among them*, nor is cod.

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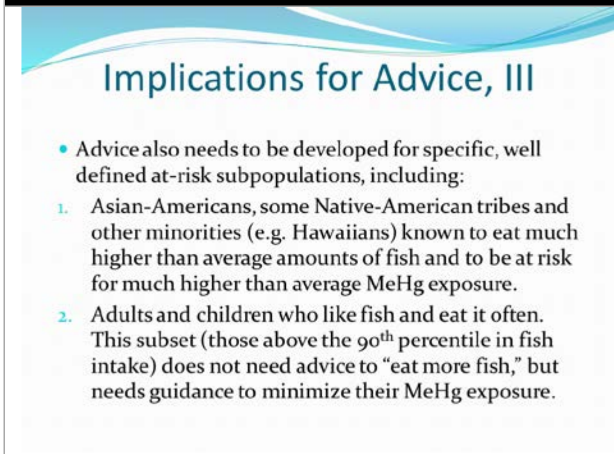

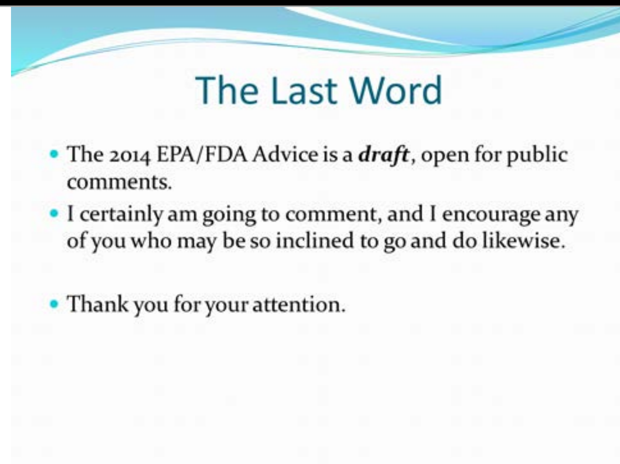

Questions and Answers

Note: There were no questions because the moderator asked that any questions be held until the general Q&A session at the end of this panel.

Neurodevelopmental Effects of Methylmercury

Glenn Rice, U.S. Environmental Protection Agency

Biosketch

Dr. Glenn Rice has served as an Environmental Health Scientist at the U.S. Environmental Protection Agency (EPA) since 1990. His research interests focus on developing human health risk assessment methods for chemical mixtures and cumulative exposures. He is one of the primary authors of EPA's Supplementary Guidance for the Health Risk Assessment of Chemical Mixtures and EPA's Mercury Study: Report to Congress. Dr. Rice holds a Doctoral Degree in Environmental Health and Health Policy Management from the Harvard School of Public Health, a Master's Degree in Microbiology from Miami University, as well as undergraduate degrees in Biology and Chemistry from Thomas More College.

Abstract

Not provided.

EPA United States Environmental Protection Agency

Neurodevelopmental Effects of Methyl Mercury

Glenn E. Rice, Sc.D.

2014 National Forum on Contaminants in Fish
September 23, 2014

The views expressed in this presentation are those of the author and do not necessarily reflect the views or policies of the U.S. EPA.

September 23, 2014

EPA United States Environmental Protection Agency

Outline

1. Risk Assessment Approaches for Addressing Neurodevelopmental Toxicity of Methyl Mercury (MeHg)
2. Low Dose MeHg Neurodevelopmental Studies
3. MeHg Toxicokinetics
4. Mercury Exposure Biomarker Imprecision
5. Importance of Epidemiologic Confounding and Effect Measure Modification

1

EPA United States Environmental Protection Agency

Assessments of Human MeHg Health Risks are Entangled with Fish Consumption

- Fish consumption- primary exposure medium for MeHg
  - In US, tuna consumption is primary source for most people
  - Variety of tuna species and sizes; piscivorous species, migrate widely
- MeHg readily absorbed through human GI tract, distributes throughout the body, passing placenta and blood-brain barrier
  - ~95% of ingested MeHg is absorbed
  - Fish preparation method does not reduce MeHg levels; associated with protein in muscle tissue (Morgan et al., 1997)
- Known fetal neurotoxicant
- Protein substitutes for fish also associated with some adverse health effects (not considered here)

2

EPA United States Environmental Protection Agency

Part 1: Two Approaches for Addressing MeHg Neurodevelopmental Toxicities in Risk Analyses

1. Reference Dose (RfD)
2. Predictive Dose-Response Functions- MeHg Dose and associated neurodevelopmental decrement

3

EPA United States Environmental Protection Agency

Approach 1: Reference Dose (RfD) MeHg RfD: 1 ug/kg-day

- Composite outcome: Neurological impairment in 7-year-olds Faroes and New Zealand epidemiology studies
- Average $BMDL_{05}$ = 0.6 ug/Kg day ➡ 1 ug/Kg-day
- Composite Uncertainty Factor = 10
  - Interindividual toxicokinetic variability in estimating ingested MeHg doses from cord-blood mercury concentrations based on NRC (2000) analysis.
  - Toxicodynamic variability. Faroe Islands population is homogeneous. The average toxicodynamic response in this population compared with that of the genetically more diverse U.S. population is unknown
- RfD ~1.2 µg/g in hair
- Neurological Tests
  - Finger Tapping, Continuous Performance Test, Boston Naming Test, California Verbal Learning Test (delayed recall)

4

Source: EPA 2001

EPA United States Environmental Protection Agency

3 Primary MeHg Neurodevelopmental Epi Studies Available when EPA completed RfD in 2001

	Faroes (N. Atlantic)	Seychelles (Indian)	New Zealand (S. Pacific)
High fish consuming populations	Caucasian	African	Multi-ethnic
	900 mom-child prs.	700 mom-child prs.	200 mom-child prs.
	Pilot whale/other fish	Variety of marine fish	Marine fish including Shark
	Cord blood	Maternal hair	Maternal hair
	Hair mean Hg: 8 ppm	4.5 ppm	6.8 ppm
	Effects in 8-10 neuro-development tests (e.g., Boston Naming Test, IQ, California Verbal Learning) children <8 yrs.	No statistically significant MeHg-associated effects DDST, McCarthy Scales, IQ children <10 yrs.	Effects in "IQ" tests, Test of Language Dev., Visuomotor tests children: 4 & 6 yrs.

Sources: Grandjean(1997) Cognitive deficit in 7-year-old children with prenatal MeHg exposure. Budtz-Jorgensen(1999) MeHg neurotoxicity independent of PCB exposure. National Research Council (2000) Toxicological effects of MeHg

Dose-Response Assessment Challenges
1. Tested different neurodevelopmental domains
2. Different mercury exposure measures
3. Differences in fish
4. Differences across populations

5

Comparison of Exposure Levels: 3 Epi Studies VS Contemporary US

US Female Hair Concentrations

- Contemporary US exposures ~10-20 × lower than dose estimates from studies available in 2000
- Geometric Mean~0.12 ppm
- Frequent Fish Eaters ~ 0.4 ppm

Source: McDowell et al., 2004 - used NHANES 1999-2000

Faroes (N. Atlantic)	Seychelles (Indian)	New Zealand (S. Pacific)
Cord blood	Maternal hair	Maternal hair
Hair mean Hg: 8 ppm	4.5 ppm	6.8 ppm

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Approach 2: Hair Mercury: IQ Coefficient

- Axelrad (2007) Bayesian Hierarchical Modeling Approach
- Maternal hair Hg:IQ coefficient: ~0.2 IQ point per ppm hair
  - Range 0.1–0.4 IQ point per ppm hair
  - Fit parameters of model in which each test-and study-specific coefficient is represented as sum of:
    - True slope
    - Domain-specific neurodevelopmental effect
    - Study-specific effect
    - Random error
  - IQ - "blunt" neurotoxicity measure; used in economic benefit analysis
- Also see Cohen (2005) for comparable alternative analysis

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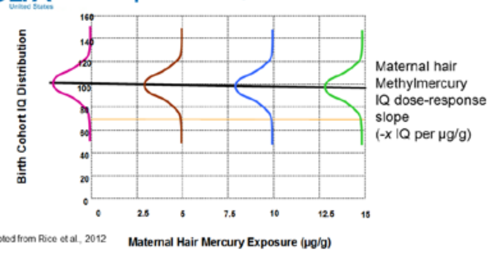
Sources: EPA's 2005 Clean Air Mercury Rule; Axelrad et al., 2007

Population IQ Distribution Shift



Adapted from Rice et al., 2012

- NAS: associations between MeHg and low-dose fetal neurotoxicity are credible, but did not address IQ
- EPA: no evidence of a threshold for MeHg-related neurotoxicity in exposure range of Faroe Islands study
- IQ likely not the ideal outcome measure for MeHg Effects

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Risk Assessment / Risk Management Paradigm

- RfD's and Predictive Dose Response Models: different policy contexts
- RfD– "safe dose" Uses: exposure limits/clean-up goals
- Predictive Dose Response Models-estimate magnitude of a health effect in affected population. Uses: Cost-Benefit Analysis/Benefits Assessment

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Part 2: Neurodevelopmental Studies Karagas et al 2012: Review Neurodevelopmental and Behavioral Effects associated with Low Dose MeHg Exposures

Exclude studies of populations with mean Hg levels above:

- 4 µg/g in hair
- 20 µg/L in cord blood
- ~12 µg/L in adult blood

Population Age	Study Number	Sample Size	Exposure Measures
Birth-2 years	10	53-1054	Cord blood, cord tissue, infant hair, maternal hair, maternal blood
3-6 years	11	72-1778	Cord blood, child hair, child blood, maternal hair, maternal blood
7-14 Years	6	100-1778	Cord blood, child hair, child blood
Adult	4	106-474	Adult hair, adult blood

Adapted from Karagas et al., 2012

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Summary of Low-dose MeHg Epidemiology Studies

Age	Study Number	Summary: MeHg Exposures: Outcome Measures neurocognitive and behavioral
Birth-2 years	10	Inconsistent effects: no effect; increased risk associated with prenatal or postnatal mercury
3-6 years	11	Adverse effects if adjusted for fish intake: multiple associations with prenatal mercury (memory, verbal skills cognition, etc.); inconsistent effects with concurrent mercury
7-14 Years	6	Inconsistent effects: protective; no effect; increased risk (e.g., electrophysiologic testing) with prenatal or postnatal mercury
Adult	4	Inconsistent effects: no effect or adverse neuropsychological test performance with current mercury

Adapted from Karagas et al., 2012

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SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY
Neurodevelopmental Effects of Methylmercury – Glenn Rice

Part 3 Pharmacokinetics

- In addition to maternal fish consumption measures during pregnancy, the different tissues used to assess MeHg exposures in epidemiology studies necessitate development of/refinement of existing physiologically-based pharmacokinetic models
- These models will need to account for maternal and fetal compartment changes during fetal development

Population Age	Study Number	Exposure Measures
Birth-2 years	10	Cord blood, cord tissue, infant hair, maternal hair, maternal blood
3-6 years	11	Cord blood, child hair, child blood, maternal hair, maternal blood
7-14 Years	6	Cord blood, child hair, child blood
Adult	4	Adult hair, adult blood

Adapted from Karagas et al., 2012

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Part 4 Imprecision of Exposure Biomarkers

- Faroe Islands prospective birth cohort: study imprecision of prenatal MeHg exposure biomarkers: cord blood, cord tissue, and maternal hair
- Evaluated mutual correlations and associations among biomarkers and neurobehavioral effects in children aged 7 years
- Using factor analysis and structural equation modeling examined "total" imprecision of each biomarker
  - Exposure biomarkers correlated well with one another
  - For cord-blood, judged "least imprecise" measure, estimated imprecision had a 95% CI of 21-38%.
  - Total biomarker imprecision >"normal" laboratory variability (<5%)
  - Such imprecision can underestimate dose-related toxicity and complicate confounder adjustment

Source: Grandjean and Budtz-Jørgensen, 2010; Table 4

Biomarker	Regression Coefficient	Error Standard Deviation	Correlation to Estimated Truth
Cord Blood	1	0.30	0.94
Cord Tissue	0.89	0.33	0.91
Maternal Hair (proximal)	0.89	0.36	0.89
Maternal Hair (full length)	0.85	0.45	0.84

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Part 5 Confounding

Confounding: non causal association that distorts relationship of interest.

Confounders must meet 3 conditions:

1. A risk factor* for disease (even among the unexposed)
2. Associated with exposure in source population from which the subjects arose
3. Not an intermediate in the causal pathway of exposure and disease

*This type of Bias can result in bias away from the null (i.e., positive confounding) or bias towards the null (i.e., negative confounding).

How well are confounders controlled *within* an epidemiology study? (e.g., regression adjustment, stratification, restriction to participants with certain characteristics.)

For dose-response modeling, how well and how consistently are confounders controlled *across* studies?

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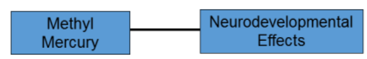
Potential Confounders



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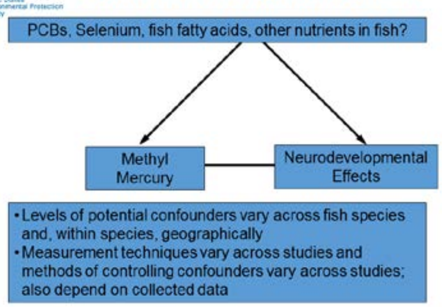
Potential Confounders (continued)



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Confounding and Fish Consumption

- Fish consumption example of confounding; factors affecting same outcome are associated, derived from the same foods
  - MeHg and fish nutrients (e.g., fatty acids, selenium) and other contaminants (e.g., PCBs)
- If confounding not addressed in study design or data analysis, associations with both contaminant exposure and nutrient intake underestimated
  - Mutual adjustment needed for beneficial and toxic effects, to better quantify the opposite "effects" of mercury and nutrient intakes from seafood (i.e., avoid underestimation of effects)
- MeHg-associated deficits estimated to increase up to 2-fold when compared with the unadjusted effects

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Source: Budtz-Jorgensen E, Keiding N, Grandjean P, Weihe P. Ann Epidemiol 2007;17:27–35.

Effect Measure Modification (EMM)

EMM occurs when the relationship between an exposure and outcome (e.g., RR) depends on (is modified by) a 3rd variable (i.e., the effect measure modifier); or, the association changes according to the level of that third variable

EMM = Heterogeneity of Effect = Interaction

Fetuses are a population sensitive to MeHg exposures

Are there sensitive fetal populations either due to maternal or in utero fetal factors?

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Conclusion: MeHg:Human Neurotoxicity

- Current focus: subtle developmental neurotoxicities across different neurodevelopmental domains associated with 'low' exposures;
  - Other stressors/nutrients affect same endpoints
- MeHg Kinetics is important; understanding variance
- Improved understanding of imprecision of exposure measures essential-quantify? Other factors affecting this variance?
- Evaluating low dose neurotoxicity risks necessitate Epi studies that evaluate additional confounders (e.g., types of fish, sources of fish, fish nutrient/contaminant levels). Still will be difficult to disentangle analytically "fish" (lots of different types that vary!) and MeHg associations
- Effect Measure Modification- are some groups of fetuses at higher/lower risk?
- From a cumulative risk perspective, reporting the effect sizes of confounders and modifiers (e.g., regression coefficients [i.e., β's for example for MeHg, fish nutrients, among others]) should increase the utility of epidemiological studies, because these coefficients could be used to estimate risks/benefits cumulatively.

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Acknowledgements

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- Amanda M. Evans
  Oak Ridge Institute of Science and Engineering Fellowship at US EPA National Center for Environmental Assessment

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Questions and Answers

Note: There were no questions because the moderator asked that any questions be held until the general Q&A session at the end of this panel.

Epidemiological Evidence of Fish Consumption, Methylmercury Exposure, and Risk of Cardiovascular Diseases in Adults

Jyrki Virtanen, University of Eastern Finland

Biosketch

Dr. Jyrki Virtanen has 10 years of experience in epidemiological research related to the cardiovascular health effects of fish consumption and environmental contaminants in fish, mainly methylmercury. He is an Adjunct Professor of Nutritional Epidemiology at the University of Eastern Finland. Dr. Virtanen has shown in the prospective, population-based cohort study from eastern Finland, the Kuopio Ischemic Heart Disease Risk Factor Study (KIHD) that increased hair mercury concentration, mainly caused by fish consumption in KIHD, is associated with several cardiovascular disease outcomes in middle-aged and older men. He also found that high hair concentration of mercury attenuates the cardioprotective effects of the Omega 3 fatty acids in fish in these men.

Abstract

Epidemiological evidence suggests that consumption of fish and long-chain Omega 3 polyunsaturated fatty acids (PUFA) in fish, n-3 eicosapentaenoic acid (EPA) and n-3 docosahexaenoic acid (DHA), are associated with lower risk of cardiovascular diseases, especially cardiovascular disease mortality. However, results from randomized controlled trials with fish oil supplements have not been as promising. Besides the potentially beneficial nutrients, fish is also a major source of environmental contaminants, such as methylmercury. The association between long-term, moderate level methylmercury exposure and risk of cardiovascular diseases was first observed in the middle-aged and older men from the prospective, population-based cohort study in eastern Finland, the Kuopio Ischemic Heart Disease Risk Factor Study (KIHD). Methylmercury exposure also attenuated the beneficial impact of the Omega 3 PUFA on the risk of cardiovascular disease. However, not all cohort studies have found such adverse effects with mercury exposure. One potential explanation may be the higher average methylmercury levels in the KIHD study population, compared to other study populations.

SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY

Epidemiological Evidence of Fish Consumption, Methylmercury Exposure, and Risk of Cardiovascular Diseases in Adults – Jyrki Virtanen

Epidemiological evidence of fish consumption, methylmercury exposure, and risk of cardiovascular diseases in adults

Jyrki Virtanen, PhD

Adjunct professor of nutritional epidemiology

UNIVERSITY OF EASTERN FINLAND

Fish consumption and risk of cardiovascular diseases

- There is fairly consistent evidence from prospective cohort studies that fish consumption and dietary intake/biomarker levels of long-chain omega-3 PUFA from fish are associated with lower risk of CVD.
  - Especially fatal CHD; little effect on non-fatal CHD.
    - Potential anti-arrhythmic properties of the long-chain omega-3 PUFA.
  - The dose-response for cardiac death appears to be non-linear; little additional benefit with intake >250 mg/d of EPA+DHA.
    - ≈2 servings of fatty fish per week.
- Similar findings were also observed in the early clinical trials with fish consumption or fish oils supplements.
- The findings from the more recent supplementation trials have been less promising.

Why the discrepancy in the study findings between the observational studies and the recent clinical studies?

Jyrki Virtanen U.S. EPA 2014, Alexandria

Fish consumption and risk of cardiovascular diseases

- Fish oil not beneficial for CVD prevention.
  - Not likely, based on the well-established experimental and physiological benefits of EPA+DHA, and the consistently lower risk of cardiac death in observational studies.
- Use of state-of-the-art antihypertensive, lipid-lowering and antiplatelet medications among the study subjects in the recent RCTs.
  - Fish oil has little additional benefit.
- Lower than expected event rates.
  - Studies underpowered to detect a clinically meaningful effect.
- Use of a composite end-point of fatal and non-fatal CVD instead of CHD mortality.
  - Effect strongest for cardiac mortality.
- Increasing use of fish oil supplements in a general population.
  - Little additional benefits at intakes above 250 mg/d.

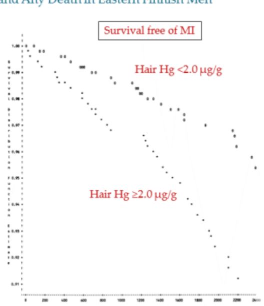
Jyrki Virtanen U.S. EPA 2014, Alexandria

Mercury exposure and risk of cardiovascular diseases

Jyrki Virtanen U.S. EPA 2014, Alexandria

Salonen 1995 - Intake of Mercury From Fish, Lipid Peroxidation, and the Risk of Myocardial Infarction and Coronary, Cardiovascular, and Any Death in Eastern Finnish Men

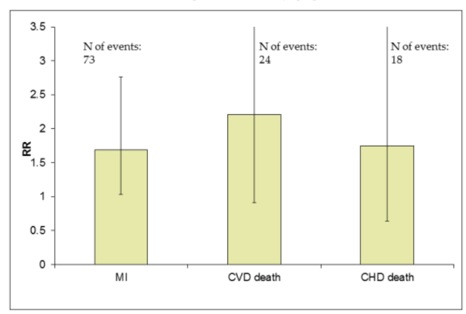
- 1833 men from Eastern Finland, free of CHD at baseline.
  - Kuopio Ischemic Heart Disease Risk Factor Study (KIHD)
- The average hair-Hg concentration at baseline was 1.9 µg/g of hair (range 0-15.7 µg/g).
- High hair-Hg concentration (≥2.0 µg/g) was associated with excess risk of MI and death from CHD, CVD, and any cause during 8 y of follow-up, after adjustment for potential confounders.



Salonen JT et al. Circulation. 1995;91:645-655

Jyrki Virtanen U.S. EPA 2014, Alexandria

Risk of an event in the highest (≥2.0 µg/g) vs. lower tertiles

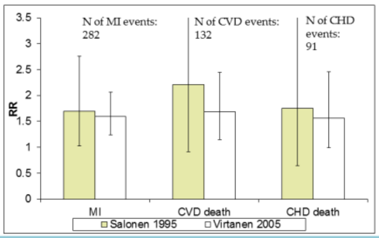


Jyrki Virtanen U.S. EPA 2014, Alexandria

SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY
Epidemiological Evidence of Fish Consumption, Methylmercury Exposure, and Risk of Cardiovascular Diseases in Adults – Jyrki Virtanen

Virtanen 2005 - Mercury, Fish Oils, and Risk of Acute Coronary Events and Cardiovascular Disease, Coronary Heart Disease, and All-Cause Mortality in Men in Eastern Finland (Arterioscl Thromb Vasc Biol)

- An updated analysis with a longer follow-up.
  - Average follow-up time 14 y.

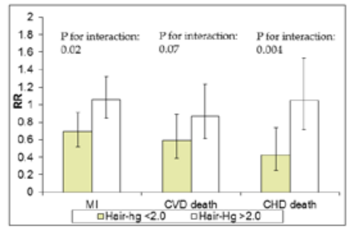


Risk of an event in the highest vs. lower tertiles

Jyrki Virtanen U.S. EPA 2014, Alexandria

Virtanen 2005 - Mercury, Fish Oils, and Risk of Acute Coronary Events and Cardiovascular Disease, Coronary Heart Disease, and All-Cause Mortality in Men in Eastern Finland (Arterioscl Thromb Vasc Biol)

- High hair-Hg also attenuated the beneficial impact of the serum long-chain omega-3 PUFA on the risk.

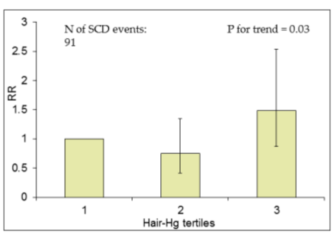


Risk of an event for each 1% increase in serum long-chain omega-3 PUFA concentration, stratified by hair-Hg (highest vs. lower tertiles).

Jyrki Virtanen U.S. EPA 2014, Alexandria

Virtanen 2012 - Serum Long-Chain n-3 Polyunsaturated Fatty Acids, Mercury, and Risk of Sudden Cardiac Death in Men (Plos ONE 2012)

- 1857 men free of CVD at baseline.
- Average follow-up time 20 y.

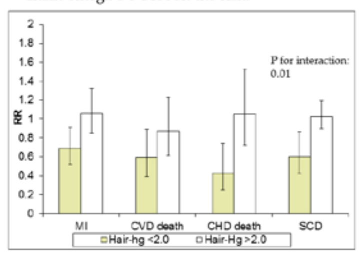


RR of a SCD event in the highest (≥2.0 µg/g) vs. lower tertiles: 1.75 (95% CI 1.13-2.70)

Jyrki Virtanen U.S. EPA 2014, Alexandria

Virtanen 2012 - Serum Long-Chain n-3 Polyunsaturated Fatty Acids, Mercury, and Risk of Sudden Cardiac Death in Men (Plos ONE 2012)

- High hair-Hg again attenuated the beneficial impact of the serum long-chain omega-3 PUFA on the risk.

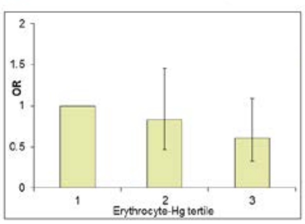


Risk of an event for each 1% increase in serum long-chain omega-3 PUFA concentration, stratified by hair-Hg (highest vs. lower tertiles).

Jyrki Virtanen U.S. EPA 2014, Alexandria

Wennberg 2011 - Fish consumption and myocardial infarction: a second prospective biomarker study from northern Sweden (AJCN)

- A prospective, nested case-control study.
  - Men and women, 30-77 y (median 53 for men, 58 for women).
  - 431 cases with first non-fatal MI, 499 controls.

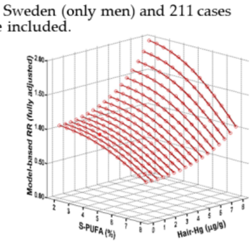


Multivariate-adjusted OR in the highest vs. lowest erythrocyte-Hg tertile 0.61 (95% CI 0.33-1.09)

Jyrki Virtanen U.S. EPA 2014, Alexandria

Wennberg 2012 - Myocardial infarction in relation to mercury and fatty acids from fish: a risk-benefit analysis based on pooled Finnish and Swedish data in men (AJCN)

- A nested case-control study combining data from Sweden and Finland.
- 361 MI cases and 416 controls from Sweden (only men) and 211 cases and 629 controls from Finland were included.
  - Only definite MIs included.
- The harmful effect of Hg was attenuated by increasing concentrations of circulation long-chain omega-3 PUFA at all Hg concentrations.
- The beneficial effect of omega-3 PUFA on MI was counteracted by Hg, but only at a high Hg.



Jyrki Virtanen U.S. EPA 2014, Alexandria

Wennberg 2012 - Myocardial infarction in relation to mercury and fatty acids from fish: a risk-benefit analysis based on pooled Finnish and Swedish data in men (AJCN)

- In Sweden: median hair-Hg 0.57 μg/g, median omega-3 PUFA 4.21%
  - Hair-Hg values converted from Ery-Hg values.
- In Finland: median hair-Hg 1.32 μg/g, median omega-3 PUFA 3.83%.

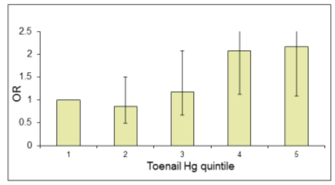
Possible explanations for the differences?

- Differences in fish consumption habits?
  - The men in KIHD consume more lean predatory fish with higher mercury content (pike, perch).
  - In Sweden, higher Ery-Hg a biomarker for intake of fatty fish.
  - In Finland, higher risk observed when hair-Hg ≥2.0 μg/g.
    - Few subjects in the Swedish cohort reached these levels.
- Genetic differences related to Hg retention or its impact on CVD?

UNIVERSITY OF EASTERN FINLAND Jyrki Virtanen U.S. EPA 2014, Alexandria

Guallar 2002 - Mercury, Fish Oils, and the Risk of Myocardial Infarction (NEJM)

- A retrospective case-control study in eight European countries and Israel (EURAMIC study).
  - Men, ≤70 y.
  - 684 cases with first non-fatal MI, 728 controls.
  - The average toenail-Hg in controls 0.25 μg/g.



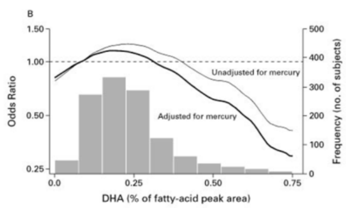
Multivariate-adjusted OR in the highest vs. lowest toenail-Hg quintile 2.16 (95% CI 1.09-4.29).

Guallar et al. NEJM 2002;347:1747-1754.

UNIVERSITY OF EASTERN FINLAND Jyrki Virtanen U.S. EPA 2014, Alexandria

Guallar 2002 - Mercury, Fish Oils, and the Risk of Myocardial Infarction (NEJM)

- The inverse association between adipose tissue long-chain omega-3 PUFA (DHA) and risk of MI was stronger after adjusting for toenail-Hg.
  - Similar finding than in the KIHD cohort.

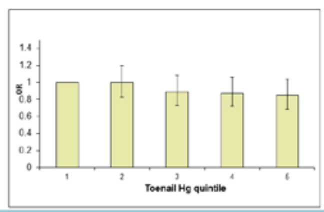


Guallar et al. NEJM 2002;347:1747-1754.

UNIVERSITY OF EASTERN FINLAND Jyrki Virtanen U.S. EPA 2014, Alexandria

Mozaffarian 2011 - Mercury Exposure and Risk of Cardiovascular Disease in Two U.S. Cohorts (NEJM)

- A nested case-control study in two US cohorts (NHS and HPFS).
  - 2,363 CHD cases with first non-fatal or fatal CHD.
  - Women 30-55 y (mean 54 y), men 40-75 y (mean 61 y).
  - The average toenail-Hg concentration 0.23 μg/g in cases, 0.25 μg/g in controls.



Multivariate-adjusted OR for CHD in the highest vs. lowest toenail-Hg quintile 0.84 (95% CI 0.62-1.14).

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Possible mechanims?

- Oxidative stress (lipid oxidation found in KIHD, Salonen 1995).
- Atherosclerosis progression (found in KIHD, Salonen 2000).
- Blood pressure (not in KIHD, Virtanen 2012).
- Inflammation (not in KIHD, Reinders 2012).
- Heart rate variability.

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Conclusions

- The strongest association between mercury exposure and risk of CVD events in a general population is found in middle-aged and older men from Eastern Finland.
  - Average Hg levels higher than in the other study populations.
- Findings from other study populations have been mixed.
  - Direct association in the EURAMIC study (Guallar, NEJM 2002).
  - Inverse association in the Swedish study (Wennberg, AJCN 2011).
  - No association in the US study (Mozaffarian, NEJM 2011).
- Few studies have evaluated the association between Hg exposure and stroke.
  - Mozaffarian, NEJM 2011: no association in the two US cohorts.
  - Wennberg, Br J Nutr 2007: no association in men and women from Sweden.

UNIVERSITY OF EASTERN FINLAND Jyrki Virtanen U.S. EPA 2014, Alexandria

Questions and Answers

Note: There were no questions because the moderator asked that any questions be held until the general Q&A session at the end of this panel.

Status of IRIS Update for Organic and Inorganic Mercury

Vince Cogliano, U.S. Environmental Protection Agency

Biosketch

Dr. Vince Cogliano serves as acting director of the Integrated Risk Information System (IRIS) at the U.S. Environmental Protection Agency in Washington DC. IRIS develops scientific reviews of the health hazards of chemicals in the environment. Previously, Dr. Cogliano served at the International Agency for Research on Cancer (IARC), which is part of the World Health Organization, in Lyon, France, as head of the IARC Monographs programme. The IARC Monographs are a series of scientific reviews that identify environmental factors that can increase the risk of human cancer. Dr. Cogliano received his Ph.D. from Cornell University. Dr. Cogliano's professional interests include qualitative and quantitative health risk assessment and its application to the protection of public health.

Abstract

Not provided.

SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY
Status of IRIS Update for Organic and Inorganic Mercury – Vince Cogliano

Status of IRIS Update for Organic and Inorganic Mercury

Vincent Cogliano
IRIS Program Director (interim)
National Center for Environmental Assessment
Office of Research and Development
U.S. Environmental Protection Agency

The views expressed here do not necessarily represent the views or policies of the U.S. Environmental Protection Agency

Overview

About IRIS

Public engagement – including state risk assessors

Multi-year plan for future assessments – coming soon

Preliminary problem formulation for mercury

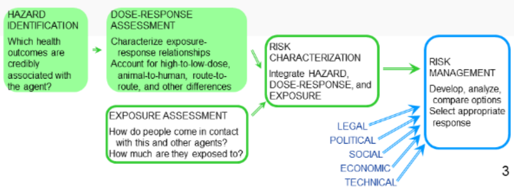
(general discussion)

2

About IRIS

IRIS assessments systematically and critically review the publicly-available peer-reviewed studies to

- Identify adverse health outcomes
- Characterize exposure-response relationships



3

IRIS Is Being Enhanced

To improve the fundamental science

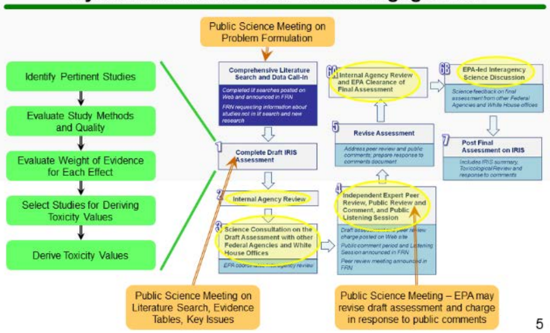
- by implementing principles of systematic review
- by strengthening peer review

To increase productivity to better meet stakeholder needs

To increase transparency so issues are identified and debated early

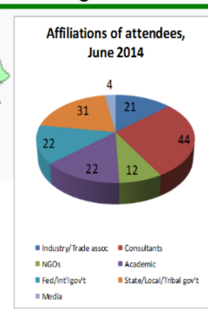
4

The Enhanced IRIS Means Systematic Review and Public Engagement



5

Many State-Agency Scientists Are Participating in These Public Science Meetings



Meetings occur every 2 months

We need your participation!

6

SESSION 4: RISK ASSESSMENT, EPIDEMIOLOGY, AND TOXICOLOGY
Status of IRIS Update for Organic and Inorganic Mercury – Vince Cogliano

One Enhancement is To Develop a Multi-Year Plan for Future Assessments

Steps

- Input from EPA's program and regional offices on highest-priority needs
- Review by senior EPA officials
- Release to the public this autumn

Mercury and methyl mercury are near the top

7

Preliminary Problem Formulation for Mercury (General Discussion)

Which agents should be evaluated?

- Methyl mercury?
- Organic mercury?
- Inorganic mercury?
- Total mercury?

Which exposure routes should be evaluated?

What key issues should be addressed?

There will be a public science meeting on mercury before the new assessment begins

8

Questions and Answers

Note: There were no questions because the moderator moved directly into the general Q&A session at the end of this panel.

General Question and Answer Session

Q. *Should we consider development of reference doses for mercury for different populations, such as adults, or for the fetus? (McCann)*

A. There was no response or comment, and the moderator moved along to the next question.

Q. *Is there a need to address fetal concentration, based on the ratio of cord blood to maternal blood concentration? There needs to be clarification when presenting information about mercury to avoid confusion from interchangeable use of total mercury and methylmercury. (Susan Buchanan)*

A. At the time of the existing reference dose, that need was not clear. Now we know that cord blood has 70% higher mercury concentration than maternal blood. This should be taken into account. (Stern).

Q. *We need to look at how mercury causes toxicity effects by analyzing selenium enzymes. We should look at the differences in mercury relative to the selenium status of subpopulations. We must understand selenium concentration to understand epidemiological studies about mercury. (Ralston)*

A. There was no response or comment, and the moderator moved along to the next question.

Q. *We need to develop reference doses for men and women for different weights. Not all adults weigh around 70 kilograms. We need to understand whether the linear relationship is accurate or not.(Burger)*

A. No single reference dose is practical or can capture a safe level for all parts of a population. The approach Glenn Rice used for dose-response is based on evaluation of risk for the dose. (Groth)

A. He is trying to do a new dose-response for arsenic and this approach may help for mercury. (Cogliano)

Q. *We need to weigh the benefits versus the risks. It may be better to use a net effects approach. If we do, then is a reference dose even necessary? (Lowery)*

A. There was no response or comment, and the moderator moved along to the next question.

Q. *He has seen that for lead, people are working off the blood level and not a point of departure. For mercury, you cannot easily define a point of departure similar to the situation with lead. For mercury, there may not be a threshold. Some form of dose-response algorithm could be derived and would be helpful. (Ginsberg)*

A. Everyone is exposed to methylmercury, but also gets health benefits from fish consumption. Also some fish species provide higher health benefits. We need to consider how we construct fish advisories to take this into account. (Stern)

Q. He has a question about the biomarker issue. Studies show inconsistent results. Is it the buildup of effects over time that allows a cardiac event to occur? What is the best biomarker? Sometimes it seems blood, sometimes toenail, and other times it seems hair is the best biomarker. (Gochfeld)

A. People develop cardiac problems over the long term. The best biomarkers may be toenails and hair. There is a proven association with high levels of mercury in hair and high lipid oxidization, and in one cohort it was associated with carotid artery problems. No association with blood pressure or inflammation has been found so far. When you look at long-term studies, if mercury exposure and cardiac problems are chronic, you have to assume fish consumption is constant. (Virtanen)

A. We have very challenging issues to work out. He believes in integrated assessment of risks, and that is the way things are now going. EPA and EPA's Integrated Risk Information System (IRIS) is the risk assessor for the government. Who is the benefits assessor in the government? He hopes that IRIS will take on benefits assessment, but do it separately and integrate it later. We need to look at subsets of the population for net negative effects. For some subsets of the population, fish consumption is low. For other subsets, such as Asians, there may be a greater proportion of them facing risks from higher fish consumption. We need much more data on the net effects of fish consumption. He also thinks current models are not adequate. (Groth)

Q. It will be helpful to look at the biochemical mechanism of mercury, especially the association with selenium enzymes. All fish that cause harm contain a lot of mercury relative to selenium. In Finland and New Zealand, there are selenium deficient populations so that may affect study results. In the Faroes, they are eating fish high in selenium. (Ralston)

A. There was no response or comment, and the moderator moved along to the next question.

Q. What does the data show about masking neurotoxicity? (Gray)

A. He is not sure there has been a definitive study. Neurotoxicity of methylmercury outside of fish consumption would make results difficult to interpret. There are a lot of other confounding factors besides mercury, and that makes it difficult to assess risks. A lot more work needs to be done. (Rice)

A. Some studies show confounding effects, but we need more data on them. These possible confounding effects have not been taken into account. (Groth)

SECTION II-F SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT

Introduction

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

Biosketch
Dr. Robert K. 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. in Biology from Heidelberg College, and his M.S. and Ph.D. in Biology from Bowling Green State University. Dr. Brodberg has worked as a risk assessor for the State of California since 1989. He has worked on human health assessments for pesticides, sediment quality objectives, and water quality issues. He is currently Chief of the Fish and Water Quality Evaluation Section, which is responsible for assessing the potential human health risks of eating chemically contaminated sport fish and seafood and issuing sport fish consumption advisories for California.

Presentations
Fatty Acid Content in Fish Species from the Great Lakes and Nearby Watersheds
Meghan Williams, Wisconsin Department of Natural Resources

Great Lakes Basin Fish Consumption, Vitamin D, Selenium, Fatty Acids, Contaminant Distributions and Associations in 154 Wisconsin Anglers
Henry Anderson, Wisconsin Department of Health Services

Mercury-Nutrient Signatures in Seafood and in Blood of Seafood Consumers
Roxanne Karimi, Stony Brook University

Mercury, Selenium, and Selenium:Mercury Ratios in Fish and Risk Management
Joanna Burger, Rutgers University, and Michael Gochfeld

Risks and Benefits of Fish Consumption for Cardiovascular Diseases
Dariush Mozaffarian, Harvard Medical School, Tufts University

Maternal Fish Intake during Pregnancy and Child Cognition
Emily Oken, Harvard Medical School

FDA Assessment of Net Effects on Neurodevelopment from Eating Commercial Fish during Pregnancy
Phil Spiller, U.S. Food and Drug Administration

Risk-Benefit of Consuming Lake Erie Fish
Satyendra Bhavsar, Ontario Ministry of the Environment and Climate Change

Updated Approach for Balancing the Risks and Benefits of Fish Consumption on Neurodevelopmental Endpoints

Gary Ginsberg, Connecticut Department of Public Health

Fatty Acid Content in Fish Species from the Great Lakes and Nearby Watersheds

Meghan Williams, Wisconsin Department of Natural Resources

Biosketch

Meghan Williams is an environmental toxicologist with the Wisconsin Department of Natural Resources (DNR), Bureau of Fisheries Management. She holds a B.A. in Zoology and English from Ohio Wesleyan University and a Master's degree in Aquatic Ecology from Bowling Green State University, where she studied the effects of the algicide copper sulfate on zooplankton and macroinvertebrates in drinking water reservoirs. Previously, she worked as an entomologist at the Stroud Water Research Center and as a chemist in the Environmental Toxicology Department at the Wisconsin State Laboratory of Hygiene. At the Wisconsin DNR, Meghan is responsible for fish consumption advisory outreach and analysis of data on fatty acids and legacy and emerging fish contaminants.

Abstract

Fish are often recommended as an easy way to incorporate lean protein and beneficial Omega 3 fatty acids into the diet. However, most research investigating fish fatty acid content is focused on marine or farmed freshwater species, with few studies investigating fatty acid content in sport fish consumed by recreational anglers and their families. Recognizing the need to quantify the benefits of consumption of wild freshwater fish, partners from the U.S. Environmental Protection Agency and the Great Lakes Consortium for Fish Consumption Advisories undertook a large-scale, multi-state effort to quantify fatty acid content in freshwater sport-caught fish. Nearly 900 samples from the Great Lakes and nearby waters were collected between 2010 and 2013 and analyzed for 37 fatty acid types, including five Omega 3 fatty acids. Mean concentrations of Omega 3 fatty acids varied from 1.73 to 22.0 mg/g in Great Lakes sport fish and from 1.01 to 10.6 mg/g in fish from inland waters. This talk will present Omega 3 fatty acid content in detail for 24 fish species, and will further examine physical and biological factors (i.e., size, trophic position, water body characteristics, season) that may contribute to variation in species' fatty acid content. Advantages and limitations to incorporating this information into fish consumption advisories will also be discussed.

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Fatty Acid Content in Fish Species from the Great Lakes and Nearby Watersheds – Meghan Williams

Wisconsin Department of Natural Resources

Fatty Acid Content in Fish Species from the Great Lakes and Nearby Watersheds

Meghan Williams

WI DNR & the Great Lakes Consortium for Fish Consumption Advisories

23 September 2014

This Study

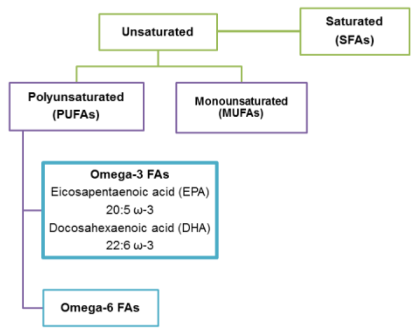
- Funding:
  - EPA GLRI Grants to Great Lakes Consortium for Fish Consumption Advisories & WI DHS
  - EPA National Coastal Condition Assessment Great Lakes Human Health Fish Tissue Study
- Goals:
  - Widespread survey of nutrients in freshwater fish
  - Enhanced fish consumption advisories and angler outreach
  - Quantitative risk-benefit analysis (Ginsberg)

Today's Presentation

- Background
  - Fatty acids
  - Current research
- Dataset information
  - Sampling locations
  - Data analysis

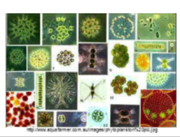
- Results
  - Great Lakes samples
  - Inland samples
- Incorporating results into fish consumption advisories
- Conclusions and future research

Types of fatty acids



Origins of fatty acids in freshwater ecosystems

- SFAs and MUFAs: synthesized *de novo* by all organisms
- Omega-6 and omega-3 fatty acids
  - Synthesized by chlorophyll-producing organisms only (algae, plants)
  - Vertebrates lack Δ12 and Δ15 desaturase enzymes needed to form PUFAs



Omega-3 fatty acid functions

- Fish
  - Stored energy
    - Growth
    - Periods of starvation (i.e. migration)
    - Production of gametes, especially eggs
  - Maintain structure and function of cellular membranes (neural tissues)
- Humans
  - Cardiovascular health: ω-3 eicosanoid compounds reduce inflammatory eicosanoids from ω-6 pathway
  - Neural and ocular tissue support

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Fatty Acid Content in Fish Species from the Great Lakes and Nearby Watersheds
– Meghan Williams

Current data and research

- FDA and USDA
  - Marine fish & shellfish
  - Advice focused on women/mothers
  - National nutrient database: generalized freshwater fish categories
- Farmed freshwater fish
  - Important research on fish nutritional requirements
  - Biosynthesis, transport, transformation of FAs

Current data and research

- North American wild freshwater fish
  - Great Lakes:

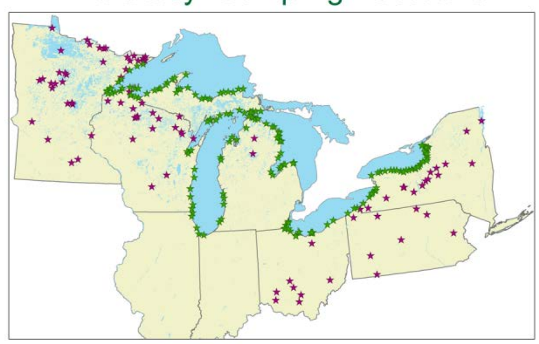
Author(s)	Year	Lake(s)	# of Species
Honeyfield et al.	2008 2012	Michigan Ontario	1 5
Czesny et al.	2011	Michigan	10
Moths et al.	2013	Superior	1
Pantazopoulos et al.	2013	All	2
Neff et al.	2014	Erie	15

North American wild freshwater fish

- Inland waters:

Author(s)	Year	Location(s)	# of Species
Glémet et al.	1997	NW Territories	1
Chan et al.	1999	St. Lawrence River (Montreal)	8
Grün et al.	1999	MO & MS Rivers	2
Dayhuff & Wells	2005	Ohio River	3
Blanchet et al.	2005	Quebec	1
Honeyfield et al.	2007	NC reservoirs	1
Wong	2008	Canadian lakes	1
Volk & Kiffney	2012	Washington streams	1
Williams et al.	2014	Wisconsin	13

This Study: Sampling Locations



Dataset information

- >900 fish tissue samples
- Great Lakes
  - Consortium states' samples
    - N = 153
    - Huron, Michigan, Superior
  - GLHHFTS samples
    - N = 157 composites (423 fish)
    - All Great Lakes
- Inland waters
  - 6 states
  - 92 waters
  - 607 samples

Parameters measured: Consortium States' samples

- Date/season: samples collected 2010 to 2013
- 37 fatty acid types
  - 16 saturated
  - 9 monounsaturated
  - 7 omega-6
  - 5 omega-3 (ETE, DPA, DHA, EPA, ALA)
- % lipid, length, weight
- Sampling site characteristics

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT

Fatty Acid Content in Fish Species from the Great Lakes and Nearby Watersheds – Meghan Williams

Parameters measured: GLHHFTS samples

- Date/season: samples collected 2010 to 2013
- 5 fatty acid types
  - 16 saturated
  - 9 monounsaturated
  - 7 omega-6
  - 5 omega-3 (ETE, DPA, DHA, EPA, ALA)
- % lipid, length, weight
- Sampling site characteristics

Data analysis: all samples

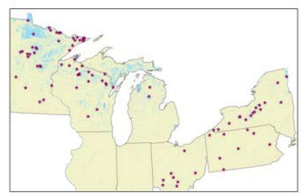
- Where necessary, transformed to approximate normality
- All variables standardized to remove effects of measurement scale
- Parameter selection: stepwise regression
  - Analysis of covariance or ANOVA

Data analysis: Great Lake samples

- Species sampled from one Great Lake:
  - Length
  - Season collected (6/9 species)
  - Length*season
- Species sampled from 2+ Great Lakes:
  - Lake
  - Length
  - Season collected (7/10 species)
  - Lake*length
  - Lake*season
  - Length*season

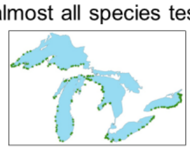
Data Analysis: Inland samples

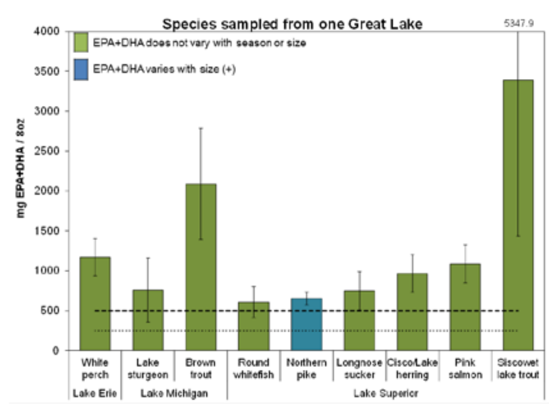
- Species sampled from more than one location:
  - Length
  - Latitude
  - Longitude
  - Length*location
  - ~~Season~~



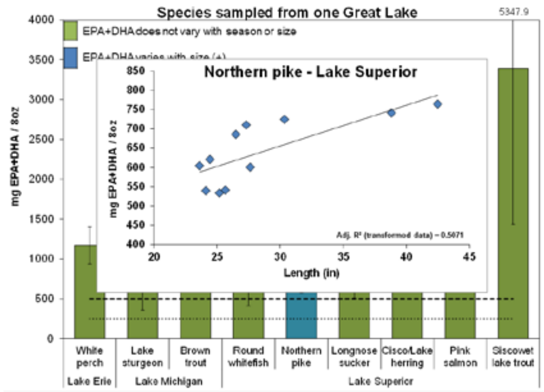
Results: Great Lakes samples

- An 8oz serving of most species from most locations provides ≥ 250 mg of EPA+DHA
- Species sampled from 1 Great Lake
  - EPA+DHA does not vary with size or sampling season for almost all species tested (P > 0.05)



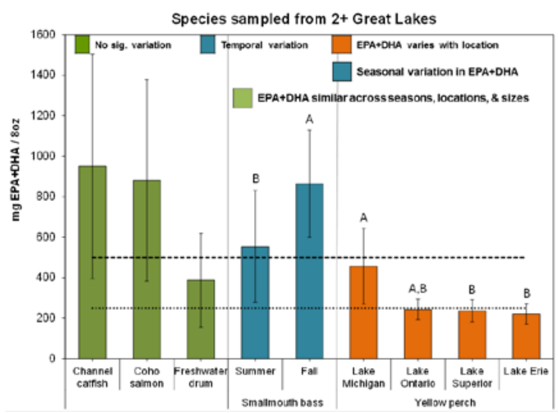


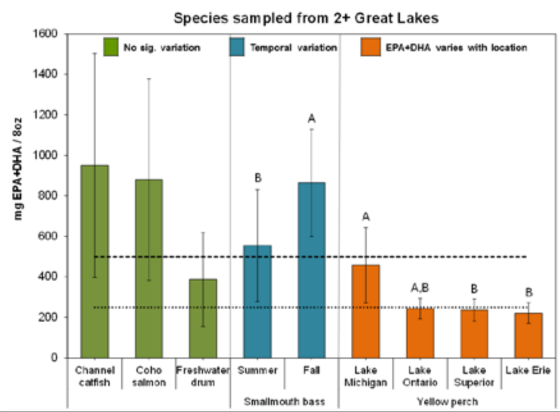
SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Fatty Acid Content in Fish Species from the Great Lakes and Nearby Watersheds – Meghan Williams

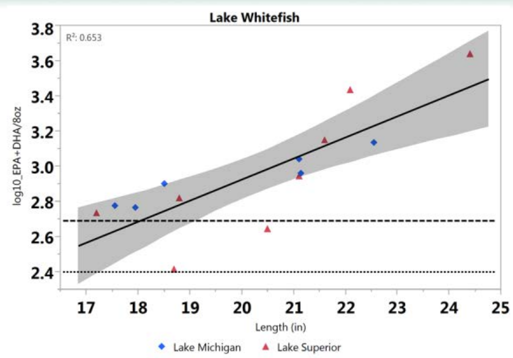


Results: Great Lakes samples

- Species sampled from 2+ Great Lakes
  - EPA+DHA content does not vary between lakes for majority of species ($P > 0.05$)
    - High variability
  - Size, season affect EPA+DHA content







Results: Great Lakes samples

- Great Lake species whose EPA+DHA content varied with multiple factors
  - Independent factors:
    - Chinook salmon: season and length (-)
    - Lean lake trout: season and length (+)
    - Rainbow trout: season and lake
  - Interactions between factors:
    - Walleye: lake*length
      - FA differences between lakes
      - Different sizes collected from different lakes

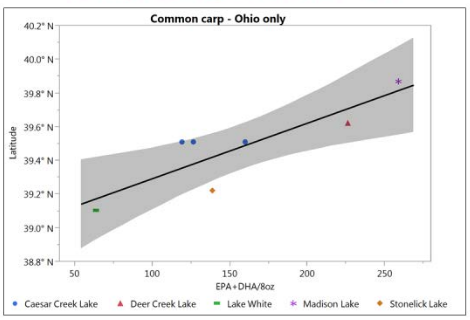
Results: Inland samples

- An 8oz serving of almost all species tested will provide ≥250 mg EPA+DHA
- Species whose FA content did not vary with sizes or between sampling locations:
  - Bluegill
  - Cisco
  - Lake whitefish
  - Rainbow trout
  - White crappie
  - Yellow perch

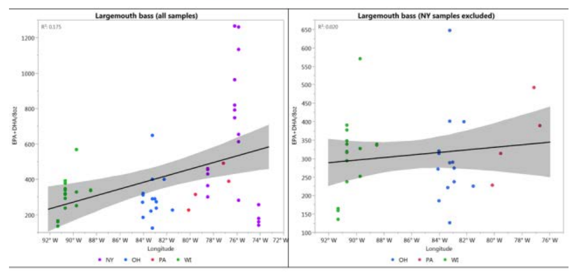
Results: Inland samples

- Species whose FA content varied with location or size:
  - Splake: size (+)
  - Channel catfish: latitude (N > S)
  - Common carp: latitude (N > S)*
  - Black crappie: longitude (E > W)
  - Largemouth bass: longitude (E > W)*

Carp: sampled from OH



Largemouth bass



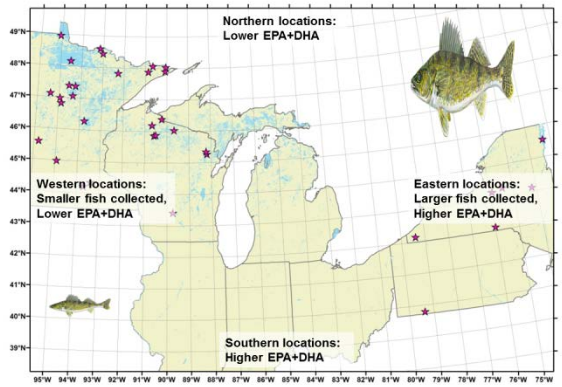
Results: Inland samples

- Species whose FA content varied with size and location:
  - Northern pike: length (+), varies with longitude
  - Smallmouth bass: length (-), latitude (S > N)

Results: Inland samples

- Species whose FA content varied with size and location:
  - Northern pike: length (+), varies with longitude
  - Smallmouth bass: length (-), latitude (S > N)
  - Walleye and lean lake trout
    - Interaction between length and sampling location
    - EPA+DHA increases with size
    - Different sizes collected at different locations

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Fatty Acid Content in Fish Species from the Great Lakes and Nearby Watersheds
– Meghan Williams



Incorporating fatty acid data into fish consumption advisories

- Species whose EPA+DHA content is not affected by size and/or season and/or location
  - Use average fatty acid value for all sites sampled

- Bluegill (inland)
- Brown trout (Lake Michigan)
- Channel catfish (Great Lakes)
- Cisco (Lake Superior & inland)
- Coho salmon (Great Lakes)
- Freshwater drum (Great Lakes)
- Lake sturgeon (Lake Michigan)
- Lake whitefish (inland)
- Longnose sucker (Lake Superior)
- Pink salmon (Lake Superior)
- Rainbow trout (inland)
- Round whitefish (Lake Superior)
- Siscowet lake trout (Lake Superior)
- Yellow perch (inland)
- White perch (Lake Erie)

Incorporating fatty acid data into fish consumption advisories

- Species whose EPA+DHA content is influenced by size or season or location
  - Incorporate qualifiers into consumption advice

- Black crappie (inland)
- Channel catfish (inland)
- Common carp (OH waters)
- Largemouth bass (inland)
- Lake whitefish (Great Lakes)
- Smallmouth bass (Great Lakes)
- Splake (inland)
- Yellow perch (Great Lakes)

Incorporating fatty acid data into fish consumption advisories

- Species whose EPA+DHA content is influenced by multiple factors and/or interactions exist between factors
  - Use fatty acid value on a site-by-site or size-by-size basis (similar to contaminant-based advisories)

- Chinook salmon (Great Lakes)
- Lean lake trout (Great Lakes & inland)
- Northern pike (inland)
- Rainbow trout (Great Lakes)
- Smallmouth bass (inland)
- Walleye (Great Lakes & inland)

Other considerations and future work

- Potential influencing factors
  - Gender differences
  - Diet/trophic position
    - Climate change and/or invasive species?
    - Previous findings: piscivorous species may contain highest EPA+DHA
      - Is "avoid predator species" still true?
      - Risk-benefit
  - Investigate the proportions and ratios of fatty acid **types** within/between species and trophic positions

Acknowledgements

- Candy Schrank
- Dr. Henry Anderson
- Pat McCann
- Consortium members
- USEPA
  - GL-00E00452-1
  - GL-00E00445-3
  - GLHHFTS

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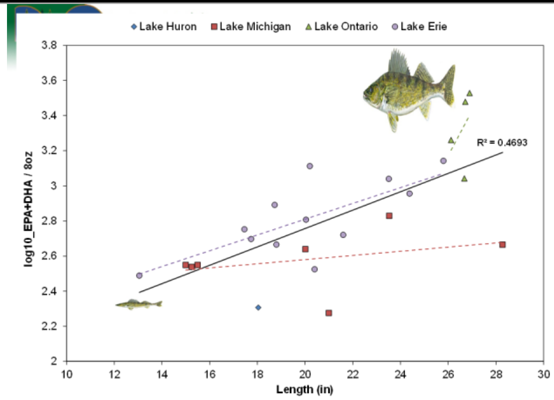
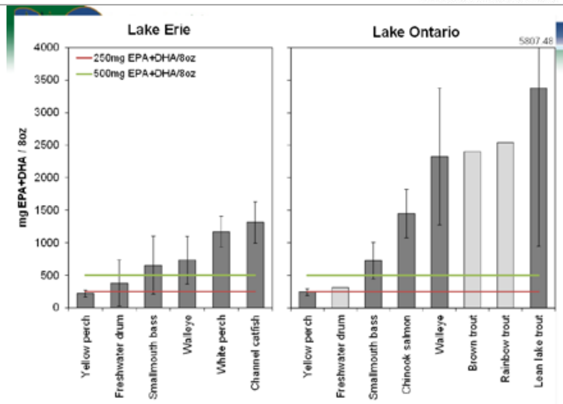
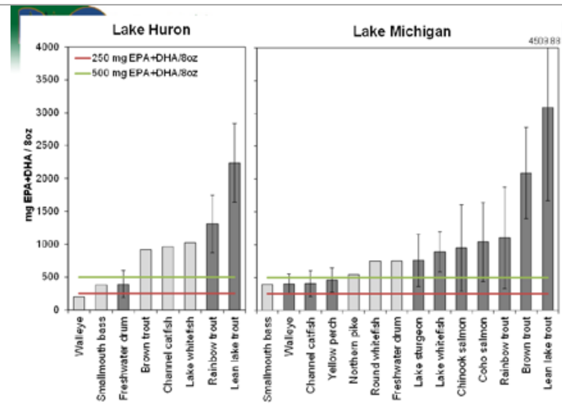
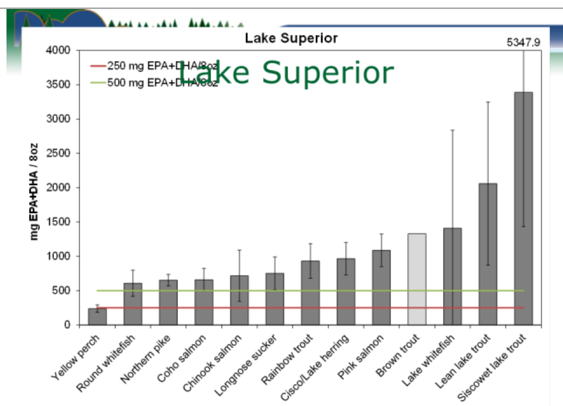
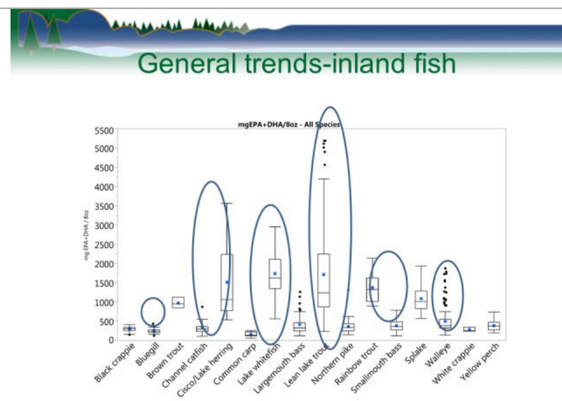






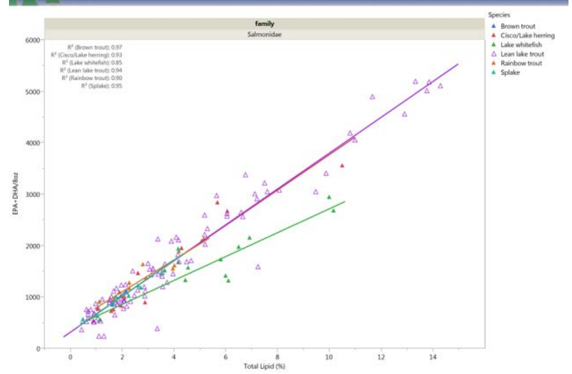


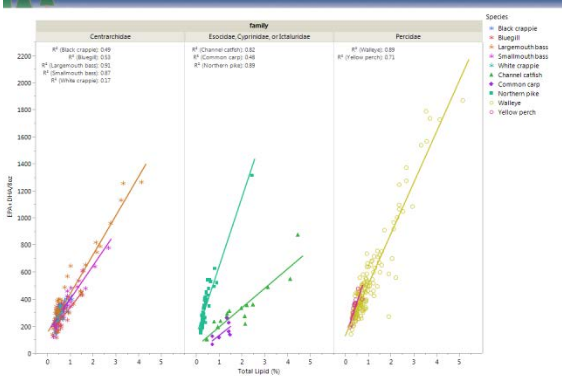


SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Fatty Acid Content in Fish Species from the Great Lakes and Nearby Watersheds – Meghan Williams

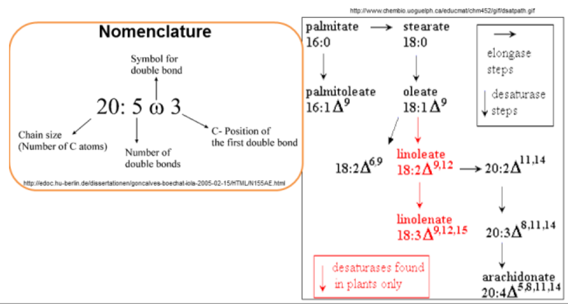
Results: Inland samples

- Inland samples: between-species comparisons
  - EPA+DHA content related to % lipid
    - Overall $R^2 = 0.922$
    - Salmonids: Higher % lipids, $R^2 > 0.85$
    - Centrarchids: less consistent $R^2 = 0.17\text{-}0.91$





Fatty Acids



- Variability in EPA+DHA can be explained by a single factor

Species	Sample Size	# of Waters	States
Black crappie	50	16	MN, WI
Channel catfish	15	6	OH, WI
Common carp*	7	5	OH
Largemouth bass*	54	22	NY, OH, PA, WI
Splake	10	2	MN

Species	Sample Size	# of Waters	States
Bluegill	29	12	MN, OH, WI
Cisco	14	9	MN, WI
Lake whitefish	12	3	MN, WI
Rainbow trout	12	3	MN
White crappie	5	5	OH
Yellow perch	23	12	MN, WI

Untitled

- Species whose variability in EPA+DHA is affected by multiple factors and interactions between factors

Species	Sample Size	# of Waters	States
Lean lake trout	94	16	MI, MN, NY, WI
Northern pike	48	13	MN, NY, WI
Smallmouth bass	25	5	MI, NY, PA
Walleye	179	35	MN, NY, PA, WI

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
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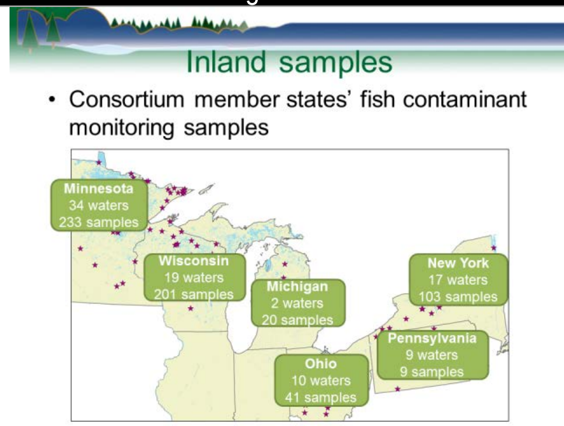

Questions and Answers

Q. What does it cost to start analyzing for Omega 3 fatty acids? (Murphy)

A. Developing lab capacity is expensive. (Williams and Henry Anderson)

A. We had to come up with a method to coordinate for standardization among labs. (Williams)

Q. How much fish tissue do you need? Do you need a muscle plug or a fillet sample to do the analysis? (Murphy)

A. Generally 2 mg is enough. (Henry Anderson)

Great Lakes Basin Fish Consumption, Vitamin D, Selenium, Fatty Acids, Contaminant Distributions and Associations in 154 Wisconsin Anglers

Henry Anderson, Wisconsin Department of Health Services

Biosketch

Dr. Henry Anderson has been Chief Medical Officer and State Environmental and Occupational Disease Epidemiologist for the Wisconsin Department of Health Services, Division of Public Health. He holds adjunct professorships at the University of Wisconsin-Madison, Department of Population Health Sciences, and the University of Wisconsin Institute for Environmental Studies, Center for Human Studies. He received his M.D. degree in 1972 from the University of Wisconsin-Madison; was certified in 1977 by the American Board of Preventive Medicine with a sub-specialty in occupational and environmental medicine and in 1983 became a fellow of the American College of Epidemiology. He has authored over 250 scientific papers. Over the past 30 years, he has lead Wisconsin's Public Health activities concerning fish consumption advisories and lead multiple research projects documenting the human health hazards of consumption of Great Lakes and other sport fish. Based upon the research, he helped develop and then evaluate the effectiveness of public health advisories. He is currently the Principal Investigator on two U.S. Environmental Protection Agency, Great Lakes Restoration Initiative grants enhancing Wisconsin's fish monitoring, human biomonitoring, and advisory activities.

Abstract

Essential nutrients such as Vitamin D, selenium, and Omega 3 fatty acids are keys to maintaining good health. Fish is an important potential source of these nutrients; however, fish, especially freshwater fish from the Great Lakes Basin, can also be a source of persistent pollutants such as methylmercury, polychlorinated biphenyls (PCBs), brominated ethers, and other contaminants all with the potential to cause adverse health outcomes. Fish consumption advisories focus on how to minimize risks while maximizing benefits. There is a paucity of nutrient information for Great Lakes Basin fish and there is even less information regarding the nutrient status of Wisconsin residents. Such information is needed to assess whether freshwater fish consumption is an important contributor to achieving optimal nutrient levels. Dietary and health questionnaires, and serum and urine samples were collected from 154 older adult men and tested for vitamin D, selenium, a suite of fatty acids, blood mercury, urine mercury, PCBs, polybrominated diphenyl ethers (PBDEs), perfluorooctane sulfonate (PFOS), and perfluorooctanoic acid (PFOA). Correlations between sport and commercial fish consumption, nutrients and contaminants will be described to explore the risks and benefits associated with consumption of fish from the Great Lakes basin. The nutrient distributions found are compared to a random sample of 50 individuals from the Wisconsin general population as well as the National Health and Nutrition Examination Survey (NHANES).

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT

Great Lakes Basin Fish Consumption, Vitamin D, Selenium, Fatty Acids, Contaminant Distributions and Associations in 154 Wisconsin Anglers – Henry Anderson

Great Lakes Basin Fish Consumption, Vitamin D, Selenium, Fatty Acids, Contaminant Distributions and Associations in 154 Wisconsin Anglers

Henry A. Anderson, MD
National Forum on Contaminants in Fish
September 23, 2014

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Introduction

- Study Purpose
  - To assess the risks and benefits associated with long-term fish consumption
  - To assess intake of omega-3 fatty acids, vitamin D and selenium among Wisconsin residents
  - Strengthen scientific basis of Wisconsin fish consumption guidelines
  - Recruited participants from those who previously participated in an online survey and indicated they would be interested in future studies
  - Study reviewed by the University of Wisconsin Human Subjects Review Board and determined to be exempt

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Introduction

Study Methods

- Target population: men age 50 and older who fish Wisconsin waters and live in the state of Wisconsin
- Hair and blood sample collection analyzed for:
  - Contaminants: polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), mercury, perfluorinated compounds (PFCs)
  - Nutrients: Fatty acids, Vitamin D, Selenium
  - Lipids: cholesterol, triglycerides
- Completion of detailed questionnaire, including:
  - Location of catch and species of fish caught and eaten
  - Awareness and source of information for local and statewide consumption guidelines
  - Consumption of locally caught and commercially purchased fish
  - Health status and demographics

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Demographic Characteristics

Table 1. Demographic characteristics of study participants (N=154)

Age[a] - Median (25th, 75th percentiles)	60.5 (56, 67)
Years living in Wisconsin - Median (25th, 75th percentiles)	58 (50, 64)
	% (n)*
Race/Ethnicity	
Identification as Hispanic/Latino,	0.7 (1)
Identification as White (alone or in combination)	98.7 (152)
Educational Attainment	
High school or less	31.2 (39)
Some college or two-year degree	14.4 (18)
College degree (four-year) or more	54.4 (68)
Employment Status	
Working (full or part-time, or self-employed)	50.0 (77)
Retired	46.1 (71)
Other	3.9 (6)

*For percentages, calculations exclude missing values
[a]One individual did not provide date of birth; this was set to the median value in the study population

- Respondents were largely non-Hispanic white men in their 60's
- Nearly full life residence in the state of Wisconsin
- Most had at least some college education
- About half were working, and half retired

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Fish and Shellfish Consumption

Table 2a. Fish and shellfish consumption levels for study participants, meals per year (N=154)

	Median (25th, 75th percentiles)
Total fish and shellfish	66.5 (47, 114)
Total fish	54.5 (36, 93)
Fish from Great Lakes	7 (2, 24)
Fish from areas of concern[a]	0 (0, 3)
Other locally caught fish	12 (6, 36)
Fish from restaurant	10 (4, 20)
Fish from store	4.5 (0, 12)
Total shellfish	9 (4, 18)
Shellfish from restaurant	4 (1, 6)
Shellfish from store	4 (1, 10)

[a]Areas of concern include: Menominee River, Fox River/Lower Green Bay, St. Louis River and Bay, Sheboygan River, Milwaukee Estuary (including the lower Milwaukee River and inner harbor, Kinnickinnic River, and Menomonee Rivers and harbor)

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Fish and Shellfish Consumption

Table 2b Fish and shellfish consumption (meals per year) – Distribution by type of fish or shellfish stratified by level of overall fish and shellfish consumption

	25th percentile	50th percentile	75th percentile
	Fish meals / Shellfish meals		
	12 / 2	33.5 / 8	95 / 16
Percentage (%) of Total Fish meals			
Fish, Great Lakes	16.7	20.9	25.3
Fish, Areas of concern	0	0	3.2
Fish, other locally caught fish	50.0	35.8	37.9
Fish, restaurant	33.3	29.9	21.1
Fish, store	0	13.4	12.6
Percentage (%) of Total Shellfish meals			
Shellfish, restaurant	50	50	37.5
Shellfish, store	50	50	62.5

- Across all consumption groups:
  - Highest proportion of fish meals from 'other locally caught fish,' followed by fish from a restaurant and Great Lakes fish
  - Shellfish meals relatively evenly distributed between those from restaurants versus stores
- Great Lakes fish contributed the highest proportion to total fish meals for those in the highest consumption group

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Great Lakes Basin Fish Consumption, Vitamin D, Selenium, Fatty Acids, Contaminant Distributions and Associations in 154 Wisconsin Anglers – Henry Anderson

Nutrient Levels

Table 3. Nutrient levels among study participants, compared with the US general population of non-Hispanic white men aged 50 years and older

	Median (25th, 75th percentiles)	
	Wisconsin Anglers (this study)	US general population (NHANES)*
DHA, mg/L	57 (44, 74)	121.59 (93.93, 171.57)
DPA-3, mg/L	19 (15, 25)	42.99 (35.57, 55.00)
EPA, mg/L	22 (13, 32)	46.97 (32.70, 67.36)
Selenium, mg/L	141.4 (132.8, 153.2)	199.92 (179.57, 218.78)
Vitamin D, ng/mL	28.3 (23.1, 36.4)	23.96 (18.24, 29.16)

*Values are taken from 2003-2004 (fatty acids), 2005-2006 (vitamin D) and 2011-2012 (selenium) cycles of the National Health and Nutrition Examination Survey (NHANES). Sample size varies by year; values are weighted for survey sampling methodology.

- Compared to the nation as a whole Wisconsin anglers have lower levels of selenium, DHA and EPA fatty acids
- Wisconsin anglers have higher levels of vitamin D

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Supplement Usage

Table 4. Supplement usage and consumption of certain foods by study participants

	Percent (n)				
How often do you take, eat or drink the following items?	Daily	2-6 times per week	Once per week	1-3 times per month	Rarely or never
Fish oil	27.9 (43)	5.8 (9)	3.3 (5)	3.3 (5)	59.7 (92)
Flaxseed oil	3.9 (6)	1.3 (2)	1.3 (2)	1.3 (2)	92.2 (142)
Cod liver oil	1.3 (2)	0 (0)	0.7 (1)	0.7 (1)	97.4 (149)
Any supplement that includes omega-3 fatty acids	17.5 (27)	3.3 (5)	2.6 (4)	3.3 (5)	73.4 (113)
Selenium supplement or multi-vitamin with Selenium added	20.8 (32)	2.0 (3)	0.7 (1)	0.7 (1)	76.0 (117)
Vitamin D supplement or multi-vitamin with Vitamin D included	44.8 (69)	6.5 (10)	4.6 (7)	5.8 (9)	38.3 (59)

- The most commonly reported supplements were vitamin D or a multivitamin with vitamin D (61.7%), and fish oil (40.3%)
- About one quarter of respondents reported taking supplements including selenium and/or omega-3 fatty acids
- Very few respondents (under 10%) reported taking flaxseed oil, cod liver oil

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Contaminant Levels

Table 5a. Contaminant levels among study participants, compared with the US general population of non-Hispanic white men aged 50 years and older

	US general population (NHANES)*	All participants (n=154)	0 to 51 fish meals per year (n=68)	52 to 103 fish meals per year (n=53)	104 or more fish meals per year (n=33)
	Median (25th, 75th percentiles)				
PFOA, ng/mL (n=150)	3.8 (2.6, 5.3)	2.5 (1.8, 3.3)	2.1 (1.7, 2.9)	2.6 (1.9, 3.3)	2.9 (2.1, 3.6)
PFOS, ng/mL (n=150)	13.7 (9.8, 19.8)	19 (9.8, 28.0)	12.0 (8.6, 23.0)	24.0 (19.0, 36.0)	19.0 (10.0, 33.0)
Hair mercury, mg/g (n=146)	(Not measured)	0.5 (0.3, 1.0)	0.4 (0.2, 0.8)	0.5 (0.3, 1.2)	0.9 (0.7, 1.3)
Blood mercury, µg/L (n=150)	1.0 (0.5, 2.2)	2.5 (1.3, 4.0)	1.7 (0.9, 3.1)	2.3 (1.2, 5.6)	3.2 (2.7, 5.6)
ΣPBDEs, ng/mL (n=150)	0.2 (0.1, 0.5)	0.2 (0.1, 0.4)	0.2 (0.1, 0.3)	0.2 (0.1, 0.4)	0.3 (0.1, 0.4)
ΣPCBs, ng/mL (n=150)	1.6 (1.3, 2.4)	1.3 (0.6, 2.5)	1.1 (0.6, 1.8)	1.9 (0.7, 3.3)	1.8 (0.8, 3.6)

*Values are taken from 2011-2012 (blood mercury and PFOA) and 2003-2004 (PBDEs and PCBs) cycles of the NHANES. Total PBDEs, and total PCBs, were calculated using different congeners for the Wisconsin anglers compared with the NHANES.

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Temporal Trends: PCB levels are declining over time

Table 5b. Median ΣPCBs (ng/mL) among male participants in three different studies

Study Group	1994-1995	2001-2005	2003-2004	2014
Referents (Low consumers, n=26)	1.4	0.9		
Charter Boat Captains (n=105)	5.0	3.0		
This study: Wisconsin Anglers (n=154)				1.3
NHANES: US General Population, non-Hispanic white males aged ≥50			1.6	

*Values are taken from 2003-2004 (PCBs) cycles of the NHANES. Total PCBs were calculated using different congeners for the three study populations.

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Preliminary Modeling - Univariate

- *Goal*: Identify possible associations between fish/shellfish consumption, and levels of contaminants and nutrients
- *Method*: Regression modeling using categories (e.g., quartile) of consumption as the predictor, and Box-Cox transformed biomarker level as the outcome

Table 6. Associations between fish/shellfish consumption and levels of contaminants and nutrients identified in preliminary modeling

	All commercial	Other locally caught	Great Lakes	Restaurant shellfish	Store-bought shellfish
ΣPBDE			X		
ΣPCB	X (negative)	X	X		
Blood Hg		X	X		
Hair HG		X	X		X
PFOA		X			
DHA	X				
DPA					
EPA	X				X
Selenium					
Vitamin D		X	X		

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Targeted Modeling - Univariate

- *Goal*: Further explore associations identified in preliminary modeling
- *Method*: Quantile regression modeling using consumption (continuous) as the predictor, fitting the 10th, 50th, and 90th percentiles of each biomarker
- Findings (Univariate):

Table 7. Associations between fish/shellfish consumption and levels of contaminants and nutrients, modeled using quantile regression (10th, 50th, 90th percentiles).

	All commercial	All locally caught	Great Lakes	Restaurant shellfish	Store-bought shellfish
ΣPBDE			X		
ΣPCB		X	X		
Blood Hg		X	X	X	
Hair HG	X	X	X	X	
PFOA		X			
DHA					
DPA					
EPA					
Selenium			X		
Vitamin D			X		

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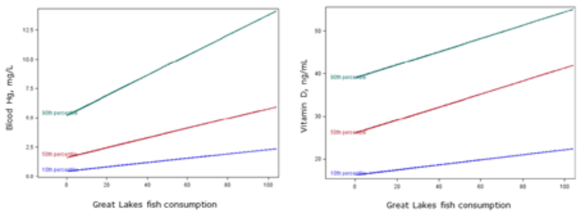
Targeted Modeling - Univariate

Quantile regression plots - association between Great Lakes fish consumption and biomarkers (blood Hg and vitamin D)



- GL fish consumption associated with blood Hg levels and vitamin D levels
- The effect of increasing GL fish consumption was stronger for the higher percentiles of blood Hg and vitamin D (see steeper slope of the lines at 90th percentiles)

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Targeted Modeling – Multivariate, Contaminants

- Multivariate models including as predictors (1) all commercial fish, (2) Great Lakes fish, and (3) other locally caught fish
- In general, even for non-significant associations, the effect of fish consumption increased with increasing quantile
  - Example: The adjusted beta (95 percent confidence interval [CI]) for the effect of Great Lakes fish consumption on hair mercury was
    - 0.004 (0.0000, 0.009) at the 10th percentile of hair mercury
    - 0.011 (0.007, 0.018) at the 50th percentile of hair mercury
    - 0.022 (0.005, 0.045) at the 90th percentile of hair mercury
- Significant associations:
  - Great Lakes fish associated with
    - Higher blood mercury, PBDEs, PCBs, and PFOS at the 50th and 90th percentiles
    - Higher PFOA at the 50th percentile
    - Higher hair mercury at the 10th, 50th and 90th percentiles
  - All commercial fish associated with higher blood mercury at the 90th percentile
  - Other locally caught fish associated with
    - Higher blood mercury at the 50th and 90th percentiles
    - Higher hair mercury, PFOS and PFOA at the 50th percentile

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Targeted Modeling – Multivariate, Nutrients

- Multivariate models including as predictors (1) all commercial fish, (2) Great Lakes fish, (3) other locally caught fish, and (4) supplement usage
- In general, effects still increased with increasing quantile. However, the effect of supplement usage was much greater compared to fish consumption
  - Example: The adjusted beta (95 percent CI) for the effect on selenium at the 90th percentile was
    - Great Lakes fish consumption: 0.125 (0.005, 0.504)
    - Selenium supplement usage: 10.677 (7.049, 35.762)
- Significant associations:
  - Great Lakes fish associated with
    - Higher selenium at the 90th percentile
    - Higher vitamin D at the 50th and 90th percentiles
  - All commercial fish associated with higher DHA at the 90th percentile
  - Supplement usage (rarely/never vs. greater frequency)
    - Fish oil, cod liver oil, flaxseed oil, or other supplement including omega 3 fatty acids → higher DHA (10th and 90th percentiles), DPA (50th and 90th percentiles) and EPA (10th, 50th, and 90th percentiles)
    - Selenium → higher selenium at the 90th percentile
    - Vitamin D → higher vitamin D at the 10th and 50th percentiles

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Take-home points

- Higher locally caught fish consumption is associated with elevated levels of certain contaminants (PCBs, PBDEs, PFOA, mercury)
- Great Lakes fish consumption is also associated with higher levels of vitamin D and selenium, even after controlling for other types of fish and supplement usage

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Next Steps

- Extend analyses to control for more/different predictors
- Explore associations with blood lipids (cholesterol, triglycerides)
- Explore how best to
  - Define contribution of different fish types to each nutrient and contaminant finding/level
  - Control for level/frequency of supplement usage

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- The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH or the EPA

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Questions and Answers

Note: There were no questions because the moderator asked that any questions be held until the general Q&A session at the end of this panel.

Mercury-Nutrient Signatures in Seafood and in Blood of Seafood Consumers

Roxanne Karimi, Stony Brook University

Biosketch

Dr. Roxanne Karimi is a research scientist in the School of Marine and Atmospheric Sciences at Stony Brook University. Dr. Karimi obtained a B.A. from the University of Pennsylvania and a Ph.D. in Biology from Dartmouth College. Dr. Karimi has a broad background in aquatic ecology and environmental health research. Dr. Karimi's research focuses on: 1) the influence of ecological factors on nutrient and contaminant patterns in fish and other aquatic organisms and 2) human exposure and risk-benefits from aquatic nutrients and contaminants from fish consumption. Dr. Karimi's research has helped to identify eco-physiological factors that drive the cycling and bioaccumulation of essential nutrients and metal contaminants, such as mercury and selenium. One major focus of this work has examined how growth dilution reduces concentrations of metals in aquatic organisms. Another focus is collaborating with epidemiologists on human exposure to fish contaminants and concomitant effects on autoimmunity and other health responses. In collaboration with the Environmental Defense Fund, Dr. Karimi developed the Seafood Mercury Database, a rich data source on global mercury concentrations in commercial seafood items, which provides information to numerous organizations in the United States that develop seafood consumption advice.

Abstract

Dietary recommendations for seafood are confusing due to the desire to balance both benefits from nutrients and risks from contaminants. The overall health value of different fish and shellfish items depends on concentrations of multiple nutrients (e.g., selenium (Se), Omega 3 fatty acids) and contaminants (e.g., mercury (Hg)). However, few studies have examined the connections between human exposure to multiple nutrients and contaminants and the consumption of specific types of seafood. Our goals were to compare: 1) Hg, Se, and Omega 3 fatty acid concentrations (Hg–nutrient signatures) among common fish and shellfish items and 2) Hg–nutrient signatures in the blood of avid seafood consumers, based on seafood consumption habits. We compiled nutrient and Hg concentration data for common fish and shellfish items from the literature. We also measured blood concentrations of Hg and seafood nutrients collected from adult, avid seafood consumers on Long Island, New York. Canonical discriminant analyses revealed distinct Hg–nutrient signatures among seafood items, and these signatures were reflected in the blood of consumers based on different consumption habits. For example, consumers with a salmon-dominated seafood diet had a relatively high percentage of Omega 3 fatty acids in blood, and consumers who tend to eat top predator seafood have higher Hg, but similar blood nutrient concentrations compared to consumers who tend to eat low trophic level seafood. These results provide direct evidence of links between the ecological characteristics of the type of seafood consumed and Hg–nutrient exposure. This approach helps assess the overall human health value of specific seafood types, leads to specific diet recommendations, and can be used to characterize risk:benefit status among seafood consumers.

Mercury-nutrient signatures in seafood and in blood of seafood consumers

Roxanne Karimi
Stony Brook University

Challenge: Health value of seafood items is complex

- Primary source of
  - **nutrients**: protein, omega-3 FAs, selenium (Se), etc.
  - **contaminants**: Mercury (Hg), PCBs, others that biomagnify
- Overall risk-benefits depend on exposure to nutrients and contaminants, which **vary**
- Need to compare multiple factors to develop advice
- Goals:
  - Describe Hg-nutrient patterns in seafood
  - Examine whether these patterns are reflected in avid seafood consumers

Nutrients and Contaminants of which Seafood is 1° Source

Typical Concentrations in Representative Foods

	Hg[1] ng/g	Omega-3s (EPA/DHA)[2] g/100g	Se[3] ng/g	Zn[3] ng/g
Milk, whole	0.0001	0/0	58.8	3967
Gr. Beef	0	0.002/0.012	308	82110
Chicken	0	0.010/0.030	578	15793
Bread, Wheat	0	0.002/0	363	14459
Apple		0/0	<0.31	280
Spinach	0	0/0	5.69	4941
Fish, Marine	0.146**	0.071/0.185*	906	5392
Fish, FW	0.004**	0.238/0.357*	393	4946
Shellfish	0.007**	0.188/0.253*	299	11466

[1]USFDA Total Diet Study; [2]USDA NDB, 2012; [3]Canadian Total Diet Study, 2007
**Skipjack Tuna, FW Bass, Blue Mussels*
***Canned Tuna, Catfish, Shrimp*

- Seafood are primary source of Hg, EPA/DHA, Se, other trace metals (to a lesser extent)
- EPA, DHA "marine omega-3s"
- Focus on Hg, Se, O-3s because of their high levels in seafood, health implications.

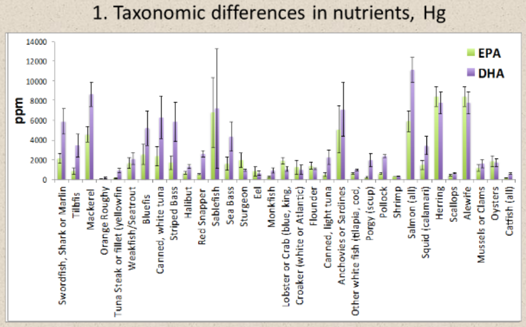
Do specific seafood taxa differ in nutrient, Hg content?

Methods

LONG ISLAND STUDY OF SEAFOOD CONSUMPTION

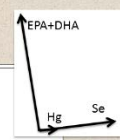
1. Recruited ~300 adult, avid seafood consumers from Long Island
2. Characterized seafood intake from FFQ (e.g., swordfish, salmon).
3. Measured exposure to seafood nutrients, Hg in *blood samples*.
   - Total Hg, Total Se
   - Omega-3s (EPA, DHA) –rbcm
4. Summarized Hg, nutrient concentrations in seafood types from literature (Seafood Hg Database, USDA Nutrient Database, others)

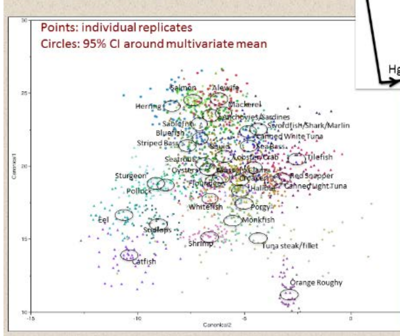
1. Taxonomic differences in nutrients, Hg



Nutrients, Hg vary in edible tissue within & among taxa. Indiv. factors make it difficult to compare overall health quality among seafood items.

2. Differences in overall Hg-nutrient composition among taxa.





Due to physiology/ecology, e.g.,
- Metabolism
- Trophic level (Hg)
- Base of Food Chain (FAs)
- Feeding habit (filter-feed).
- Habitat

Karimi *et al.* Sci Tot Env 2014

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Mercury-Nutrient Signatures in Seafood and in Blood of Seafood Consumers – Roxanne Karimi

Do avid seafood consumers have Hg-nutrient patterns reflecting seafood choices?

Participants consumed fish 2-3x per week, average. Most popular seafood choices:

Rank	Seafood Item	Avg. Frequency
1	Salmon	3-4x per month
2	Canned white tuna	2-3x per month
3	Shrimp	2-3x per month
4	Whitefish (tilapia, sole, . .)	1-2x per month
5	Canned light tuna	1-2x per month
6	Tuna steak/fillet	Once/month
7	Flounder	Few times per yr
8	Lobster, crab	Few times per yr
9	Mussels, clams	Few times per yr
10	Scallops	Few times per yr

1. Seafood rankings similar to national patterns.
2. [Hg], [Se], elevated, omega-3s similar to reference population
3. [Hg] more variable than [Omega-3s], [Se], likely due to seafood choices.

Hg/Nutrient	Geometric Mean	CV	Compared to Reference
$[Hg]_{blood}$	4.61 µg L^{-1}	108.5	4.4x US adults (NHANES, 2013); 42% subjects exceed EPA "safe" level, ≤5.8 µg L^{-1}
$[Se]_{blood}$	273 µg L^{-1}	34.6	2x US pop. (NHANES, 03-04), (Laclaustra, 2010)
$[EPA + DHA]_{rbcm}$	4.74 %	33.4	4.5% common in US (Harris, 2013)

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Results

Hg and Seafood Consumption Rate

	N	*Geom. mean blood THg, µg L⁻¹ (95% CI)*	*95%ile blood THg (µg L⁻¹)*	*≥ 5.8 µg L⁻¹, N (%)*
A few times yr^{-1}	6	2.83 (0.99-8.10)	9.82	2 (33)
Once $month^{-1}$	5	1.91 (0.34-10.65)	11.00	1 (20)
2-3 times $month^{-1}$	17	2.41 (1.16-5.02)	14.5	4 (24)
Once $week^{-1}$	31	3.17 (2.18-4.62)	19.88	9 (29)
2 times $week^{-1}$*	68	3.05 (2.28-4.09)	18.05	15 (22)
3-4 times $week^{-1}$	105	5.94 (4.99-7.08)	26.88	54 (51)
5-6 times $week^{-1}$	35	7.67 (5.19-11.32)	31.60	22 (63)
Once d^{-1}	7	17.03 (11.14-26.04)	36.10	7 (100)

*AHA, USDA minimum

Total Seafood Consumption Rate

- Strongly associated with blood Hg ($p<0.0001$)
- Marginally associated with blood EPA+DHA as % total FAs ($p=0.05$) , not associated with EPA+DHA
- Not associated with blood Se ($p=0.56$)

among these seafood consumers

→ suggests possible threshold effects for Se and Omega-3s

→ does seafood type matter?

Categorize consumers based on types of seafood in diet

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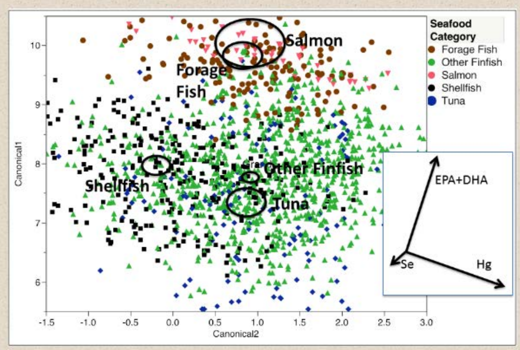
Are there seafood "specialists"?

Yes, but they are not common. Most are "generalists".

Seafood Category	# subjects (of 296) whose seafood diet included ≥50% (cups/week)
Mixed	230
Tuna (all)	31
Salmon	8
Shellfish (bivalves, shrimp, etc.)	20
Whitefish (all)	4
Sport-caught (striped bass, bluefish, etc.)	3
Forage fish (anchovies, sardines, etc.)	0
Swordfish/shark/marlin	0

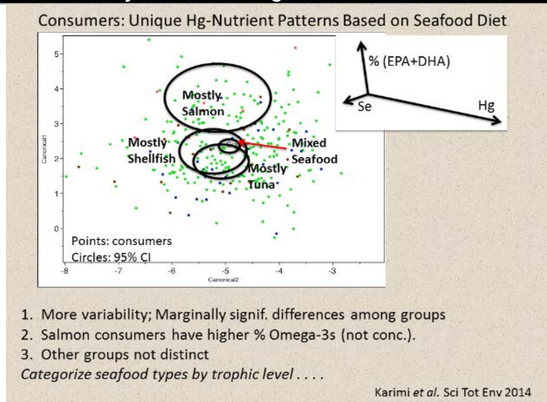
Next: Compare Hg-nutrient patterns among seafood (edible tissue) and types of seafood consumers (blood concentrations) using these broad categories. . . .

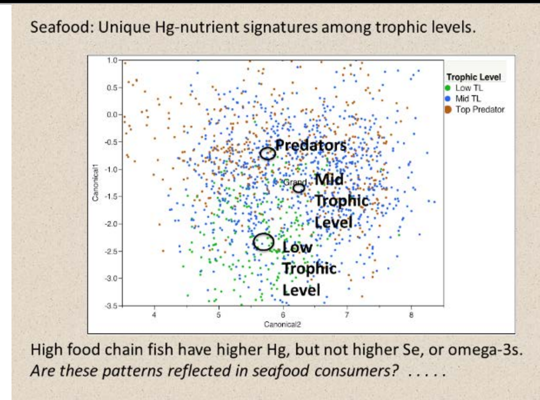
Seafood: Unique Hg-nutrient signatures among broad categories.

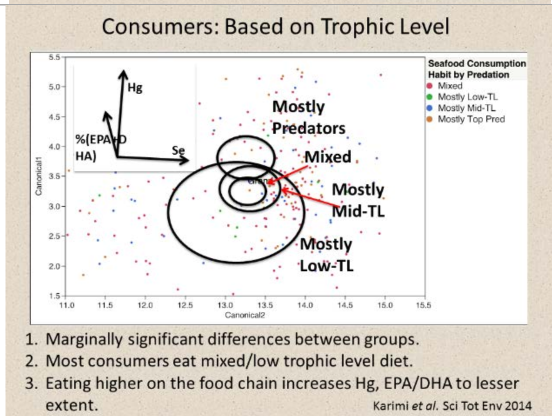


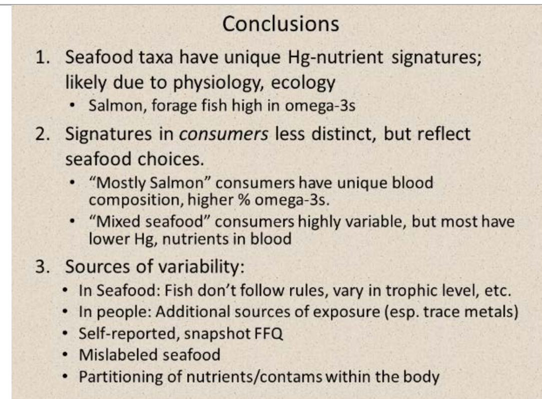
SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT

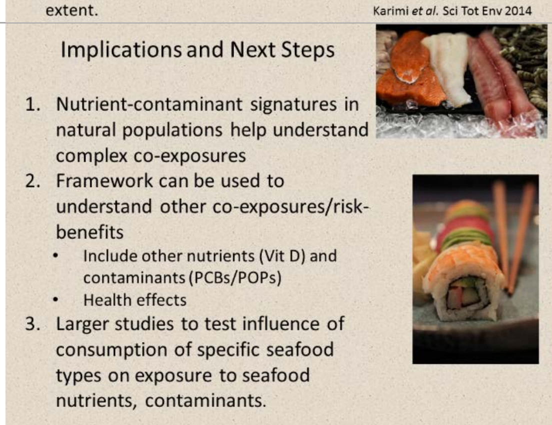
Mercury-Nutrient Signatures in Seafood and in Blood of Seafood Consumers – Roxanne Karimi











Questions and Answers

Note: No questions were asked.

Mercury, Selenium, and Selenium:Mercury Ratios in Fish and Risk Management

Joanna Burger, Rutgers University, and Michael Gochfeld

Biosketch

Dr. Joanna Burger is Distinguished Professor of Biology, a Professor in the School of Public Health, and a member of the Environmental and Occupational Health Sciences Institute at Rutgers University. Her main research interests are in the interactions between the biotic world and humans, including risk from contaminants in fish and shellfish to humans and other biota; understanding fishing, fish consumption, risk assessment, and risk management of mercury and other contaminants in fish; using fish, birds, and other organisms as indicators of human and ecological health and well-being; food chain accumulation; and ways to mitigate the effects of people on species and ecosystems. She has conducted research on fishing, fishing consumption, and risk in New Jersey, New York, South Carolina, Georgia, Ohio, Idaho, Washington, Alaska, and Puerto Rico. She led a biological expedition to the Aleutians of Alaska to determine if the food chain (invertebrates, shellfish, fish, birds) was safe, both to the organisms themselves, to the food chain, and to humans. Her work is collaborative with local people, Native Americans, local governments, and the U.S. Environmental Protection Agency (EPA). She is particularly interested in environmental justice, and presented several talks at EPA meetings and Fish Forums, including one on environmental justice. She has also been involved with assessing heavy metals and radionuclides for several U.S. Department of Energy sites, including developing biomonitoring plans to protect human health and the environment. Much of her work is in collaboration with Dr. Michael Gochfeld. She has published several books and over 500 papers in refereed journals, many on fishing, fish consumption, risk, and risk management. She has served on several local and national committees, including for the National Academy of Sciences, EPA, National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, and Nuclear Regulatory Commission. She has a Distinguished Achievement Award from the Society of Risk Analysis, and is a Fellow in the International Union for Pure and Applied Chemistry, and the American Association for the Advancement of Science.

Abstract

Fish provide healthy protein, as well as recreational and cultural benefits, but can also contain mercury, polychlorinated biphenyls (PCBs) and other contaminants that have adverse effects on humans and other organisms, particularly developing fetuses. Recently some authors have suggested that a molar excess of selenium (e.g., selenium:mercury molar ratio >1) confers protection from mercury toxicity derived from fish consumption. We review our studies of mercury and selenium in freshwater, marine, and commercial fish (mainly marine), examining the following questions: 1) how selenium:mercury molar ratios vary among species; 2) how the molar ratios vary within species; 3) whether the molar ratios differ between freshwater and saltwater fish; 4) whether mean molar ratio values provide a reliable indication of potential risk to fish consumers; and 5) whether mean selenium:mercury molar ratios are sufficiently constant (e.g., low variation) to allow for use in risk assessment, risk management, or risk communication. In saltwater fish, mean selenium:mercury molar ratios varied from 0.3 in mako shark to 68.1 in whiting. For freshwater fish, the mean ratios varied from 0.68 in bowfin to 20.8 in black crappie. Commercial seafood (mainly saltwater) showed great variation in ratios; shrimp and scallops had very high ratios. There was somewhat less variability in the ratios for freshwater fish, compared to the fish from saltwater, but there was no

overall predictable difference in variation in selenium:mercury molar ratios. For both saltwater and freshwater fish, some species with mean molar ratios above 1 had a significant proportion of individual fish with molar ratios below 1. Overall, this indicates great variation in measures of central tendencies (means), and in measures of dispersion. We suggest that relying on the selenium:mercury molar ratio as a method of predicting reduced risk from mercury toxicity is problematic because of the great variation among and within fish species, and the variation is not predictable because mercury varies by season, size of fish, and location of fish (which is not available for commercial fish). With the high variation in ratios, and low predictability, the ratios are currently not useful for risk assessment and risk management, and vulnerable individuals cannot rely on mean selenium:mercury molar ratios for protection from mercury toxicity. Thus, the public cannot assume that high levels of selenium in marine fish will protect them from mercury toxicity.

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Mercury, Selenium, and Selenium:Mercury Ratios in Fish and Risk Management
– Joanna Burger and Michael Gochfeld

Mercury, Selenium and Selenium: Mercury ratios in Fish and Risk Management

Joanna Burger and Michael Gochfeld
Rutgers University
NIEHS Center and EOSHI

RUTGERS THE STATE UNIVERSITY OF NEW JERSEY

1

Objectives: Variability -> unpredictability

- Brief background on mercury and selenium
- Mean levels of mercury and selenium among species
- Mean levels of mercury and selenium within species
- Variations in level with fish size and location
- Selenium:mercury molar ratios for species or locations
- Selenium:mercury molar ratios in individuals
- Selenium:mercury molar ratios in other tissues

Bluefin Tuna

2

Mercury and Selenium

- Selenium is both a toxic and essential element
- Mercury has high affinity for sulfur AND selenium
- Mercury can disrupt selenoenzymes including those that defend against oxidative stress (thioredoxin reductase)
- Selenium can confer some protection against Hg
- How much protection does selenium in fish confer against MeHg in fish

3

A Tale of Two Metals

- **Mercury**
  - Many forms
  - Toxic in bioavailable forms
  - Multiple effects -- form and dose
  - Natural and anthropogenic
  - Contaminant of foods, particularly piscivorous fish and mammals
- **Selenium**
  - Many forms
    - Se^{6+}, Se^{4+}, Se^{0}, Se^{-}
  - Essential element
  - Effects of both deficiency and excess
  - Natural and anthropogenic
  - Found in water and several foods including fish

4

Selenium Deficiency Does Not Look Like Mercury Toxicity Clinically

- Impaired cell-mediated immunity
- Liver damage
- White muscle disease in livestock
- Pancreatic atrophy in chickens
- Alopecia
- Myopathy
- Cardiomyopathy Keshan disease (China)
- Degenerative osteoarthritis-dwarfism (Kashin-Beck disease)
- "Nephrosis"
- Goiter
- Neural tube defects
- Small testes immotile abnormal sperm
- Male infertility in livestock

Slide from M. Gochfeld 5

Hypothesis : Molar ratio

- It has been suggested that if the Se:Hg ratio >1, there would be no mercury effects
- However,
  - Choi et al (2008)
    - Se was present in Faroese cord blood: 10 fold molar excess above MeHg. "Overall, no evidence was found that Se was an important protective factor against MeHg neurotoxicity".
  - Saint-amour et al (2006)
    - Visual evoked potential in Inuit children affected by MeHg; no interaction with measured cord blood Se; average blood Se =5.6 umole/L; 20% of population, Se at levels > safe level for adults.
- The protective ratio in fish is NOT KNOWN

6

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
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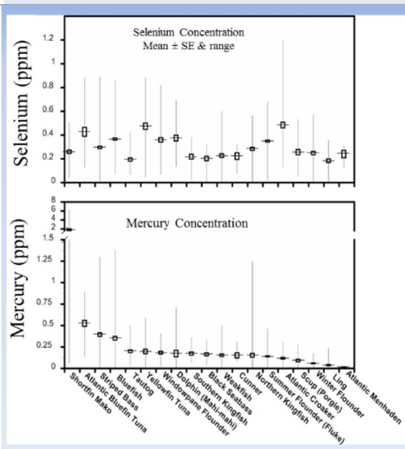
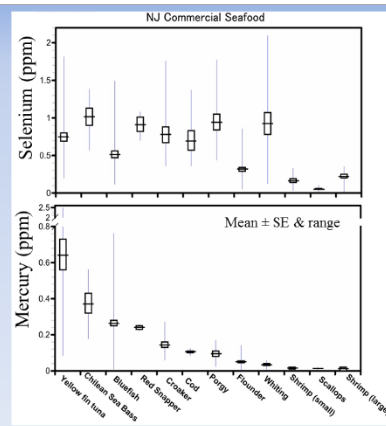
Modes of action

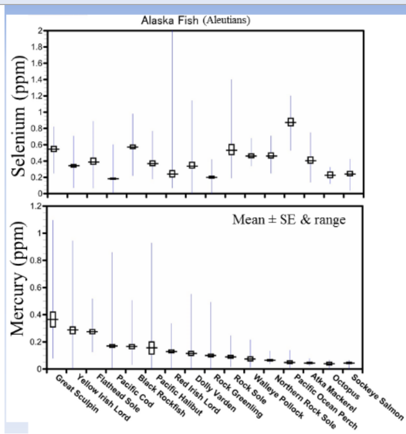
- Mercury does other things than bind and deplete selenium
  - Disruption of S-S bonds in enzymes
  - Alters temporal sequencing of polysialyated NCAM and sialytransferase
  - Timing of dose influenced impact during synaptogenesis in cerebellum (Dey et al.)
  - Disrupts microtubules, neuronal migration, processes and synapses
- **Selenium has to do other things than bind mercury**
  - **Binds other cations (copper and cadmium)**

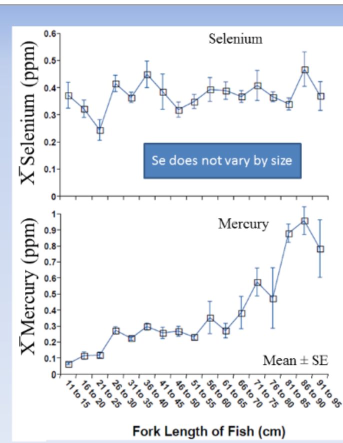
Current status

- There is a rapidly growing amount of phenomenologic data on Hg-Se interactions.
- Studies are not consistent
- Some selenium compounds protect against some mercury toxic effects in some organisms under some test systems.
- Oxidative stress is one mechanism of mercury toxicity (inhibition of GPx and ThR-R)
- Conversely antioxidant defense is a mechanism of Se protection
- How this effects interpretion of the selenium:mercury ratio in fish needs more research.



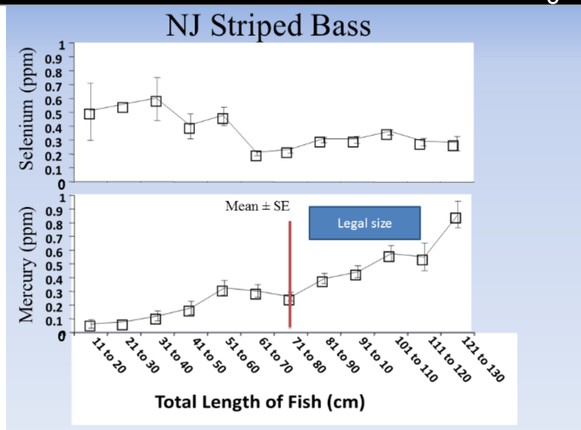


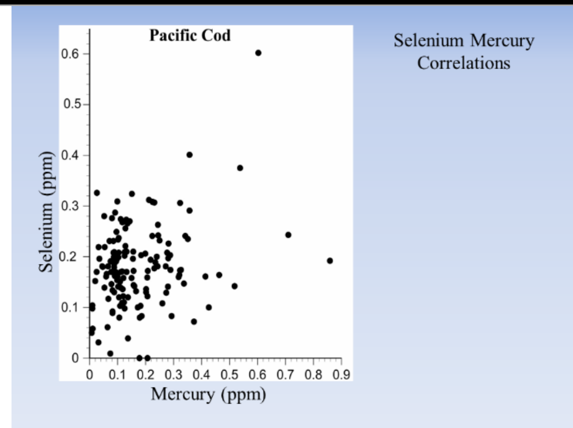


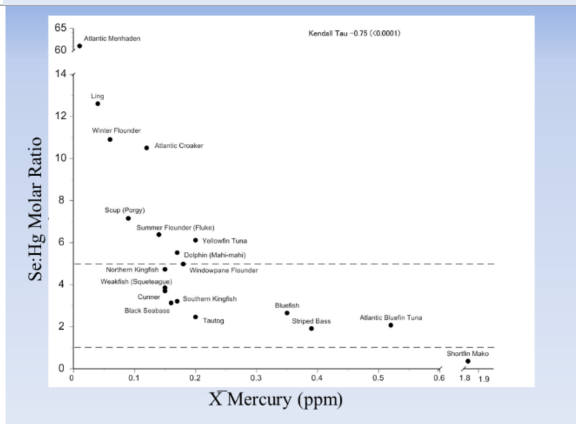


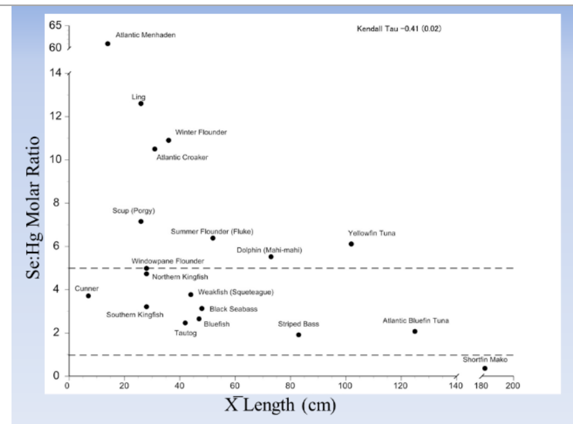
Bluefish

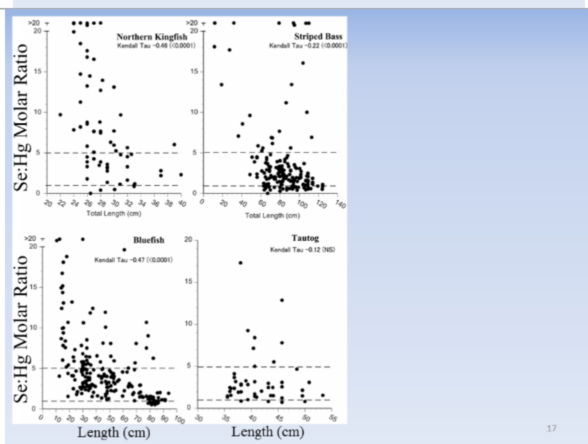
SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Mercury, Selenium, and Selenium: Mercury Ratios in Fish and Risk Management
– Joanna Burger and Michael Gochfeld

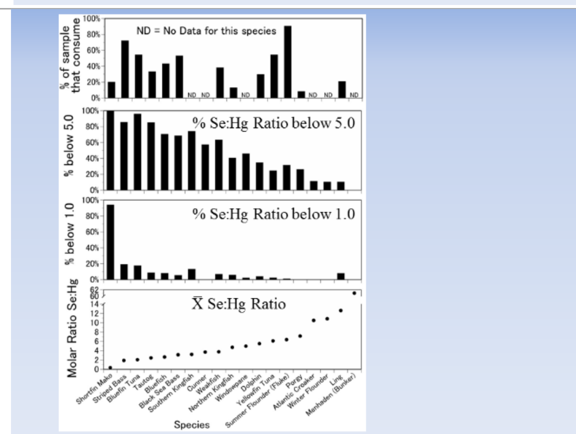












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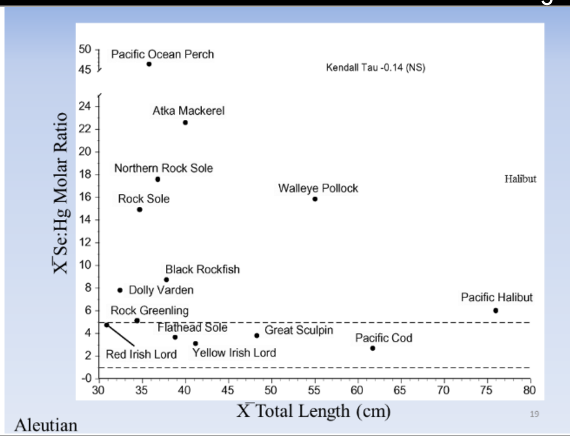

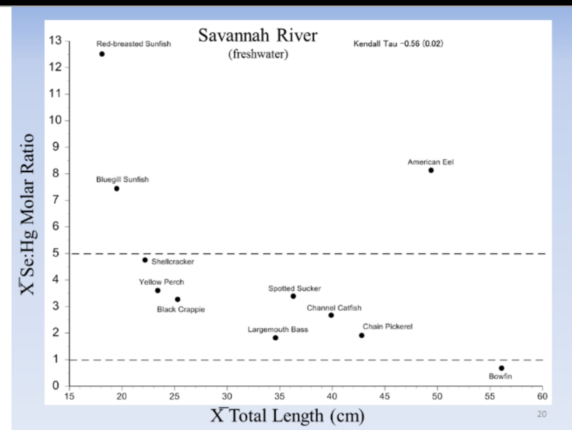

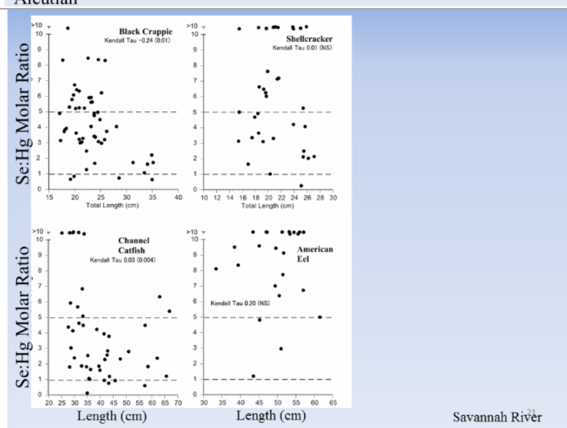

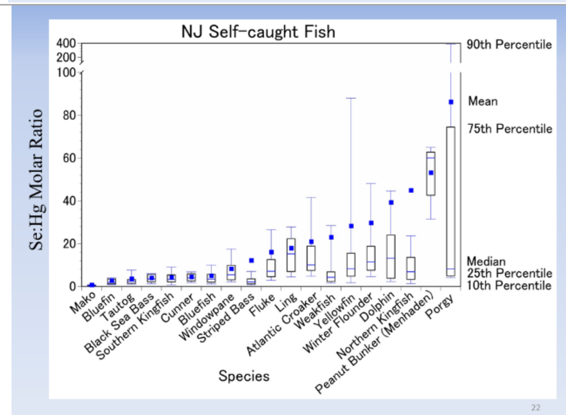

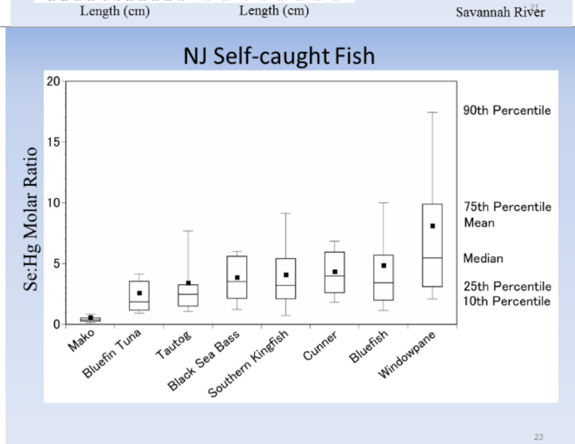

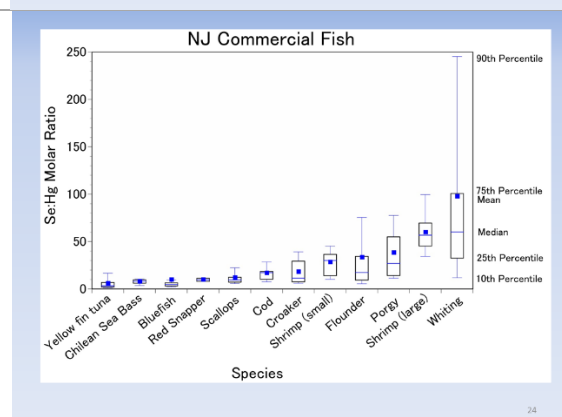

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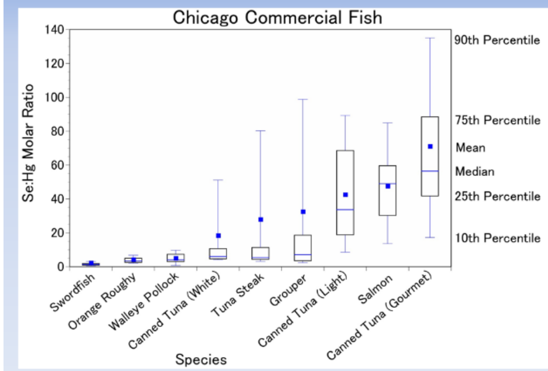
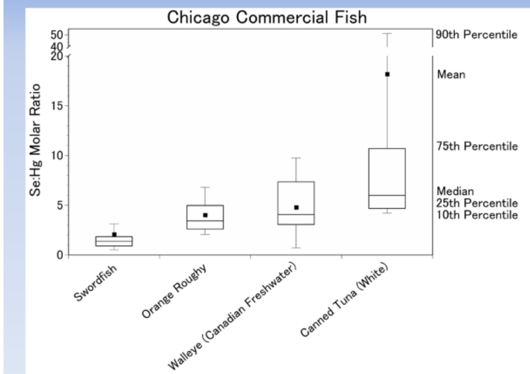
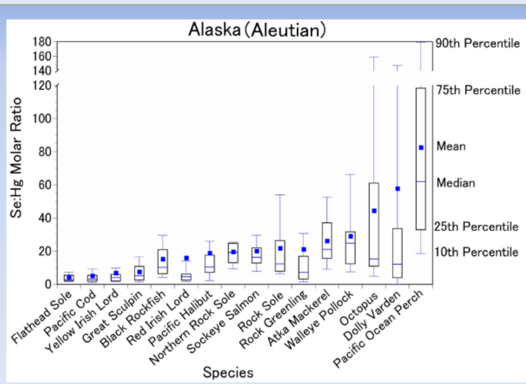
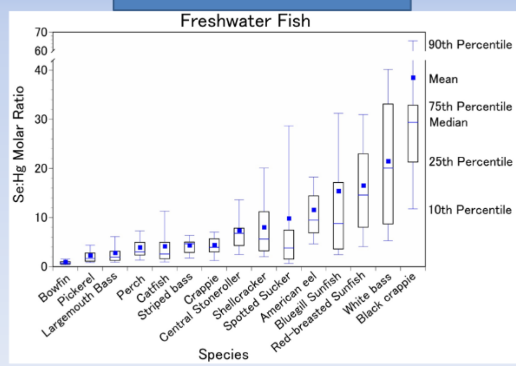


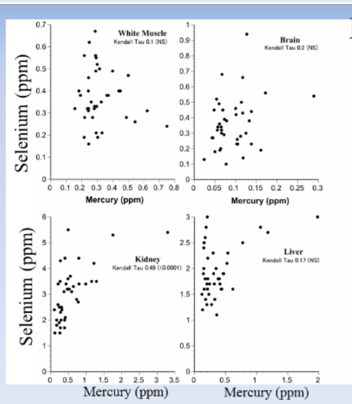




SAVANNAH RIVER, SC



Bluefish



New Jersey

Implications for Risk Management and Fish Advisories

- There is variation within and among Fish in:
  - Hg levels
  - Se levels
  - Se/Hg ratio

- There is seasonal and yearly variations in all three
- High variability   Low predicatbility
- Se/Hg molar ratio not yet usable for Fish Advisories

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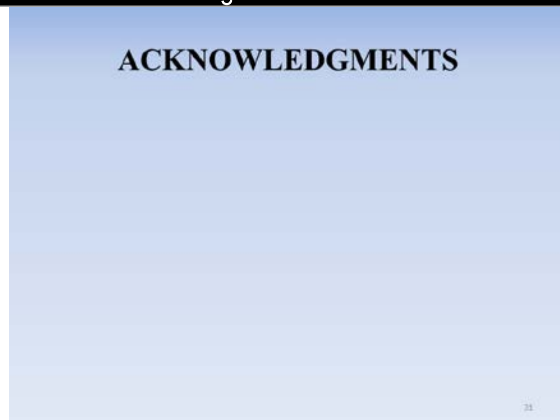


Questions and Answers

Q. He agrees with Dr. Burger's results that high variability in the selenium:mercury molar ratio is an issue. He believes that you must include the selenium:mercury molar ratio in studies. He emphasized that it is important to look at both mercury and selenium and to know a person's selenium status before analysis of health effects from fish consumption. (Ralston)

A. The selenium:mercury molar ratio can be highly variable, and is not predictable. (Burger)

Comment: He will be doing a round robin effort on measuring selenium and mercury. If anyone wants to be included in this effort, please contact him directly. (Ralston)

A. In response to a request from the moderator, Dr. Gochfeld said that he accepted there was significant inconsistency and complexity in the data on this selenium:mercury issue. (Gochfeld)

Q. Do you have any sex data on the fish, because of mercury mobilization in gametes? (Richardson)

A. There is a lot of that data for birds, but much less for fish. They have some age variation data for fish. (Burger)

General Question and Answer Session

Note: There were no questions because the moderator announced they would take the scheduled break.

Risks and Benefits of Fish Consumption for Cardiovascular Diseases

Dariush Mozaffarian, Harvard Medical School, Tufts University

Biosketch

After 10 years on the faculty at Harvard University, Dr. Dariush Mozaffarian has been appointed the Dean of the Friedman School of Nutrition Science and Policy at Tufts University. He is a cardiologist and epidemiologist whose research focuses on the effects of diet and lifestyle on cardiometabolic health, including global impacts of suboptimal diet and effectiveness of policies to improve diets around the world. Dr. Mozaffarian has authored more than 200 scientific publications on lifestyle and cardiovascular health, including on global dietary burdens of disease, Omega 3 fatty acids, trans fatty acids, diets and weight gain, and healthy dietary patterns. He has served in numerous advisory roles, including for the American Heart Association, U.S. and Canadian governments, World Health Organization, and United Nations Food and Agriculture Organization. He chairs the Global Burden of Diseases Nutrition and Chronic Diseases Expert Group (NutriCoDE). Dr. Mozaffarian received a B.S. in Biological Sciences from Stanford University (Phi Beta Kappa), an M.D. from Columbia University (Alpha Omega Alpha), an M.P.H. from University of Washington, and a Doctorate in Epidemiology from Harvard. He is board-certified in Cardiovascular Medicine and, until serving as Dean, remained clinically active on the cardiology service at Brigham and Women's Hospital in Boston, Massachusetts.

Abstract

Controversy has arisen among the public and in the media regarding the health effects of fish intake in adults. Substantial evidence indicates that fish consumption reduces coronary heart disease mortality, the leading cause of death in nearly all nations globally. Conversely, concerns have grown regarding potential effects of exposure to mercury and other contaminants found in some fish. Because fish consumption appears to have important health benefits in adults, elucidating the relationships between fish intake, mercury and other contaminant exposure, and health risk is of considerable scientific and public health relevance. Modest consumption of fish (e.g., 1-2 servings/week), especially species higher in the n-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), appears to reduce risk of coronary death by 36% (95% confidence interval, 20%-50%; $P<.001$) and may favorably affect other clinical outcomes. Women of childbearing age and nursing mothers should also consume seafood for optimal brain development in their children, limiting intake of only a few selected species. Chronic health effects of low-level methylmercury in adults are not established; the best available evidence suggests no effects on hypertension, diabetes, or cardiovascular diseases. A variety of seafood should be consumed; individuals with very high consumption (≥ 5 servings/week) may wish to limit intake of species highest in mercury levels. Levels of dioxins and polychlorinated biphenyls in fish are low, and potential carcinogenic and other effects are greatly outweighed by potential benefits of fish intake and should have little impact on individual choices for commercial seafood consumption. (All individuals should consult regional advisories for local sport-caught fish). In sum, for major health outcomes among adults, based on both the strength of the evidence and the potential magnitudes of effect, the benefits of fish intake greatly exceed the potential risks. These findings demonstrate that quantitative and comparable assessment of risks and benefits is needed to make informed recommendations about optimal fish consumption. Such evaluation has been limited in the past by widely varying standard methods for assessing nutritional benefits versus toxicological risks.

Risks and Benefits of Fish Consumption for Cardiovascular Diseases

Dariush Mozaffarian, MD DrPH
Dean, Friedman School of Nutrition Science & Policy

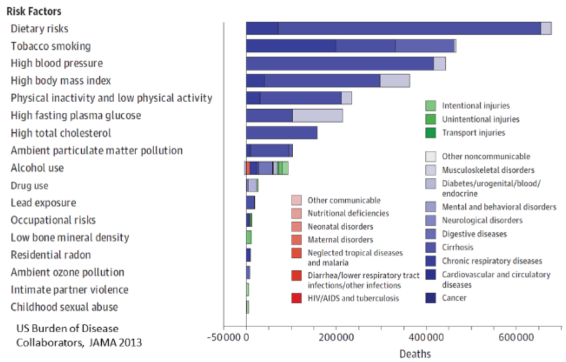
EPA 2014 National Forum on Contaminants in Fish
Alexandria, VA, Sept 23, 2014

Tufts University | Gerald J. and Dorothy R. Friedman School of Nutrition Science and Policy

Disclosures

- Research support: NIH, Gates Foundation.
- Ad hoc honoraria for scientific presentations on diet: Quaker Oats, Pollock Institute, Bunge.
- Ad hoc consulting: Foodminds, Nutrition Impact, Amarin, Astra Zeneca, Life Sciences Research Organization.
- Scientific Advisory Board: Unilever North America.

Top Risk Factors for US Mortality, 2010



US Burden of Disease Collaborators, JAMA 2013

Strength of Evidence

Randomized Trials of Disease Outcomes

Prospective Cohorts of Disease Outcomes

Randomized Trials of Physiologic Biomarkers / Risk Factors

Retrospective Case-Control Studies of Disease Outcomes

Animal Studies

Ecologic Studies

Prevalence Studies

Harris, Mozaffarian et al., J Nutrition 2009

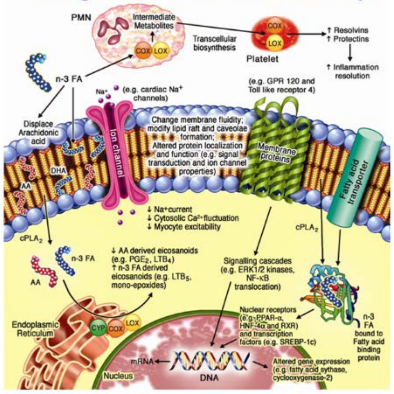
Potential Health Benefits of Eating Fish / Seafood

- **Heart**
  - Cardiac death
  - Nonfatal heart attacks
  - Atrial fibrillation
  - Congestive heart failure
- **Brain**
  - Neurodevelopment (in utero, infancy)
  - Ischemic stroke
  - Mood and depression
  - Cognitive decline and dementia
  - Postpartum depression
- **Other**
  - Diabetes mellitus
  - Inflammatory diseases
  - Cancer
  - Bone health

Potential Bioactive Compounds in Fish

- **Omega-3 fatty acids (EPA, DHA)**
- **Selenium (selenomethionine)**
- **Vitamin D**
- **Amino acids**
- **Other acids (e.g., taurine)**
- **L-carnitine, phosphatidylcholine**

Omega 3's: Molecular Pathways



Mozaffarian and Wu, J Am Coll Cardiol 2011

Omega-3's Improve Multiple CVD Risk Factors

Established in human clinical trials:

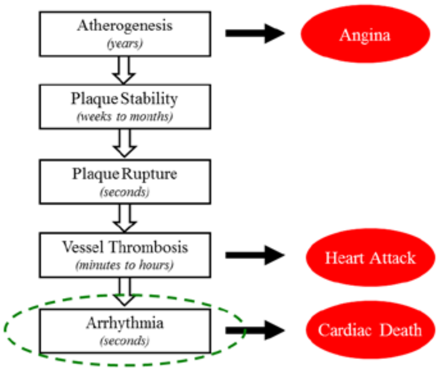
- Lower heart rate
- Lower blood pressure
- Improved arterial compliance
- Improved endothelial function
- Improved heart rate variability
- Lower triglycerides
- Higher adiponectin
- Improved left ventricular filling
- Lower cardiac oxygen consumption

Seen in animal studies:

- Anti-arrhythmic effects
- Anti-inflammatory effects
- Improved insulin resistance
- Anti-atherosclerotic effects

Mozaffarian & Wu, JACC 2011

Spectrum of Coronary Heart Disease



Harris, Mozaffarian, et al., J Nutr 2009

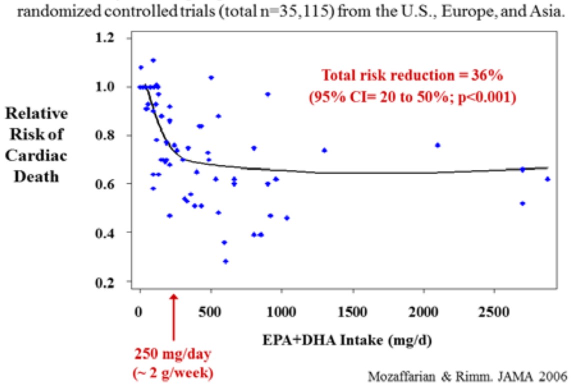
Fish Intake & Cardiac Death: Prospective Cohorts

Total of **326,572** individuals (4,473 cardiac deaths) in U.S., Europe, and Asia.

Study	Number of Participants	Number of CHD Deaths
1. Kromhout 1985 – Zutphen Elderly Study	852	78
2. Dolecek 1991 – Multiple Risk Factor Intervention Trial	16,258	175
3. Fraser 1992 – Adventist Health Study	26,473	260
4. Kromhout 1995 – Rotterdam Cohort Study	272	58
5. Daviglus 1997 – Chicago Western Electric Study	1,822	430
6. Albert 1998 – Physicians Health Study	20,551	133
7. Oomen 2000 – Seven Countries Study	2,738	463
8. Yuan 2001 – Shanghai Cohort Study	18,244	74
9. Hu 2002 – Nurses Health Study	84,688	484
10. Mozaffarian 2003 – Cardiovascular Health Study	3,910	247
11. Osler 2003 – Danish Monica Cohort	7,529	247
12. Folsom 2004 – Iowa Women's Health Study	41,836	922
13. Mozaffarian 2005 – Health Professionals Follow-up Study	45,722	218
14. Nakamura 2005 – Japan Nippon Study	8,879	124
15. Iso 2006 – Japanese Public Health Center Cohort	41,578	62
16. Jarvinen 2006 – Finland Cohort Study	5,220	498
Totals	**326,572**	**4,473**

Pooled Analysis of Studies of Cardiac Death

Meta-analysis of 16 prospective cohort studies (total n=326,572) and 4 randomized controlled trials (total n=35,115) from the U.S., Europe, and Asia.



Mozaffarian & Rimm. JAMA 2006

Fish/n-3 PUFA & Cardiac Death: Trials

Randomized Controlled Trials	Number of Participants	Cardiac Deaths
DART – 1989	2,033	194
DART 2 – 2003	3,114	319
GISSI-Prevenzione – 1999	5,664	273
JELIS Primary & Secondary Prevention – 2007	18,645	60
GISSI-Heart Failure – 2008	6,975	632
Alpha-Omega – 2010	4,837	138
Omega – 2010	3,350	57
SU.FOL.OM3 – 2010	2,501	40
ORIGIN – 2012	12,536	547
Risk & Prevention – 2013	12,513	158
Totals	**72,198**	**2,418**

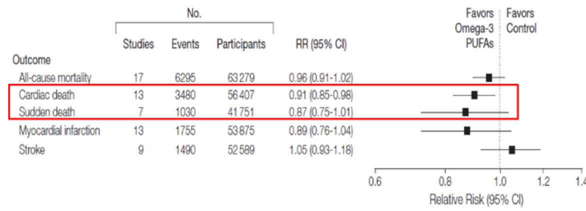
SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT

Risks and Benefits of Fish Consumption for Cardiovascular Diseases – Dariush Mozaffarian

Recent Fish Oil Trials: Possible Reasons for No Effect

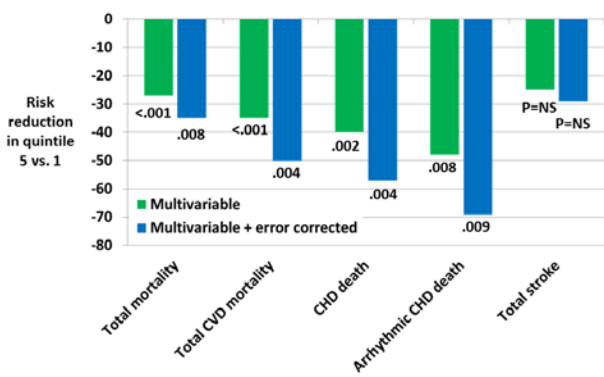
- Fish oil (1 g/d) does not actually reduce CVD risk.
- Significant background medical therapy.
- Wrong endpoint: total CVD, rather than CHD death.
- Substantial background fish consumption (nonlinear, threshold effect for CHD death).

Meta-Analysis of RCTs of Fish / Fish Oil



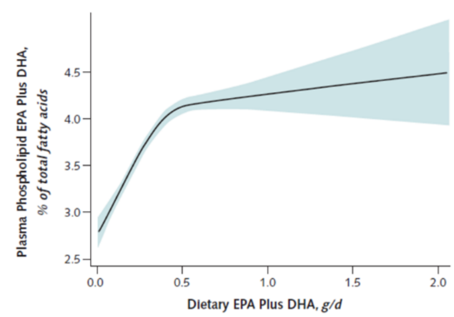
Rizos et al., JAMA 2012

Blood EPA+DHA and CVD Outcomes



Mozaffarian et al., Ann Intern Med 2013

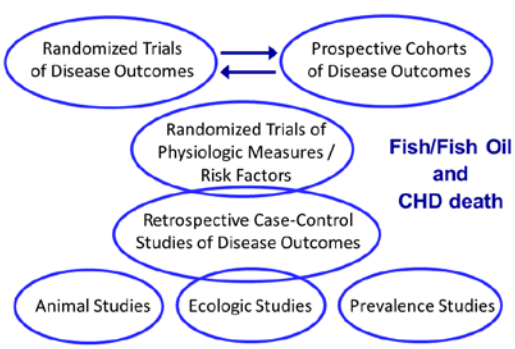
Dietary vs. Blood EPA+DHA



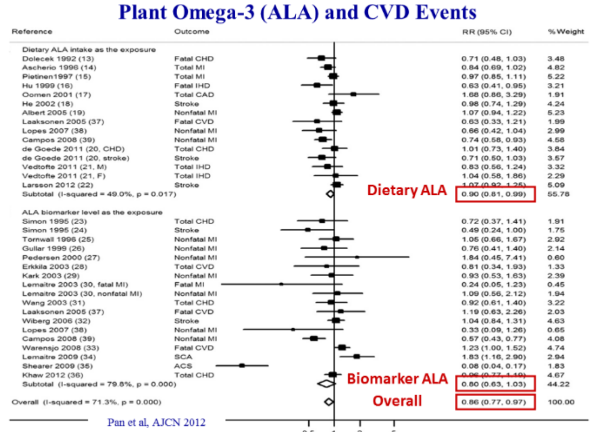
N = 2,692 generally healthy US adults

Mozaffarian et al., Ann Intern Med 2013

Strength of Evidence



Plant Omega-3 (ALA) and CVD Events



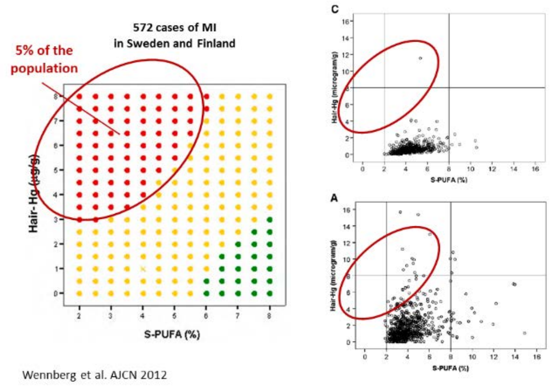
Pan et al, AJCN 2012

The New York Times: Front Page, Jan 23, 2008

"High Mercury Levels Are Found in Tuna Sushi"

"Tuna sushi is a popular item in New York but may be risky."

Mercury in Adults: Cardiovascular Risk ?



Wennberg et al. AJCN 2012

Mercury in Adults: Cardiovascular Risk ?

Baseline characteristics for subjects with different combinations of amounts of S-PUFA and hair-Hg[1]

	n	Low S-PUFA and low hair-Hg	High S-PUFA and low hair-Hg	Low S-PUFA and high hair-Hg	High S-PUFA and high hair-Hg
Hair-Hg (µg/g)	1613	0.570 (0.590)[2]	0.930 (0.620)	2.96 (1.88)	3.22 (2.68)
S-PUFA (%)	1613	3.78 (1.14)	6.22 (1.18)	3.93 (1.37)	6.89 (2.28)
Age (y)	1613	53.1 ± 6.54[3]	54.1 ± 6.11	54.2 ± 4.41	54.3 ± 3.90
Smoking habits (%)	1581				
Never		36.6	41.8	28.2	23.5
Former		31.6	35.3	36.7	44.7
Current		31.8	22.9	35.1	31.8
BMI (kg/m^2)	1585	26.2 (4.30)	25.8 (4.10)	26.9 (4.10)	27.4 (5.90)
Systolic blood pressure (mm Hg)	1578	136 ± 16.6	136 ± 17.0	137 ± 17.2	138 ± 16.5
Diastolic blood pressure (mm Hg)	1578	87.6 ± 9.78	86.7 ± 8.98	90.0 ± 10.3	90.1 ± 9.80
Diabetes (%)	1581	4.57	10.5	6.43	4.71
Serum cholesterol (mmol/L)	1582	6.08 ± 1.17	6.11 ± 1.16	6.17 ± 1.21	6.17 ± 0.861
apo B and apo A-I ratio	1598	1.00 ± 0.252	0.989 ± 0.248	1.10 ± 2.33	1.08 ± 0.181
Educational level (%)	1562				
Low		58.8	41.4	83.1	68.2
Medium		32.4	33.6	12.1	20.0
High		8.82	25.0	4.84	11.8
Alcohol consumption (%)	1274				
<1 time/wk		74.6	67.4	55.0	46.5
1 to <2 times/wk		17.7	21.0	27.8	35.2
≥2 times/wk		7.70	11.6	17.2	18.3
Physical inactivity (%)	1486	26.5	29.9	17.9	10.7

Wennberg et al. AJCN 2012

Mercury and CVD: 3,427 cases in US men and women

Variable	No. of Case Participants	Sex-Specific Quintile of Toenail Mercury					P Value for Trend
		1	2	3	4	5	
Mean mercury (µg/g)		0.09	0.17	0.25	0.38	0.95	
Coronary heart disease	2363						
No. of cases		542	506	446	450	419	
Multivariate RR (95% CI)							
Model 1†		1.00 (reference)	0.97 (0.81–1.15)	0.82 (0.69–1.00)	0.81 (0.68 – 0.97)	0.78 (0.65–0.94)	0.006
Model 2‡		1.00 (reference)	1.00 (0.83–1.20)	0.89 (0.73–1.08)	0.87 (0.72–1.06)	0.85 (0.69–1.04)	0.10
Stroke	1064						
No. of cases		233	226	209	209	187	
Multivariate RR (95% CI)							
Model 1†		1.00 (reference)	0.91 (0.70–1.19)	0.89 (0.68–1.17)	0.94 (0.72–1.23)	0.77 (0.59–1.02)	0.09
Model 2‡		1.00 (reference)	0.95 (0.72–1.26)	0.95 (0.71–1.28)	0.98 (0.73–1.31)	0.84 (0.62–1.14)	0.27

Model 1: Adjusted for age, sex, race, and smoking status.

Model 2: Further adjusted for body mass index, physical activity, alcohol use, diabetes mellitus, hypertension, high cholesterol, and dietary EPA+DHA.

Mozaffarian et al. NEJM 2011

Mercury and Hypertension

Table 5. Multivariable-Adjusted Risk of Incident Hypertension According to Deciles of Mercury Exposure Among 6045 US Men and Women in 2 Separate Prospective Cohorts

	Deciles of Toenail Mercury Concentration										
Variable	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	*P* for Trend
Median, µg/g	0.07	0.11	0.14	0.17	0.21	0.25	0.31	0.38	0.52	0.92	
Geometric mean, µg/g	0.06	0.11	0.14	0.17	0.21	0.25	0.31	0.38	0.52	1.06 **~ 2.9 ug/g in hair**	
No. of events	372	354	382	355	354	364	343	359	349	308	
Age- and sex-adjusted HR (95% CI)	1.00 (reference)	0.87 (0.75–1.01)	1.03 (0.90–1.19)	0.87 (0.76–1.01)	0.89 (0.77–1.03)	0.92 (0.79–1.06)	0.86 (0.74–1.00)	0.94 (0.81–1.08)	0.91 (0.78–1.05)	0.79 (0.67–0.92)	0.01
Multivariable-adjusted HR (95% CI)*	1.00 (reference)	0.89 (0.77–1.03)	1.08 (0.93–1.25)	0.90 (0.78–1.04)	0.94 (0.81–1.09)	0.94 (0.81–1.09)	0.91 (0.78–1.06)	0.96 (0.82–1.12)	0.95 (0.82–1.11)	0.81 (0.69–0.96)	0.02
Multivariable+ diet-adjusted HR (95% CI)†	1.00 (reference)	0.89 (0.77–1.03)	1.08 (0.93–1.25)	0.89 (0.77–1.03)	0.93 (0.80–1.08)	0.94 (0.81–1.09)	0.92 (0.79–1.07)	0.96 (0.83–1.12)	0.96 (0.82–1.12)	0.82 (0.69–0.96)	0.03

HR indicates hazard ratio.

*Data were adjusted for age (y), sex, race (white or nonwhite), month of toenail return, family history of hypertension (yes or no), smoking status (never, former, or current), body mass index (quintiles), diabetes mellitus (yes or no), hypercholesterolemia (yes or no), future cardiovascular disease status (case or control), physical activity (quintiles), alcohol use (quintiles), and fish consumption (quintiles).

†Data were adjusted for consumption of whole grains, unprocessed meats, processed meats, fruits, and vegetables (each in quintiles).

Mozaffarian et al. Hypertension 2012

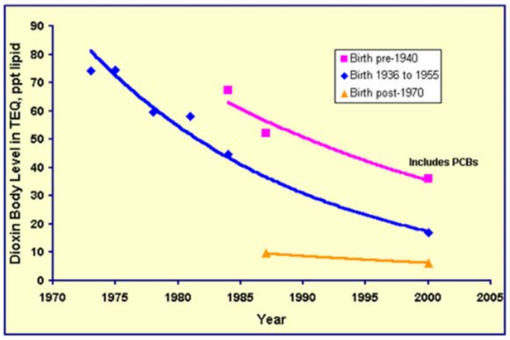
Mercury and Diabetes

	Quintile of toenail mercury concentration†					
	Q1	Q2	Q3	Q4	Q5	*P* for trend
All participants combined (n = 9,267)					**~ 2.2 ug/g in hair**	
Mercury median (µg/g)	0.09	0.16	0.23	0.34	0.66	
Geometric mean (µg/g)	0.08	0.16	0.23	0.35	0.76	
Cases of incident diabetes (total = 1,010)	233	224	186	181	186	
HR (95% CI)						
Age and sex adjusted	1.00 (reference)	1.06 (0.86–1.30)	0.79 (0.63–0.98)	0.78 (0.63–0.98)	0.89 (0.72–1.10)	0.17
Multivariable‡	1.00 (reference)	1.05 (0.85–1.29)	0.77 (0.61–0.97)	0.76 (0.60–0.96)	0.81 (0.64–1.02)	0.05
Multivariable + diet§	1.00 (reference)	0.98 (0.79–1.22)	0.75 (0.59–0.94)	0.75 (0.59–0.95)	0.77 (0.61–0.98)	0.04

Mozaffarian et al. Diabetes Care 2013

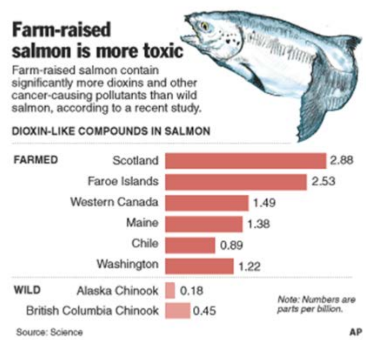
SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Risks and Benefits of Fish Consumption for Cardiovascular Diseases – Dariush Mozaffarian

Dioxins/PCBs Over Time (U.S., Canada, Europe)

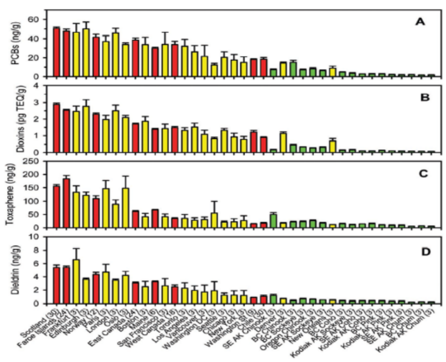


Aylward et al. J Expo Anal Environ Epidemiol 2002

2004 *Science* report on PCBs/Dioxins in Salmon



Web blogs:

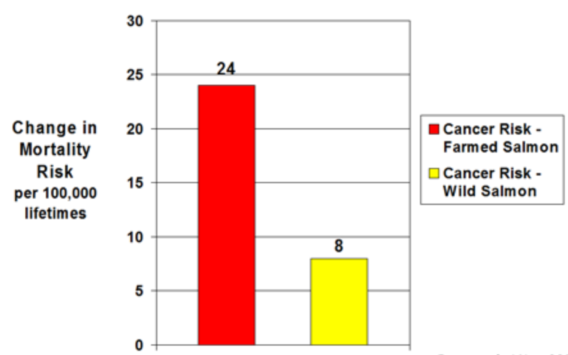


Farmed Salmon Wild Salmon

Hites et al. Science 2004

Estimated Effects of Lifetime Salmon Intake

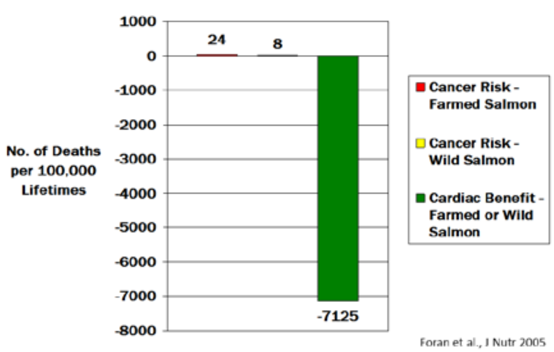
(7 servings/wk wild salmon, 3 servings/wk farmed salmon, for 70 years)



Foran et al., J Nutr 2005

Estimated Effects of Lifetime Salmon Intake

(7 servings/wk wild salmon, 3 servings/wk farmed salmon, for 70 years)



Foran et al., J Nutr 2005

Balancing Risks & Benefits of Fish Consumption

- In adults, little evidence for meaningful harms.
- Substantial evidence for CVD benefits, esp. for CHD death, the #1 cause of death in American men and women.
- For the general population:
  - Risks vs. benefits do not warrant any recommendations to limit fish intake.
  - Choose and eat a variety of fish species.
  - Frequent consumers (e.g. 5+/week) may wish to minimize high mercury fish.
- For women of childbearing age:
  - Current guidelines are conservative and seek to minimize risks.
  - PCBs/dioxins may be especially relevant.
- For public health: Important to reduce mercury and PCBs/dioxins in fish, which could be *partly offsetting* benefits.

Dietary Priorities for Good Health

EAT:

- **Fruits**
- **Nuts, Seeds**
- **Fish, Seafood**
- **Vegetables**
- **Vegetable Oils***
- **Whole Grains**
- **Moderate Dairy**

LIMIT:

- **Refined Grains, Potatoes, Sugars**
- **Processed Meats**
- **Sweetened Drinks**
- **Industrial Trans Fat**
- **Salt**
- **Alcohol**

*Especially soybean oil and extra-virgin olive oil

Mozaffarian , Appel, and Van Horn. Circulation 2011

Questions and Answers

Note: There were no questions because the moderator asked that any questions be held until the general Q&A session at the end of this panel.

Maternal Fish Intake during Pregnancy and Child Cognition

Emily Oken, Harvard Medical School

Biosketch

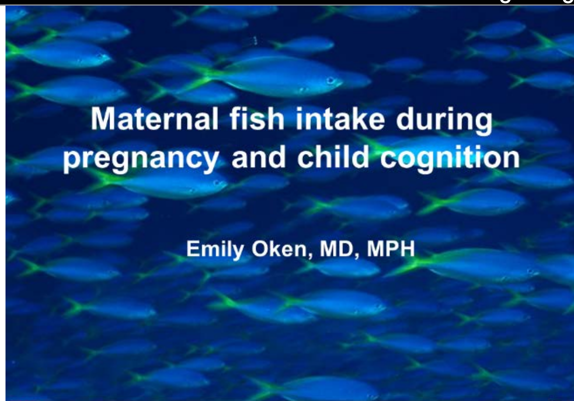
Dr. Emily Oken is an Associate Professor in the Department of Population Medicine at Harvard Medical School and Harvard Pilgrim Health Care Institute. She practices as a Primary Care Physician at the Gretchen and Edward Fish Center for Women's Health at Brigham and Women's Hospital, where she pursues her interest in medical care for women before, during, and after pregnancy. Dr. Oken received her medical degree from Harvard Medical School in 1996 and completed her internship and residency in internal medicine and pediatrics at the Harvard Combined Medicine/Pediatrics Residency Program. She completed her fellowship in general internal medicine at Harvard Medical School and obtained her Master's degree in public health from Harvard School of Public Health. Dr. Oken's research focuses on the influence of nutrition and other modifiable factors during pregnancy and early childhood on long-term maternal and child health, especially cardiometabolic health and cognitive development. She has also led a number of studies examining predictors and sequelae of maternal overweight, weight gain, and related conditions such as gestational diabetes mellitus in the peripartum period. Her work on the toxicant risks and nutrient benefits of prenatal fish consumption has influenced national guidelines for fish consumption during pregnancy, helping to shift the previous focus of risk-only or benefit-only studies to a broader emphasis on the overall health effects of fish consumption for mother and baby. She has also published widely on perinatal influences on child health including asthma and atopy. In support of this work, she has led longitudinal studies commencing in the peripartum period and following mothers and children throughout childhood. She is co-Principal Investigator of Project Viva, a unique U.S. pre-birth cohort study that has followed pregnant women and their children since 1999. She is also Principal Investigator and co-leader of the team assessing cardiometabolic, respiratory, and neurocognitive outcome measures on children enrolled 1996-7 in the Promotion of Breastfeeding Intervention Trial (PROBIT), a cluster-randomized trial of breastfeeding promotion in the Republic of Belarus.

Abstract

The possible combinations of matters related to fish consumption are many, but few, if any, fish consumption patterns optimize all domains. Fish provides a rich source of protein and other nutrients, but because of contamination by methylmercury and other toxicants, more fish intake often leads to greater toxicant exposure. In this talk, I will summarize the issue of fish consumption choice, with a focus on pregnancy and early childhood. I will also present results from an observational analysis of fish consumption during pregnancy and childhood cognition. From 1999-2002 we enrolled pregnant women into a prospective cohort, and followed their children since. At 24-28 weeks gestation, we estimated maternal fish intake using a semiquantitative food frequency questionnaire and collected blood. We assayed stored erythrocytes for total mercury (Hg) and plasma for fatty acids including n-3 docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). In mid-childhood, we administered verbal and nonverbal subscales of the Kauffman Brief Intelligence Test (KBIT) to children. We performed multivariable linear regression analyses adjusting for maternal and child characteristics, including home environment and maternal IQ. Finally, I will discuss results from a pilot randomized trial, in which we recruited 61 women in the greater Boston, Massachusetts area at 12–22 weeks gestation who consumed <=2 fish servings/month, and obtained outcome data from 55. We randomized participants to three arms:

Advice to consume low-mercury/high-DHA fish (n=18); Advice plus grocery store gift cards to purchase fish (n=17); or Control messages (n=20). At baseline and 12-week follow-up, we estimated intake of fish, DHA, and mercury using a 1-month fish intake food frequency questionnaire, and measured plasma DHA and blood and hair total mercury. We found that the educational intervention successfully increased consumption of fish and DHA but not mercury.

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Maternal Fish Intake during Pregnancy and Child Cognition – Emily Oken



HarvardPilgrim HealthCare Institute
Department of Population Medicine
Harvard Medical School

Should we advise pregnant women to eat fish? ?

- If so,
  - How much?
  - Which types?
  - How strong is the evidence?
- If not fish, what?

Why is this question so complex?

- 4 major perspectives have influenced fish consumption advice:
  - Toxicant risks, nutritional benefits, ecologic concerns, economic influences
- Complexities include:
  - Within each one, uncertainty exists
  - Different perspectives often in conflict
  - Previous advice (often from 1 perspective) has had unintended, adverse consequences

Toxicant exposure - complexities

- Multiple contaminants may co-occur, with different or interactive health effects
  - PCBs and other persistent organic compounds, heavy metals, “contaminants of emerging concern” such as pharmaceuticals, personal care products, and perfluorinated organic compounds
- Most studies (and advisories) focus on single contaminants

Toxicant exposure - complexities

- Toxicant levels vary!
  - Within fish species – FDA threshold
    - Swordfish (“do not eat”) – mean 1 ppm mercury, but some fish 0 ppm
    - Halibut (not listed) – mean 0.24 ppm, but up to 1.5 ppm
  - By source
    - Tilefish (“do not eat”) – high mercury if from Gulf of Mexico, low mercury if from Atlantic

Toxicant exposure - complexities

- Variable susceptibility to toxicities
  - Variation among individuals, also by stage of lifecourse
  - Fetus especially susceptible
  - US EPA/FDA advice specific to pregnancy, no advice for non-pregnant adults
  - Very limited information about effects on children
- Confounding by nutritional benefits

Fish is the primary dietary source of omega-3 long-chain polyunsaturated fatty acids

- Omega-3 LCPUFA:
  - Essential nutrients – we can't synthesize them, have to eat them
  - Necessary for fetal optimal fetal brain, eye development (DHA)
  - Most women eat too little: recommended 1400 mg DHA/week, US mean ~500 mg/wk

Nutrient benefits - complexities

- Multiple co-occurring nutrients: protein, iodine, vitamin D, selenium, etc.
  - Some studies suggest lean fish in pregnancy at least as beneficial for birth outcomes
- Nutrient levels vary across species.
  - What does a 6 ounce meal give you?
    - Shrimp: ~250 mg DHA
    - Pollock: ~700 mg DHA
    - Salmon: ~2500 mg DHA
- Confounding by contaminant risk
- Null results from supplement trials

DHA Supplementation in Pregnancy, Birth Outcomes & Bayley Scores

(Makrides et al, JAMA 2011)

Birth outcomes	**RR (95% CI)**
Birth <34wks	0.5 (0.3, 0.94)
Birth wt <2500 g	0.7 (0.4, 0.96)
NICU admission	0.6 (0.3, 0.97)

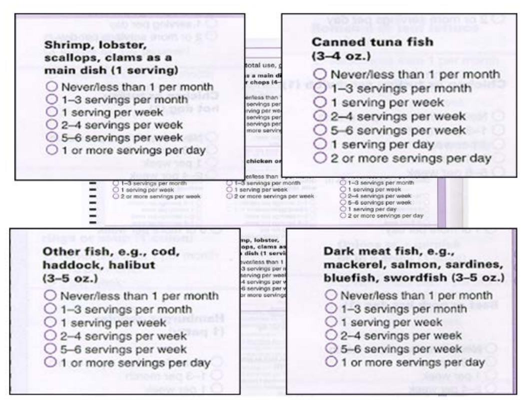
Cognition at 18 months	**Beta (95% CI)**
Cognition	0.01 (-1.4, 1.4)
Language	-1.4 (-3.1, 0.2)
Motor	0.08 (-1.2, 1.3)
Adaptive behavior	-1.5 (-3.2, 0.1)

Limitations of existing data on prenatal fish intake

- Most prior studies have studied one exposure (Hg) but not several (fish, Hg, DHA, Selenium)
  - Newer study from Seychelles that includes Hg, n-3 PUFA has small numbers, outcomes only among toddlers
- Confounding remains a concern (e.g. maternal education, IQ)
- Limited information on fish types

PROJECT Viva

- Prospective longitudinal cohort study of mothers and children
- Boston, MA area
- Enrollment 1999-2002 in 1st trimester of pregnancy


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

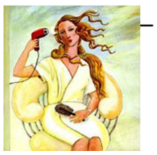
Other fish, e.g., cod, haddock, halibut (3–5 oz.)
- Never/less than 1 per month
- 1–3 servings per month
- 1 serving per week
- 2–4 servings per week
- 5–6 servings per week
- 1 or more servings per day

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

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Maternal Fish Intake during Pregnancy and Child Cognition – Emily Oken

PROJECT Viva

- Exposure biomarkers
  - Maternal erythrocytes collected at 26-28 weeks gestation (N~1600)
    - Total Hg (Direct Mercury Analyzer 80)
    - Fatty acids (Gas Chromatography)
    - Selenim (DRC-ICP-MS)
  - Maternal hair at delivery (N~200)



Results in 6 month old infants (n=135)

	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

Oken E, et al. Env Health Perspect 2005;113:1376-80.

Results in 6 month old infants (n=135)

	Maternal 2nd tri fish intake (per svg/wk)	Maternal hair mercury at delivery (per ppm)
	Change in 6 month VRM score	
Fish	2.8 (0.2, 5.4)	---
Mercury	---	-4.0 (-10.0, 2.0)
Fish & mercury	4.0 (1.3, 6.7)	-7.5 (-13.7, -1.2)

Adjusted for maternal age, race/ethnicity, education, marital status; infant sex, gestational age, fetal growth, breastfeeding, age at testing

Oken E, et al. Env Health Perspect 2005;113:1376-80.

Results at age 3 years (n=341) – Language and visual motor function

Child Test Score	MV	MV + Hg
PPVT		
Fish > 2x/wk	1.2 (-3.5, 6.0)	2.2 (-2.6, 7.0)
Fish <= 2x/wk	-2.1 (-5.7, 1.4)	-1.8 (-5.4, 1.8)
Fish never	Referent	Referent
WRAVMA total		
Fish > 2x/wk	5.3 (0.6, 9.6)	6.4 (2.0, 10.8)
Fish <= 2x/wk	1.1 (-2.2, 4.4)	1.5 (-1.8, 4.7)
Fish never	Referent	Referent

*MV adjustment = Child: fetal growth, gestation length, breastfeeding duration, birth order, language; Maternal: PPVT score, age, BMI, race/ethnicity, education, marital status, smoking; Paternal: education.

Results at age 3 years (n=341)– Language and visual motor function

Child test score	MV	MV + fish
PPVT		
Hg top decile	-4.0 (-8.0, 0.0)	-4.5 (-8.5, -0.4)
Hg < 90th %ile	Referent	Referent
WRAVMA total		
Hg top decile	-3.5 (-7.2, 0.2)	-4.6 (-8.3, -0.9)
Hg < 90th %ile	Referent	Referent

*MV adjustment = Child: fetal growth, gestation length, breastfeeding duration, birth order, language; Maternal: PPVT score, age, BMI, race/ethnicity, education, marital status, smoking; Paternal: education.

Summary: findings to date

- Higher maternal prenatal fish intake associated with
  - Improved visual memory at 6 months
  - Improved expressive language and visual motor function at 3 years
- Opposite findings for blood Hg
- Estimates for fish and Hg each strengthened with mutual adjustment
- No associations with blood n-3 PUFA
- Small numbers, young children

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Maternal Fish Intake during Pregnancy and Child Cognition – Emily Oken

Age 7 year data

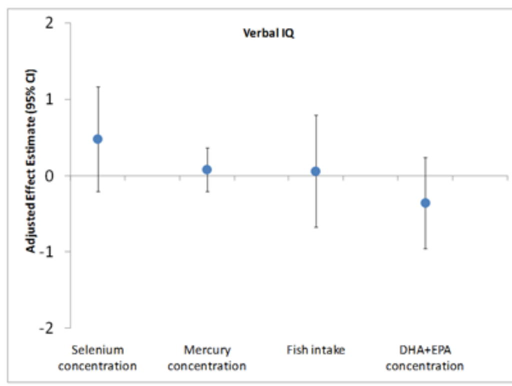
- Selenium assayed
- Larger N
  - ~650 (depending on exp/outcome)
- More outcomes
  - Verbal and nonverbal IQ (KBIT)
  - Visual motor function (WRAVMA)
  - Visual memory (WRAML)
  - Behavior (SDQ), Executive function (BRIEF)
- New covariates
  - Maternal IQ, home stimulation

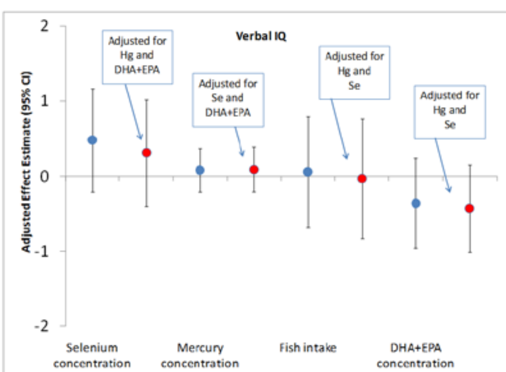
Exposures

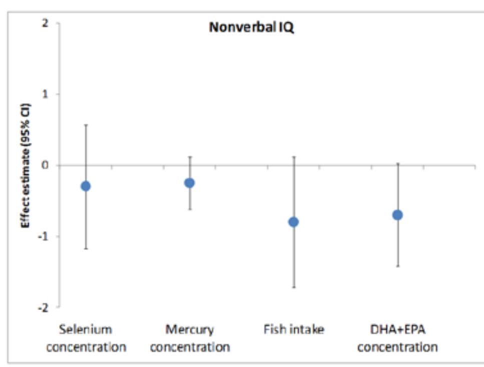
Diet	Mean (range)
Fish intake (svg/week)	1.4 (0-20)
EPA+DHA intake (mg/day)	160 (0-2700)
Biomarkers	**Mean (range)**
RBC Selenium (ng/ml)	202.8 (44-406)
RBC Hg (ng/g)	3.9 (0.06-38.2)
Hair Hg (n=66) (ppm)	0.56 (0.04-1.89)
EPA+DHA RBC Conc (%)	5 (0.2-11)

Some correlations

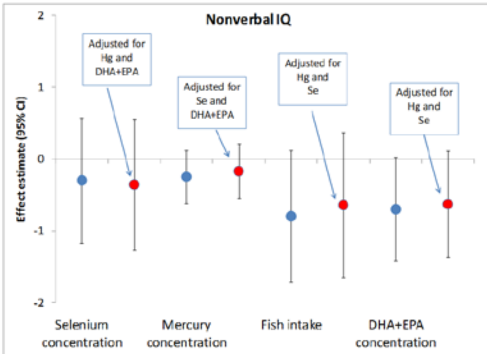
	Se	Hg	Fish	DHA+ EPA Intake	DHA+ EPA RBC
Se	1	0.14 <0.001	0.10 0.005	0.09 0.006	0.07 0.03
Hg		1	0.51 <0.001	0.50 <0.001	0.39 <0.001
Fish			1	0.83 <0.001	0.32 <0.001
DHA+EPA intake				1	0.37 <0.001
DHA+EPA RBC					1

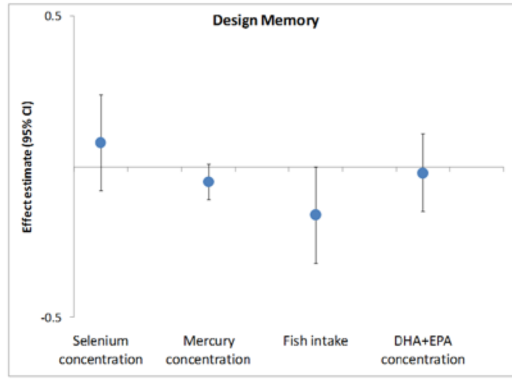


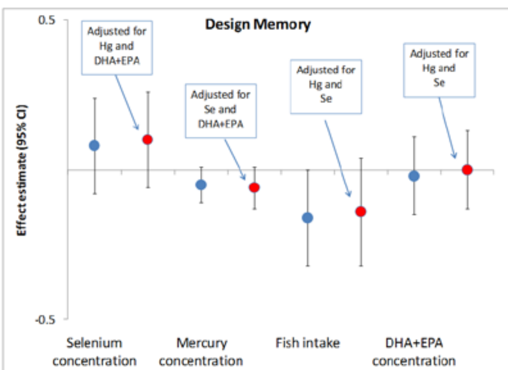


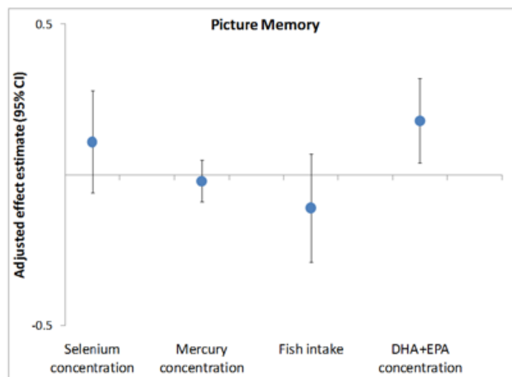


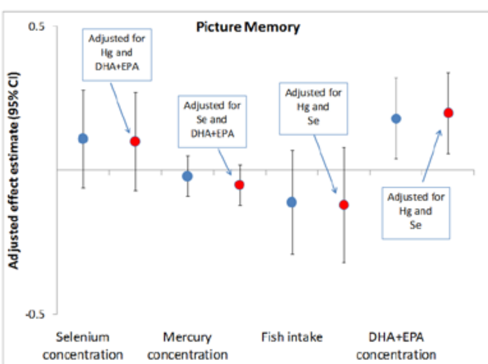
SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Maternal Fish Intake during Pregnancy and Child Cognition – Emily Oken











Other results

- Overall null results for other outcomes:
  - Visual motor ability
  - Executive function
  - Behaviors
- Similar results when outcomes dichotomized as lowest 10% vs. higher
- No major differences unadjusted vs. adj.
- No evidence for interactions
  - By sex
  - Se x Hg

Summary of findings

- Overall, no associations of child cognition and behavior with prenatal
  - Fish intake
  - Mercury levels
  - Selenium levels
- Given null results, unable to demonstrate any interactions between mercury and Se or DHA+EPA
- Higher blood DHA+EPA associated with better visual memory
  - One of many exposures x outcomes

Conclusions

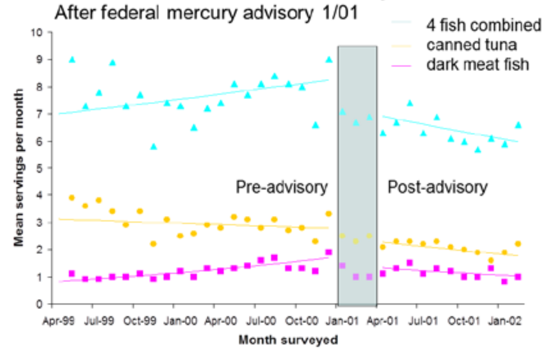
- Results differ from those at earlier ages
  - Lack of persistence?
  - Different population?
- No evidence that prenatal Hg or Se exposure influenced child cognition or behavior at age 7 years in a population with low Hg levels
- Some evidence that prenatal fatty acid status associated with improved visual memory in childhood

What is Optimal Fish Consumption Advice?

- Communicate harms only – assume switch to lower Hg fish to achieve benefit

Decline in fish consumption

After federal mercury advisory 1/01



Oken E, Kleinman K, Berland WE, Simon S, Rich-Edwards JW, Gillman MW. Obstetrics and Gynecology 2003;102(2):346-351.

What is Optimal Fish Consumption Advice?

- Communicate harms only – assume switch to lower Hg fish to achieve benefit
- Communicate benefit only – assume benefit outweighs harms

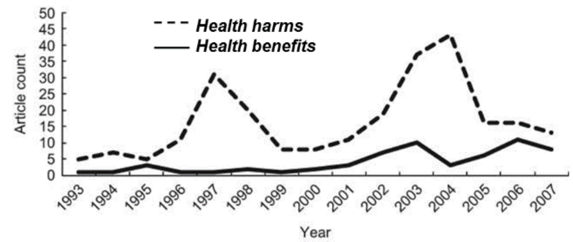
"Increase the amount and variety of seafood consumed by choosing seafood in place of some meat and poultry."

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Maternal Fish Intake during Pregnancy and Child Cognition – Emily Oken

What is Optimal Fish Consumption Advice?

- Communicate harms only – assume switch to lower Hg fish to achieve benefit
- Communicate benefit only – assume benefit outweighs harms
- Communicate harms and benefits

The Press

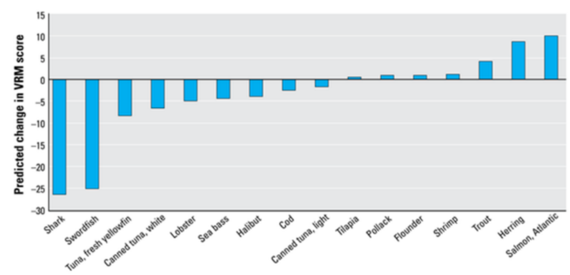


Grenier et al, Public Health Nutr 2010

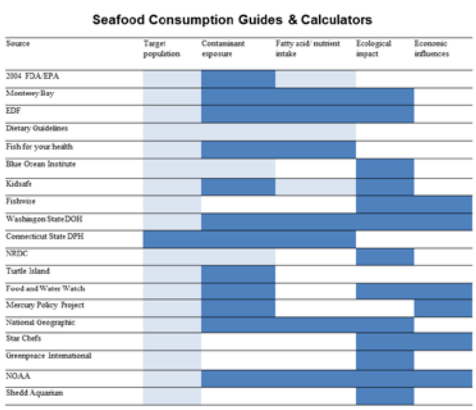
What is Optimal Fish Consumption Advice?

- Communicate harms only – assume switch to lower Hg fish to achieve benefit
- Communicate benefit only – assume benefit outweighs harms
- Communicate harms & benefits
- Species specific harm-benefit measures (e.g., net effect)

Balancing health harms and benefits



Source: Ginsberg & Toal, EHP, 2009



Oken E, Choi AL, Karagas MR, Mariën K, Rheinberger CM, Schoeny R, Sunderland E, Korrick S. Environ Health Perspect. 2012 Jun;120(6):790-8.

No wonder women are confused

- "That's the main thing I find confusing – so, like, salmon, that's a pretty big fish, so maybe we shouldn't eat it, but then maybe we should eat it because, like it's higher in mercury but it's also higher in good fat, so don't eat it, but no, do eat it."
- "You hear that fish is so good for you, yet on the other hand it's filled with mercury and we need to look out for that…but yet we're supposed to eat it at least twice a week."

Bloomingdale A, Guthrie LB, Price S, Wright RO, Platek D, Haines J, **Oken E**. A qualitative study of fish consumption during pregnancy. American Journal of Clinical Nutrition 2010 Nov;92(5):1234-40.

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT

Maternal Fish Intake during Pregnancy and Child Cognition – Emily Oken

Even MD's are confused

Dear Dr. Oken,

I am sorry to bother you, but my wife (a nephrologist) and I (a thoracic surgeon) read your chapter and thought you would be the best person to possibly answer our question.

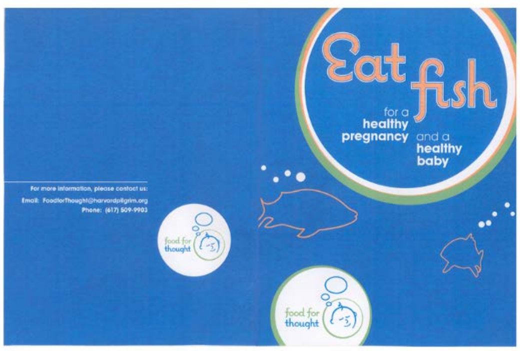
My wife is breastfeeding our 2 month old and last night had grouper in a restaurant not realizing that this is a high mercury fish. **Is this worrisome and should she stop breastfeeding?**

Can women act on a nuanced message?

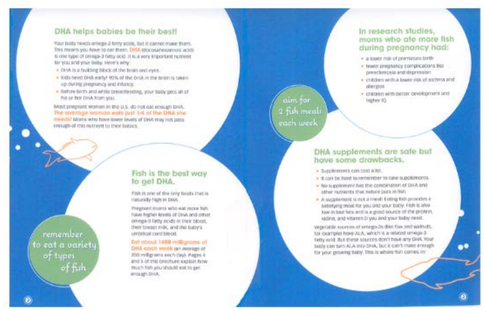
food for thought

food for thought

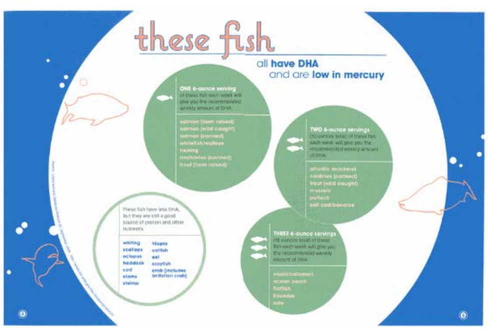
Intervention Brochure



food for thought



food for thought



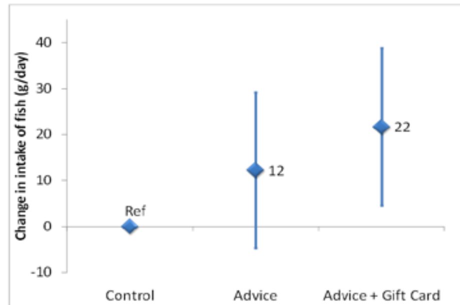
food for thought

Untitled

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Maternal Fish Intake during Pregnancy and Child Cognition – Emily Oken

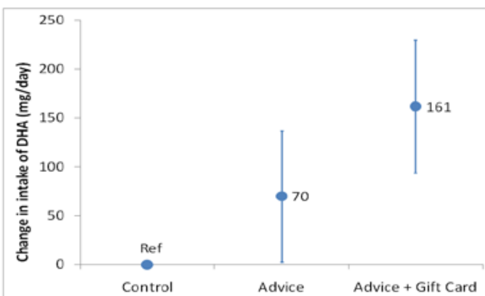
Wallet card

Fish Intake



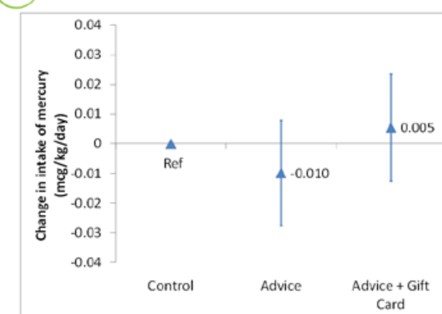
Oken et al. Nutrition Journal 2013, 12:33

DHA Intake



Oken et al. Nutrition Journal 2013, 12:33

Mercury Intake



Oken et al. Nutrition Journal 2013, 12:33

How much fish do people eat?

Depends on how you ask

	1 question	4 questions	36 questions
Fish (sv/wk)	0.28	0.9	1.4
DHA (mg/d)	22	69	97
Hg (mcg/d)	0.42	1.25	1.60
200 mg/d DHA	0%	27%	36%

Oken et al. Public Health Nutr. 2013 Jul 24:1-11

Thanks!

US EPA

Funders:

- NIEHS (R01ES016314)
- The HSPH Kresge Center for Environmental Health (P30ES000002)
- Harvard Clinical Nutrition Research Center (P30DK040561)

Colleagues:

- Robert Wright
- Chitra Amarasiriwardena
- Sheryl Rifas-Shiman
- David Bellinger,
- Matthew Gillman
- Lauren Guthrie
- Sarah Price
- Arienne Bloomingdale
- Jess Haines
- Deb Platek

Questions and Answers

Note: There were no questions because the moderator asked that any questions be held until the general Q&A session at the end of this panel.

FDA Assessment of Net Effects on Neurodevelopment from Eating Commercial Fish during Pregnancy

Phil Spiller, U.S. Food and Drug Administration

Biosketch

Philip Spiller has been with the U.S. Food and Drug Administration (FDA) since 1981. He spent the first nine years in the Office of Legislative Affairs in the Office of the Commissioner, becoming the Deputy to the Director of that office. In 1990, Mr. Spiller became a special assistant to the Commissioner of the FDA on seafood-related matters. In 1992, he became Special Assistant to the Director of FDA's newly formed Office of Seafood. His major responsibility involved development of the new preventive control program for seafood safety, known as Hazard Analysis Critical Control Point (HACCP). Mr. Spiller became the Director of the Office of Seafood in 1994. In 2007, he became Senior Advisor for Special Projects to the Director of FDA's Center for Food Safety and Applied Nutrition in order to devote time to managing development of a quantitative assessment of the health effects of methylmercury in fish. That assessment was published as a draft in 2009 and then updated in June 2014. In recent years, he has served in a variety of "acting" positions in the Center for Food Safety and Applied Nutrition, including acting director of the dietary supplement program, acting Deputy Center Director, and presently acting Director of the Office of Nutrition, Labeling, and Dietary Supplements. Mr. Spiller has a law degree from Boston College and an undergraduate degree from the University of Virginia.

Abstract

On June 10, 2014, the FDA issued a quantitative assessment that estimates effects from commercial fish consumption during pregnancy on the developing nervous system of the fetus. The assessment was originally intended to address the likelihood of harm to the fetus from methylmercury in those fish. However, research results in the past decade consistently report beneficial associations between fish consumption during pregnancy and fetal neurodevelopment even though the fish contain methylmercury. These results raise important questions about when fish consumption during pregnancy might be harmful and when it might be beneficial. The assessment attempts to address these questions by estimating the "net effects" that fish consumption can have on fetal neurodevelopment. "Net effects" contain both adverse contributions from methylmercury at U.S. levels of exposure plus beneficial contributions from fish, presumably from one or more nutrients in the fish. Among other things, the assessment modeled net effects from 47 individual commercial fish species and market types. Almost all species and market types are estimated to be net beneficial at relatively low levels of consumption, although the size of any net benefit is smaller than it otherwise would be due to methylmercury. This beneficial net effect increases with consumption until a peak benefit is reached. Consumption beyond that amount causes the net benefit to become smaller as exposure to methylmercury increases. If consumption is great enough, the net effects become adverse. This sequence of increasing benefit, followed by decreasing benefit, followed by adverse effects, is estimated to occur for most species of commercial fish. The implications for risk management are significant. It should be possible to advise pregnant women about how minimize risk from methylmercury and, at the same time, get the most benefit to neurodevelopment that fish could provide to their children.

FDA Assessment of Net Effects on Neurodevelopment from Eating Commercial Fish During Pregnancy – Phil Spiller

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FDA Assessment of Net Effects on Neurodevelopment from Eating Commercial Fish During Pregnancy

Philip Spiller
Center for Food Safety and Applied Nutrition
U.S. Food and Drug Administration
September 23, 2014

U.S. Food and Drug Administration
Protecting and Promoting Public Health
www.fda.gov

FDA's Mission Relating to Fish

- FDA has federal regulatory authority responsibility for human food safety of commercial fish.
  - Fish may be removed from interstate commercial if they contain a toxic substance in an amount that may render the fish injurious to health.
- The Challenge: what is the likelihood of injury, and to whom, from eating commercial fish containing MeHg?
  - A neurotoxin that is in essentially all fish

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1990's: Our Attention Shifts To Developing Fetus

- Our focus was originally on the general population (1970's)
- But growing concern (as reflected by focus on research) on consequences of prenatal exposure since the fetus is more sensitive to MeHg than the adult.
- Key issue: Whether subclinical effects are occurring in the developing fetus and if so, under what circumstances and how significant they might be.
  - 1994: Without knowing the answer, FDA issued first advice to pregnant women to limit consumption of fish higher in MeHg.

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FDA Risk Management Focuses on Advice to Pregnant Women as Matter of Prudence

2001: First major advice (involving commercial fish)
- Safe to eat up to 12 oz/wk of fish during pregnancy.
- 4 fish to avoid (shark; swordfish; king mackerel; tilefish)
- *Caveat:*
  - -- Risk (likelihood & severity) over 12 oz: *not estimated.*
  - -- Risk (likelihood & severity) at 12 oz: *not estimated.*
  - -- Risk (likelihood & severity) below 12 oz: *not estimated.*

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FDA Started Considering Quantitative Risk Assessment for MeHg (2004-5)

- To estimate:
  - ***likelihood*** ***of neurodevelopmental effects; and***
  - ***size*** ***of those effects…***

  through range of U.S. exposures to MeHg that are occurring from mothers' consumption of commercial fish during pregnancy.

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But Then…. Studies Published Beginning in 2004

- Eating fish during pregnancy associated with better cognitive outcomes in offspring.
  - Eating more than 12 oz/wk generally associated with better outcomes than eating less (but greatest gains associated with less than 12).
- Most studies that looked also found adverse associations with MeHg.
  - Found evidence of both beneficial and adverse effects occurring at the same time.

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These Findings Lead Us (Eventually) To Think "Net Effects"

Net Effects Are:

- The difference between eating fish during pregnancy and eating no fish (in terms of neurodevelopment).
- The sum of
  - Adverse effects from MeHg independent of any beneficial effect from fish; and
  - Beneficial effects independent of any adverse effect from MeHg.

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Fast Forward: July 2014 European Food Safety Agency Opinion

- "Scientific Opinion on the Health Benefits of Seafood (fish and shellfish) Consumption in Relation to Health Risks Associated with Methylmercury"
- Conclusion: up to 3-4 servings per week during pregnancy has been associated with better functional outcomes of neurodevelopment in children compared to no consumption of seafood.
-

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New Questions for Us:

1. *When are commercial fish during pregnancy beneficial to neurodevelopment and when are they adverse?*
2. *When effects are beneficial, how big are they? When adverse, how big are the deficits?*

- To address these questions, we needed a new approach that would estimate overall, "net" effects from eating fish.

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Our "Net Effects" Approach

1. Estimate dose-response function(s) for adverse effects on cognitive development from MeHg, independent of any benefit;
2. Estimate D/R function(s) for beneficial effects on cognitive development (presumably from one or more nutrients), independent of MeHg.
3. Calculate D/R function(s) for net effects (adverse and beneficial effects added together).

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Key Modeling Decisions

- Assess specific N/D endpoints for which we can model both beneficial and adverse D/R's for that endpoint.
  - So far: IQ, early age verbal development; later age verbal development
- Conduct both population level modeling and species-by-species modeling (47 species);

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Key Modeling Decisions (2)

- **MeHg:**
  - D/R's for MeHg are linear and indefinite;
  - Probably no threshold. Adverse effects start at lowest exposure;
- **Benefits:**
  - D/R's for beneficial effects are non-linear and reach a plateau;
  - Benefits don't start at lowest possible consumption. Need circa 2 oz/wk for beneficial effect to begin.
  - Model both (a) "fish;" and (b) omega-3 fatty acids as sole source.

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SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
FDA Assessment of Net Effects on Neurodevelopment from Eating Commercial Fish During Pregnancy – Phil Spiller

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Species-by-Species Modeling

- 8 models:
  - 2 IQ: fish as a "package;" omega-3 as sole source;
  - 2 IQ with 20% more MeHg in every fish
    - Fish/"package;" omega-3 as sole source.
  - 2 early age verbal: fish/"package;" omega-3;
  - 2 later age verbal: fish/"package:" omega-3;
- For IQ, used the more toxic of 2 D/R's for MeHg

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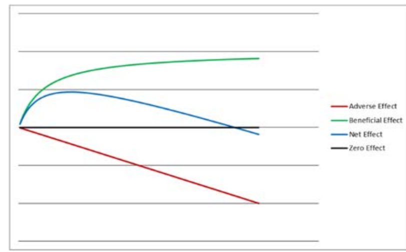
Species-by-Species Modeling for a Typical Commercial Fish



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Population Level Estimates

Changes in IQ through 99.9% of the population

- **Average** for all children: +0.67 (0.38- 1.34) IQ pts
- **Net adverse**: approx 5%
  - Includes both high consumption of high MeHg fish and very low consumption of any fish (below 2 oz/wk).
  - All net effects are a fraction of an IQ point
- **Flat**: approx 15% (central estimates)
  - Women who eat no fish
- **Net beneficial**: approx 80%
  - Net beneficial effects range from fraction of an IQ point to 3+ IQ points

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Net Effects Estimates in the FAO/WHO Risk-Benefit Assessment

More than 70 types of fish:

- All are net beneficial through at least 24.5 oz/week with lower bound estimate for MeHg.
- All species below 0.5ppm MeHg net beneficial through at least 24.5 oz/week with upper bound estimate for MeHg.
  - Some high MeHg fish are net adverse immediately when upper bound for MeHg is used (marlin, orange roughy, bigeye tuna, king mackerel, shark, swordfish).

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How to Find

The Assessment:

www.fda.gov/Food/PopularTopics/ucm341987.htm

Located under "Spotlight" on that page

Me:

Philip.Spiller@fda.hhs.gov

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Questions and Answers

Note: There were no questions because the moderator moved along to the next speaker on this panel.

Risk-Benefit of Consuming Lake Erie Fish

Satyendra Bhavsar, Ontario Ministry of the Environment and Climate Change

Biosketch

Dr. Satyendra Bhavsar is a Research Scientist with the Fish Contaminant Monitoring Program of the Ontario Ministry of the Environment and Climate Change. He represents the Ministry at various provincial, national, and international committees on contaminants. He is a Professional Engineer and received his Ph.D. in Chemical Engineering and Environmental Engineering from the University of Toronto. Dr. Bhavsar's research focuses on studying contaminant fate, transport, food web dynamics, and exposure to humans through fish consumption. The overarching goal of his work is to guide policies and management actions regarding contaminants in the environment, in general, and for safe human consumption of fish, in specific.

Abstract

Fish consumption is promoted as a healthy way to obtain essential fatty acids in the diet, yet the risk of ingesting harmful contaminants remains a concern. At present, the risks and benefits of consuming fish from the Great Lakes, which sustain important commercial and recreational fisheries, are unclear. We report the concentration of contaminants and beneficial fatty acids in 146 skinless fillets of 15 fish species from Lake Erie and assess whether recommended fatty acid dietary requirements can be met by safe fish consumption. A simulated consumption advisory (maximum recommended number of meals per month) was calculated for each sample, and used to calculate the maximum amount of beneficial fatty acids (EPA+DHA) that would be consumed if the advisory was followed. These beneficial fatty acids are n-3 eicosapentaenoic acid (EPA) and n-3 docosahexaenoic acid (DHA). Large, fatty species had the highest EPA+DHA content, but had the most restrictive advisories due to high polychlorinated biphenyl (PCB) concentrations. To minimize contaminant exposure (e.g., PCBs) while maximizing EPA+DHA intake, consumers should consider small lake whitefish and lake trout, small panfish species, and/or walleye. While very few species had EPA+DHA content sufficient to safely meet the highest dietary guidelines, consumption of certain Lake Erie fish, within the limits of our simulated fish consumption advisories, can be a good supplemental source of beneficial fatty acids.

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Risk-Benefit of Consuming Lake Erie Fish – Satyendra Bhavsar

Risk-benefit of consuming Lake Erie fish

Margaret Neff, **Satyendra Bhavsar**, Felicity Ni, David Carpenter, Ken Drouillard, Aaron Fisk, Michael Arts

Ontario Ministry of the Environment and Climate Change
University of Toronto, University at Albany
University of Windsor, Ryerson University

Ontario

No disclaimer!

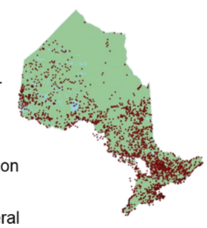
Ontario

PROGRAM BACKGROUND

Ontario

Ontario's Fish Contaminant Monitoring Program

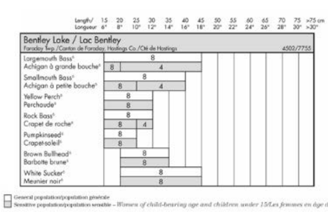
- Since 1970s
- Various contaminants including emerging
- Over 2300 locations across Ontario
- Partnership/collaboration with MNR and other agencies
- Assesses health risk based on health protection guidelines developed by Health Canada
- Develop fish consumption advisories for general and sensitive populations based on most restrictive contaminant
- Communicate risk to the public through consumption advisories

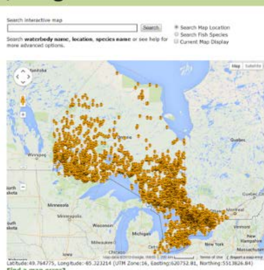


Ontario

Guide to Eating Ontario Sport Fish

www.ontario.ca/fishguide



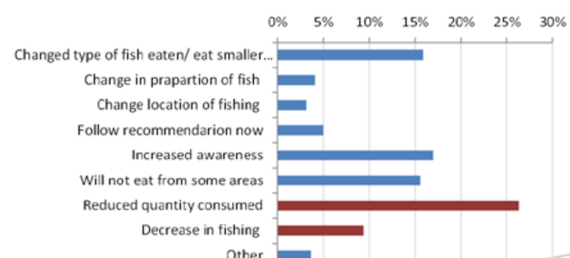


Interactive map available since 2011

Ontario

Ontario's sport fish consumption survey

Has information in the Guide change your fish consumption habits?



Ontario

Eating fish is healthy

- Excellent source of protein, vitamins and minerals
- Contain Omega-3 fatty acids (eg, EPA and DHA) essential for optimal brain and cardiovascular development
  - Not made in our body, need to get them from our diet
- Sport fishing contributes to a healthy life style
- For subsistence fishers (eg, First Nations), fish consumption is a part of their culture

Various health agencies including WHO, American Heart Association, and Health Canada recommend that adults eat fish (particularly fatty fish) at least two times a week

Ontario

Limitation: Omega-3 data availability

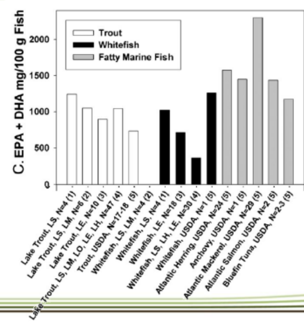
Risks and Benefits of Consumption of Great Lakes Fish

Mary E. Turyk,[1] Satyendra P. Bhavsar,[2] William Bowerman,[3] Eric Boysen,[4] Milton Clark,[5] Miriam Diamond,[6] Donna Mergler,[7] Peter Pantazopoulos,[8] Susan Schantz,[9] and David O. Carpenter[10]

CONCLUSIONS: Our knowledge of Great Lakes fish has critical gaps, particularly regarding the benefits of consumption. A risk–benefit analysis requires more information than is currently available on the concentration of omega-3 fatty acids in Great Lakes fish and their absorption by fish eaters in addition to more information on the social, cultural, and health consequences of changes in the amount of fish consumed.

Ontario

Great Lakes Fish ~ Marine Fish



Ontario

RISK BENEFIT FOR LAKE ERIE FISH

Ontario

Why Lake Erie?

- Fresh water commercial fishery in Lake Erie is the largest in the Great Lakes and Canada
- Lake Erie is the most popular Great Lake amongst U.S. anglers for recreational fishing

Ontario

Data collection: FAs & Contaminants

- 15 species sampled
- Total of 146 samples

Species	Total N	Length (cm)	Weight (g)	Total Lipid (%)	Sample Sizes: Sex NS	Sex F	Sex M	Season Spring	Season Summer	Season Fall	NS	Location LE1	LE2	LE2a	LE3	LE4
Black Crappie	5	22.1 (2.1)	197.4 (54.0)	4.3 (0.4)		4	1			5				5		
Bluegill	5	17.0 (2.0)	109.0 (49.0)	4.1 (0.4)		2	3		1	4						5
Channel Catfish	13	49.5 (10.0)	1546.5 (1132.7)	21.7 (10.3)		8	5	4	2	7		5	5	3		
Coho Salmon	2	66.6 (6.4)	3933.5 (1287.6)	21.7 (7.4)		1	1		1	1					2	
Lake Trout	10	52.7 (19.5)	2617.7 (2422.6)	22.3 (9.6)		2	8		10						10	
Lake Whitefish	18	50.7 (4.7)	1334.4 (415.0)	30.7 (11.6)	1	7	10	10		8		7	6		5	
Largemouth Bass	10	31.9 (7.8)	578.1 (464.6)	3.7 (0.7)		1	9		2	8						10
Northern Pike	10	57.5 (8.9)	1025.5 (430.5)	3.3 (0.6)		8	2		1	9						10
Pumpkinseed	5	15.8 (1.1)	95.8 (18.8)	4.7 (0.1)		3	2	5						5		
Rainbow Trout	6	60.0 (15.8)	2733.7 (1493.9)	28 (12.5)	1	3	2			6			6			
Smallmouth Bass	13	36.6 (3.0)	833.0 (215.9)	6.9 (3.4)	1	7	5		13					13		
Walleye	21	54.8 (9.9)	1829.0 (969.8)	10.8 (9)	3	14	4	19		2		7	7		7	
White Bass	16	31.1 (5.1)	458.5 (241.2)	13.6 (8.1)	2	8	6	2	4	10		5	5		6	
White Perch	13	25.3 (2.9)	277.9 (85.4)	17.2 (5.9)		8	5	2	7	2	2	4	3	3	3	
Yellow Perch	5	19.8 (4.6)	106.2 (77.8)	3.6 (0.6)		4	1		2	3						5

Ontario

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Risk-Benefit of Consuming Lake Erie Fish – Satyendra Bhavsar

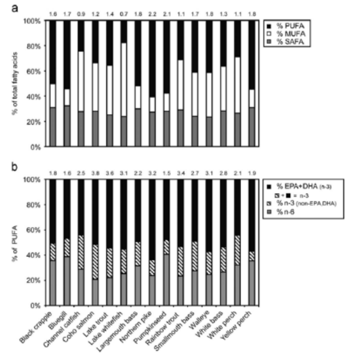
FA results

Mean fatty acid content (mg/100 g ww) ± standard deviation in Lake Erie fish species.

Species	LIN	ALA	EPA	DHA	EPA+DHA	n-3	n-6	n-3:n-6	SAFA	MUFA	PUFA	PUFA:SAFA	FA	Lipid
Black crappie	16 ± 4	7 ± 2	15 ± 4	111 ± 4	126 ± 5	161 ± 11	89 ± 7	1.8 ± 0.2	156 ± 17	98 ± 24	252 ± 12	1.6 ± 0.2	505 ± 48	888 ± 89
Bluegill	29 ± 11	12 ± 5	17 ± 3	89 ± 12	106 ± 13	139 ± 20	87 ± 10	1.6 ± 0.2	138 ± 17	58 ± 10	231 ± 29	1.7 ± 0.1	427 ± 52	746 ± 75
Channel catfish	80 ± 56	92 ± 58	161 ± 75	162 ± 65	398 ± 214	660 ± 377	275 ± 161	2.5 ± 0.3	1159 ± 764	2121 ± 1624	950 ± 544	0.9 ± 0.1	4230 ± 2905	5543 ± 3128
Coho salmon	10 ± 4	0	275 ± 92	660 ± 201	944 ± 293	1459 ± 478	392 ± 170	3.8 ± 0.4	1570 ± 677	2188 ± 1074	1851 ± 648	1.2 ± 0.1	5608 ± 2399	6675 ± 2597
Lake trout	8 ± 4	0.4 ± 1	256 ± 145	639 ± 292	896 ± 435	1323 ± 703	381 ± 226	3.6 ± 0.4	1213 ± 668	2084 ± 1396	1706 ± 924	1.4 ± 0.1	5003 ± 2976	6145 ± 3341
Lake whitefish	122 ± 93	51 ± 45	373 ± 217	341 ± 119	714 ± 330	961 ± 432	323 ± 136	3.1 ± 0.8	1828 ± 861	4679 ± 2602	1302 ± 563	0.7 ± 0.1	7809 ± 4009	9502 ± 4761
Largemouth bass	9 ± 9	4 ± 0	13 ± 9	98 ± 31	111 ± 36	153 ± 47	71 ± 25	2.2 ± 0.5	128 ± 37	78 ± 29	225 ± 70	1.8 ± 0.3	431 ± 127	755 ± 145
Northern pike	5 ± 6	3 ± 5	21 ± 7	113 ± 32	134 ± 38	160 ± 47	50 ± 14	3.2 ± 0.5	93 ± 17	42 ± 9	211 ± 60	2.2 ± 0.3	350 ± 83	658 ± 130
Pumpkinseed	21 ± 5	5 ± 0.5	27 ± 4	115 ± 24	142 ± 26	176 ± 28	119 ± 8	1.5 ± 0.3	145 ± 6	75 ± 10	299 ± 21	2.1 ± 0.2	519 ± 19	985 ± 66
Rainbow trout	210 ± 106	189 ± 103	357 ± 177	613 ± 267	967 ± 440	1395 ± 625	435 ± 218	3.4 ± 0.6	1875 ± 1025	2618 ± 1671	1928 ± 900	1.1 ± 0.2	6422 ± 3483	8587 ± 4392
Smallmouth bass	20 ± 32	12 ± 22	36 ± 25	172 ± 78	208 ± 102	313 ± 166	123 ± 77	2.7 ± 0.4	246 ± 126	437 ± 365	438 ± 243	1.7 ± 0.2	1121 ± 728	1584 ± 855
Walleye	52 ± 119	49 ± 114	141 ± 185	250 ± 171	391 ± 351	532 ± 518	190 ± 236	3.1 ± 0.4	406 ± 401	734 ± 982	725 ± 756	1.8 ± 0.2	1864 ± 2135	2627 ± 2786
White bass	47 ± 43	55 ± 54	169 ± 124	264 ± 204	434 ± 322	607 ± 487	225 ± 188	2.8 ± 0.3	688 ± 581	949 ± 1016	862 ± 678	1.3 ± 0.2	2499 ± 2267	3268 ± 2632
White perch	6 ± 3	0.4 ± 0.5	215 ± 80	225 ± 100	440 ± 164	685 ± 278	322 ± 133	2.1 ± 0.3	932 ± 375	1614 ± 715	1008 ± 406	1.1 ± 0.2	3554 ± 1474	4117 ± 1696
Yellow perch	9 ± 5	4 ± 3	22 ± 4	109 ± 20	131 ± 24	148 ± 67	81 ± 16	1.9 ± 0.6	131 ± 27	64 ± 26	230 ± 32	1.8 ± 0.1	425 ± 84	725 ± 100

Ontario

FA results



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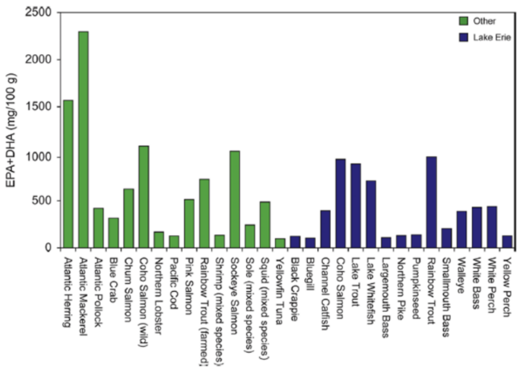
FA: Erie vs marine & freshwater seafood



Simulated fish consumption advisories

- Advisory calculated for each individual fish sample
- Max number of fish meals/month (up to 32) that can be safely consumed based on contaminant conc
- Meal size: 227 g (8 oz)
- Used OMOE advisory benchmarks; similar to US Gr Lk States
- Separate benchmarks for the general & sensitive population (i.e., women of child-bearing age and children under the age of 15).

Ontario

Compared to suggested EPA+DHA Intake

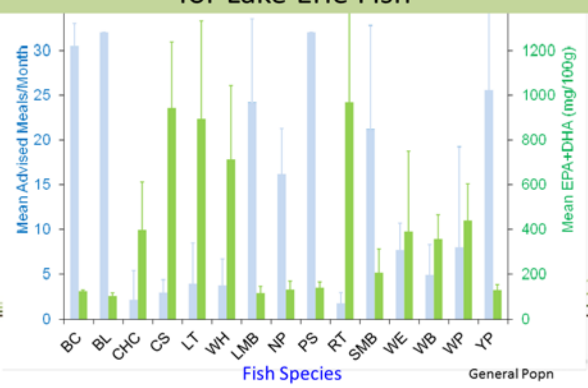
- Calculated FA intake if advisories followed and compared with the following recommendations

Source	Recommendation	EPA+DHA mg/month
American Dietetic Association/Dietitians of Canada	500 mg/day EPA+DHA	15000
AFSSA[a], CNERNA[b] & CNRS[c]	500 mg/day EPA+DHA	15000
Superior Health Council of Belgium	667 mg/day EPA+DHA	20010
International Society for the Study of Fatty Acids and Lipids	500 mg/day EPA+DHA	15000
United Kingdom Scientific Advisory Committee on Nutrition	450 mg/day EPA+DHA	13500
World Health Organization	1-2 servings/week of 200-500 mg EPA+DHA	1600-4000

[a] Agence française de sécurité sanitaire des aliment
[b] Centre national d'études et de recommandations sur la nutrition et l'alimentation
[c] Centre national de la recherche scientifique

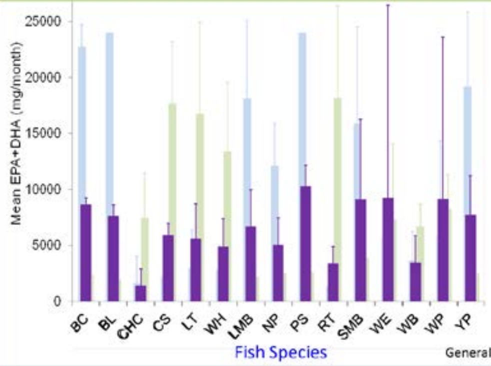
Ontario

Advisory & EPA+DHA content for Lake Erie Fish

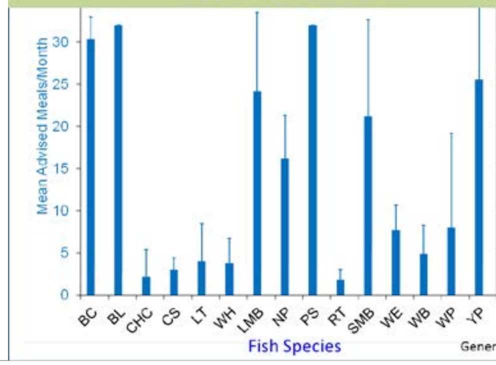


SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Risk-Benefit of Consuming Lake Erie Fish – Satyendra Bhavsar

EPA+DHA intake for Lake Erie Fish

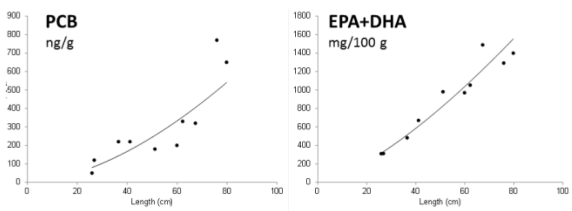


Advisory & EPA+DHA content for Lake Erie Fish



PCB and EPA+DHA vs Fish Length

Lake Trout



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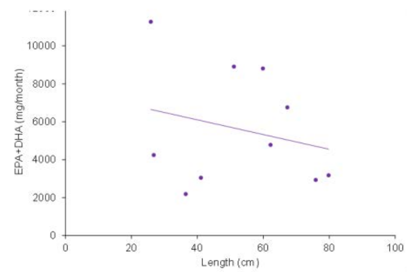
EPA+DHA intake vs Fish Length

Lake Trout, General Population



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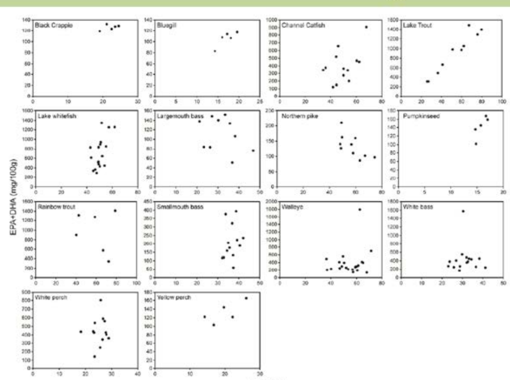
EPA+DHA vs Fish Length



Summary

- All 15 species had nutritionally desirable PUFA:SAFA (>0.4) and n3:n6 (>1).
- Large, fatty species had the highest EPA+DHA content, but had the most restrictive consumption advisories due to high PCB concentrations.
- To minimize contaminant exposure while maximizing EPA+DHA intake, consumers should consider small lake whitefish and lake trout, small panfish species, and/or walleye.
- However, very few species had an EPA+DHA sufficient to safely meet highest dietary guidelines while following advisories.
- Consumption of certain Lake Erie fish within the limits of our simulated fish consumption advisories, can be a good supplemental source of beneficial n-3 long chain PUFA.

Ontario

Questions and Answers

Note: There were no questions because the moderator moved along to the next speaker on this panel.

Updated Approach for Balancing the Risks and Benefits of Fish Consumption on Neurodevelopmental Endpoints

Gary Ginsberg, Connecticut Department of Public Health

Biosketch

Dr. Gary Ginsberg is a toxicologist at the Connecticut Department of Public Health, where he is the lead toxicologist on site risk assessments for remedial programs and evaluation of contaminants in consumer products, the built environment, food products (including fish), and a variety of other media and exposure sources. Dr. Ginsberg is adjunct faculty at the Yale School of Public Health and is assistant professor of community medicine at the University of Connecticut Health Center campus. He has served on a number of U.S. Environmental Protection Agency advisory committees and National Academy of Science panels. His research on fish contaminants has led to two peer reviewed publications, a 2000 paper on single meal fish limits, and a 2009 risk-benefit analysis of fish consumption. He is involved with establishing the scientific basis for Connecticut's fish consumption advisory program and assists with development of risk communication materials in this area.

Abstract

A previous risk/benefit modeling approach (Ginsberg and Toal 2009) predicted net neurodevelopmental risk for 9 of 16 commonly eaten fish species. However, epidemiological studies suggest that fish consumption during pregnancy, on average, leads to improved neurodevelopment. This suggests that the beneficial nutrients in fish may offset the adverse effects of mercury to produce a net benefit in the average case. We revisited our risk/benefit model by running it against a composite marketbasket fish meal to represent average consumption of mercury and Omega 3 fatty acids. This result was calibrated against the net neurodevelopmental benefit (visual recognition memory - VRM) per fish meal reported by Oken et. al. (2005). This calibrated model was then compared to other fish risk/benefit models that use IQ as an endpoint (e.g., FAO/WHO 2010; Zeilmaker et, al. 2013). The calibrated model estimated greater benefit for low mercury species but greater risk for high mercury species than the other models. With respect to a commonly eaten high mercury fish, swordfish, the calibrated model yielded risks that are supportive of current fish advisories that guide against consumption of this species during pregnancy while the other models predicted net neurodevelopmental benefits. The calibrated model was then used as the basis for a proposed 3-step framework for setting fish consumption advisories as follows: 1) set initial consumption level based upon mercury reference dose, 2) adjust consumption upward if risk/benefit model indicates a net neurodevelopmental benefit, 3) cap fish consumption based upon saturation of Omega 3 benefit. The implications of this approach for six species are used to illustrate the framework.

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT

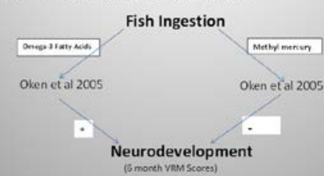
Updated Approach for Balancing the Risks and Benefits of Fish Consumption on Neurodevelopmental Endpoints – Gary Ginsberg

Updated Approach for Balancing the Risks and Benefits of Fish Consumption on Neurodevelopmental Endpoints

Gary Ginsberg
Toxicologist
Connecticut Dept of Public Health

2009 Risk Benefit Model

- Based upon visual recognition memory (VRM) at 6 months in Boston area children



- Based upon visual recognition memory (VRM) at 6 months in Boston area children

Updated Approach

- Review lit for Hg and O-3 FA slopes on ND
- Evaluate recent risk/benefit models of fish consumption
- Calibrate VRM model for net effect of fish on ND
  - Construct baseline marketshare diet
  - Does the 2009 model predict a net benefit from baseline diet
  - Adjust model to benefit seen in epi
- Calibrated model compared to IQ-based models
- Calibrated model used to predict risk/benefit of market species
- Calibrated model used in new Consumption Advisory Framework
- Evaluation of (DHA+EPA)/Hg ratio to screen fish species

Hg ND Risk Epi

- 14 studies, various ages, biomarkers, endpoints
- Some adjusted for beneficial effect of fish consumption, others did not
- 10 of the 14 found significant effect of Hg
  - Faroes, NZ, Boston, New Bedford, Brazil, Hong Kong, NYC, Poland

Omega-3 Effect on ND

- 6 studies of maternal fish ingestion on ND
- Some corrected for maternal Hg, others not
- 5 of 6 show beneficial effect
  - UK, Boston, NYC
- Benefit incorporated into FDA 2014, FAO/WHO 2010 models
- Earlier analysis of O-3 postnatal supplementation showed lower ND benefit (Cohen et al. 2005)

Comparison of Mercury Risk and O-3 FA Benefit Slopes Across Studies

Model	ND Parameter	Hg Effect / ppm hair	% Change[1]	Change in SD units	O-3 Effect / 100 mg/day	% Change[1]	Change in SD units
Original VRM	VRM	-7.5	-12.5	-0.42	2	3.3	0.11
Calibrated VRM	VRM	-3.5	-5.8	-0.20	3.04	5.1	0.17
Zeilmaker et al. 2013	IQ	-0.2	-0.2	-0.013	0.087[2]	0.087	0.006
Cohen et al. 2005a,b	IQ	-0.7	-0.7	-0.047	0.087[2]	0.087	0.006
FAO/WHO 2010	IQ	-0.2 to -0.7	-0.2 to -0.7	-0.01 to -0.05	2.7[2,3]	2.7	0.18
Lederman et al. 2008	Bayley Scales	-3.33	-3.33	-0.27	---	---	---
Orenstein et al. 2014	Visual memory	-2.8	-3.2	-0.21	---	---	---

[1]Slope expressed as percent change in the parameter mean value (VRM 60 points, IQ and Bayleys scales, 100 points) per unit exposure.
[2]Original Cohen et al (2005) and FAO/WHO (2010) slopes expressed per unit DHA. Slopes in this table expressed per unit of EPA+DHA by adjusting with 0.67 factor as per WHO/FAO (2010) and Chen et al. (2014).
[3]O-3 FA benefit modeled to saturate at 5.8 IQ points.

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT

Updated Approach for Balancing the Risks and Benefits of Fish Consumption on Neurodevelopmental Endpoints – Gary Ginsberg

Benefits of VRM as Endpoint

- Early postnatal endpoint (6 months) predictive of later IQ
- More likely to reflect prenatal influences than testing at older ages
- Visual learning and memory sensitive to meHg
  - E.g., Orenstein et al. 2014 – 8 yr old children

Calibration of VRM Model

- Develop estimate of baseline fish diet – Composite MarketShare Model
  - US National Marine Fisheries Service survey
  - Relative % of fish sold in US market, 51 species
- Hg in fish from FDA TDS database (FDA 2009)
- O-3 in fish from USDA database (USDA, 2010; FAO/WHO, 2010)
- Resulted in Hg and O-3 content of composite marketshare fish meal

Basic Features of Composite Marketshare Fish Diet

	Fish Content	Dietary Exposure (2 meals/week)	Recommended Value
EPA+DHA	918 mg/6 oz	262 mg/d	100 mg/d [1]
meHg	0.085 ug/g	0.069 ug/kg/d	0.1 ug/kg/d[2]
Ratio mg O-3/ug Hg	64 mg/ug	---	17 mg/ug [1]

[1]Recommended for optimal neurodevelopment as cited in Tsuchiya et al. (2008). The O-3 FA/Hg ratio recommended by Tsuchiya et al. (2008) is based upon DHA content of fish.
[2]USEPA methyl mercury RfD.

- **Mercury exposure from 1 meal/wk yields 0.34 ppm adult hair Hg**
  - this matches NHANES 50th percentile hair Hg
  - this approximates Oken et al. 2005 mean hair Hg

Calibration of VRM Model Against MarketShare Diet

- Previous risk/benefit model: +0.072 VRM pts per fish meal/wk
- Oken et al. 2005: +2.8 pts
- Iteratively lowered Hg slope and raised O-3 slope to match +2.8 pts per meal of marketshare fish
  - 47% decrease in Hg slope
  - 52% increase in O-3 slope

Comparison of Mercury Risk and O-3 FA Benefit Slopes Across Studies

Model	ND Parameter	Hg Effect / ppm hair	% Change[1]	Change in SD units	O-3 Effect / 100 mg/day	% Change[1]	Change in SD units
Original VRM	VRM	-7.5	-12.5	-0.42	2	3.3	0.11
Calibrated VRM	VRM	-3.5	-5.8	-0.20	3.04	5.1	0.17
Zeilmaker et al. 2013	IQ	-0.2	-0.2	-0.013	0.087[2]	0.087	0.006
Cohen et al. 2005a,b	IQ	-0.7	-0.7	-0.047	0.087[2]	0.087	0.006
FAO/WHO 2010	IQ	-0.2 to -0.7	-0.2 to -0.7	-0.01 to -0.05	2.7[2,3]	2.7	0.18
Lederman et al. 2008	Bayley Scales	-3.33	-3.33	-0.27	---	---	---
Orenstein et al. 2014	Visual memory	-2.8	-3.2	-0.21	---	---	---

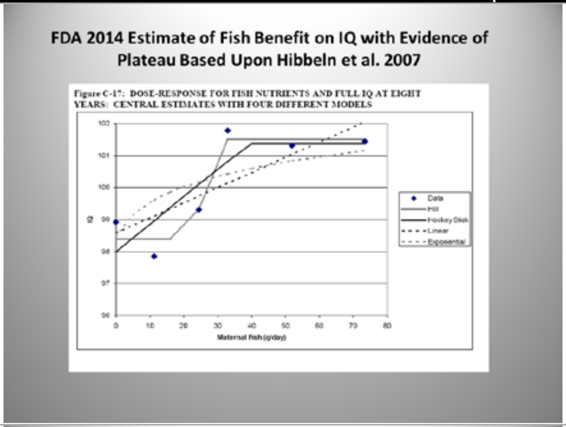
[1]Slope expressed as percent change in the parameter mean value (VRM 60 points, IQ and Bayleys scales, 100 points) per unit exposure.
[2]Original Cohen et al (2005) and FAO/WHO (2010) slopes expressed per unit DHA. Slopes in this table expressed per unit of EPA+DHA by adjusting with 0.67 factor as per WHO/FAO (2010) and Chen et al. (2014).
[3]O-3 FA benefit modeled to saturate at 5.8 IQ points.

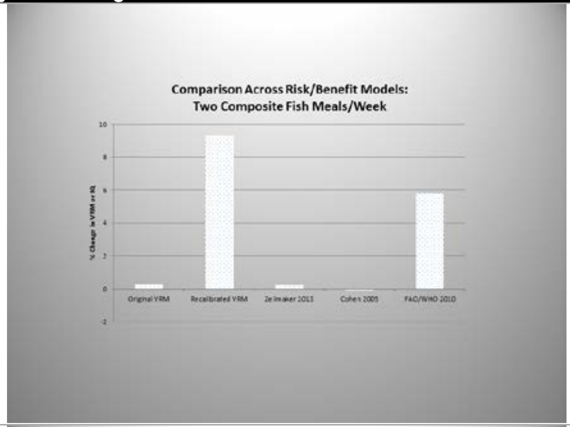
Saturation of O-3 Benefit

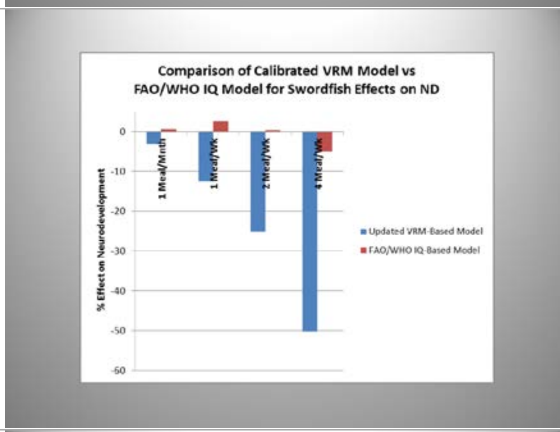
- FAO/WHO: max of 5.8 point IQ gain max across fish consumption categories in ALSPAC, Proj Viva
  - Also used by FDA, 2014
- VRM Saturation of Benefit
  - Oken et al. 2008: > 2 fish meals/wk improved ND results compared to < 2 fish meals
    - Suggests that 3 fish meals/wk continues to have a benefit
    - Oken et al. 2005: 2.8 pt VRM gain per fish meal* 3 mls
      - 8.4 pt VRM gain is conceivable – 14% improvement
      - FAO/WHO – only 5.8% max benefit from fish consumption

SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT

Updated Approach for Balancing the Risks and Benefits of Fish Consumption on Neurodevelopmental Endpoints – Gary Ginsberg







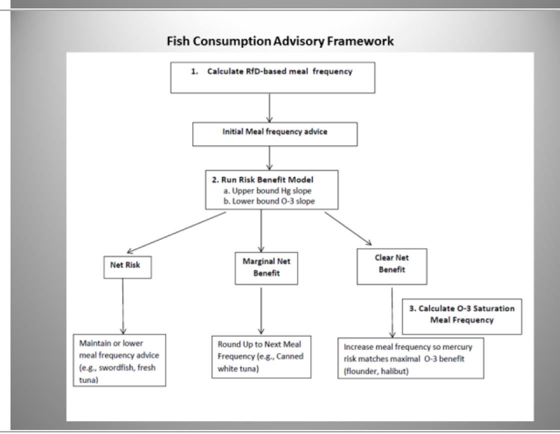
FDA 2014 Table V-7. Fish Consumption Effects on IQ

SPECIES OR MARKET TYPE	MEAN MeHg LEVEL*	OZ. PER WEEK TO REACH MAXIMUM BENEFIT	SIZE OF MAXIMUM BENEFIT EXPRESSED AS A NUMBER OF IQ POINTS	OZ. PER WEEK TO BECOME ADVERSE
Tilefish, Gulf	1.45 ppm	8 (0, 13)	1.4 (0.0, 2.6)	16 (0, 30)
Swordfish	1.00 ppm	8 (7, 13)	2.0 (0.7, 3.0)	24 (12, 43)
Shark	0.98 ppm	8 (7, 13)	2.0 (0.7, 3.0)	24 (12, 44)
Mackerel, King	0.73 ppm	8 (7, 13)	2.4 (1.4, 3.2)	32 (16, 59)
Orange Roughy	0.57 ppm	8 (8, 13)	2.6 (1.7, 3.4)	41 (21, 76)
Grouper	0.46 ppm	8 (8, 13)	2.7 (1.9, 3.6)	54 (26, 94)
Tuna, Fresh	0.39 ppm	9 (8, 13)	2.8 (2.1, 3.7)	60(31, 111)
Mackerel, Spanish	0.37 ppm	9 (8, 13)	2.8 (2.2, 3.7)	64 (33, 117)
Sable Fish	0.37 ppm	9 (8, 13)	2.8 (2.2, 3.7)	64 (33, 117)
Bluefish	0.35 ppm	9 (8, 13)	2.8 (2.2, 3.7)	64 (33, 117)
Tuna, Albacore Canned	0.35 ppm	9 (8, 13)	2.8 (2.2, 3.7)	67 (35, 123)

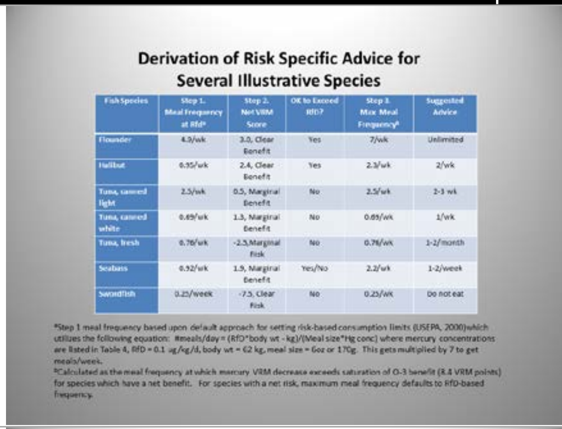
Risk/Benefit Analysis of Commercial Fish Species Based Upon the Calibrated VRM Model (results shown for 1 meal/week)

Fish Species	O-3 Content mg/170 g meal	Hg Content (ug/g)	O-3/Hg Ratio (mg/ug)	Net VRM Score	Net VRM Upperbound Hg Slope[1]	Net VRM Lowerbound O-3 Slope[2]
Marketshare Meal	918	0.085	63.5	2.8	1.7	1.4
Cod	258	0.11	14.3	-0.37	-1.0	-0.8
Flounder	852	0.05	100.2	3.0	2.7	1.7
Halibut	1398	0.26	31.6	2.43	0.9	0.3
Herring Atlantic	3424	0.04	503.5	14.3[b]	14	9.0
Lobster	816	0.24	20.0	0.2	-1.3	-1.0
Pollack	922	0.06	90.4	3.2	2.8	1.8
Salmon Atlantic (Farmed)	3650	0.014	1534	15.7[a]	15.6	10.2
Sea Bass	1294	0.27	28.2	1.9	0.2	-0.1
Shark	1170	0.99	7.0	-8.1	-15	-11
Shrimp	535	0.01	314.7	2.2	2.1	1.4
Swordfish	1392	0.97	8.4	-7.5	-11	-9.6
Tilapia	280	0.01	141.2	0.90	0.84	0.54
Tuna: Canned Light	425	0.1	25	0.45	-0.15	-0.2
Tuna: Canned White	1462	0.36	23.9	1.31	-0.65	-0.88
Tuna: Fresh[a]	474	0.325	8.6	-2.5	-4.4	-3.2

[1]Upperbound Hg slope is the calibrated mercury slope + SE = -5 VRM points/ppm hair Hg.
[2]Lowerbound O-3 slope is the calibrated O-3 slope minus SE = 1.99 VRM points/100 mg O-3/d.



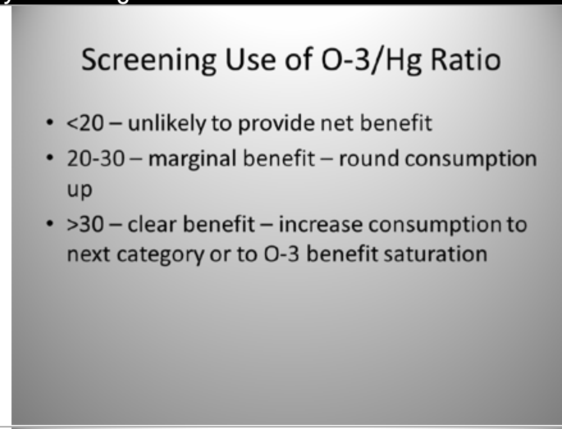
SESSION 5: HEALTH BENEFITS AND RISK MANAGEMENT
Updated Approach for Balancing the Risks and Benefits of Fish Consumption on Neurodevelopmental Endpoints – Gary Ginsberg

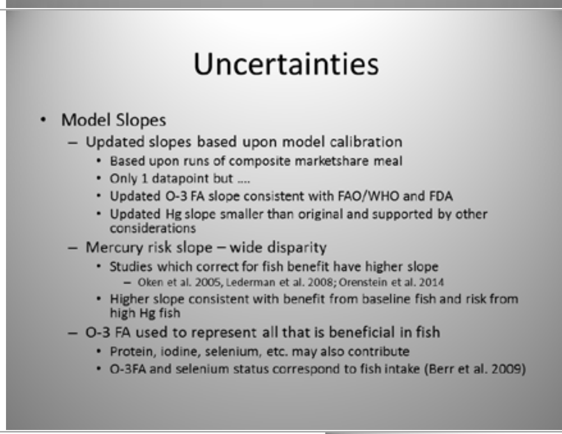


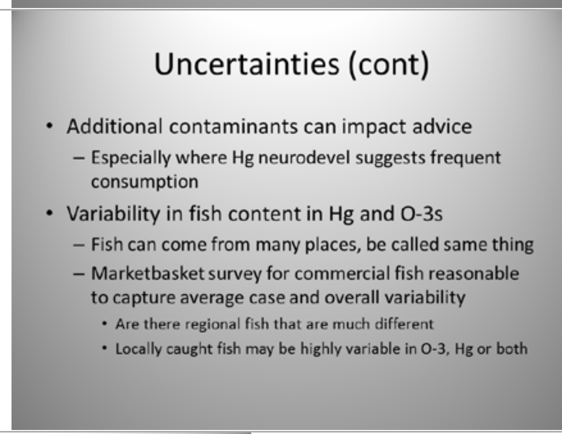
Derivation of Risk Specific Advice for Several Illustrative Species

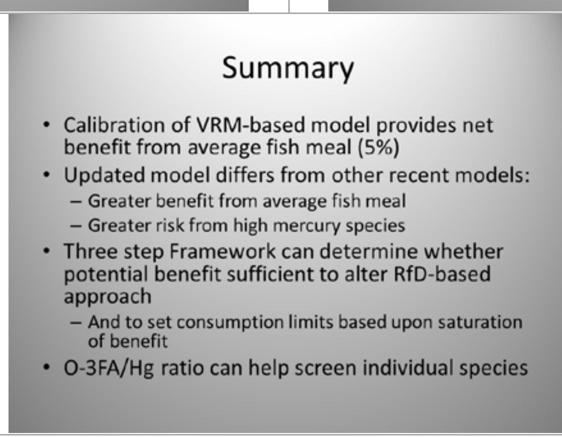
Fish Species	Step 1. Meal Frequency at RfD[a]	Step 2. Net VRM Score	OK to Exceed RfD?	Step 3. Max Meal Frequency[b]	Suggested Advice
Flounder	4.9/wk	3.0, Clear Benefit	Yes	7/wk	Unlimited
Halibut	0.95/wk	2.4, Clear Benefit	Yes	2.3/wk	2/wk
Tuna, canned light	2.5/wk	0.5, Marginal Benefit	No	2.5/wk	2-3 wk
Tuna, canned white	0.69/wk	1.3, Marginal Benefit	No	0.69/wk	1/wk
Tuna, fresh	0.76/wk	-2.5,Marginal Risk	No	0.76/wk	1-2/month
Seabass	0.92/wk	1.9, Marginal Benefit	Yes/No	2.2/wk	1-2/week
Swordfish	0.25/week	-7.5, Clear Risk	No	0.25/wk	Do not eat

[a]Step 1 meal frequency based upon default approach for setting risk-based consumption limits (USEPA, 2000)which utilizes the following equation: #meals/day = (RfD*body wt - kg)/(Meal size*Hg conc) where mercury concentrations are listed in Table 4, RfD = 0.1 ug/kg/d, body wt = 62 kg, meal size = 6oz or 170g. This gets multiplied by 7 to get meals/week.
[b]Calculated as the meal frequency at which mercury VRM decrease exceeds saturation of O-3 benefit (8.4 VRM points) for species which have a net benefit. For species with a net risk, maximum meal frequency defaults to RfD-based frequency.









Questions and Answers

Note: There were no questions because the moderator moved directly into the general Q&A session at the end of this panel.

General Question and Answer Session

Comment: The graph in the U.S. Food and Drug Administration (FDA) presentation with the blue curve was the best information presented today. Our goal should be to work toward a public health policy to encourage health benefits by guiding people to eat fish low in mercury and high in Omega 3. (Groth)

Q. This question was for Dariush Mozaffarian. There is a lot of research on genetic variability. Is there any evidence regarding genetic variability for Omega 3 and cardiac benefits? (Groth)

A. There is some evidence. However, doing research on genetic variability and dietary interactions would require a large group of people. (Mozaffarian)

Q. He has three points: 1) If you do analyses assuming the nutritional benefits and risk effects are linear, you will not get good estimates of nutritional effects or mercury effects—instead, this may be a multivariate effect; 2) If you have a plateau, you will need different amounts of fish to get to the plateau, depending on the fish species; and 3) When people think of controlled studies, they tend to think of clinical trials where you give a drug to a population that you already know is deficient. (Carrington)

A. Thank you for these comments. If you are operating on the linear part of a curve, you need to consider that. (Stern)

A. The ratio is very simplistic and should be subject to further analysis. (Ginsberg)

A. The dose-response was only for heart disease death. Reducing heart disease death is where most of the cardiac benefit from fish consumption seems to occur. Fish consumption may also have health benefits for some other endpoints such as anger and depression. (Mozaffarian)

Q. This question was for Dariush Mozaffarian. You pointed to the Wennberg study. Did you intentionally exclude the EURAMIC study? (Stern)

A. The EURAMIC study was a retrospective case-control study, which is a study design with known disadvantages. It was a retrospective study of survivors of heart attacks. (Mozaffarian)

Q. He published a paper with Joanna Burger on health benefits. They found there was no increase of health benefit on the plateau. At over five fish meals per week, you would get harm. There was no threshold for toxicity but no threshold for benefit either. Can you add the beneficial fatty acids EPA (n-3 eicosapentaenoic acid)and DHA (n-3 docosahexaenoic acid)together as the same benefit? The graph in FDA's presentation with the blue curve should show where you should get a beneficial net benefit before harm starts. (Gochfeld)

A. FDA used a sigmoidal slope assuming there was a threshold. Also their empirical data set supported that assumption, specifically the Alspac data set. For these two reasons, FDA decided to model it that way. This approach does increase the percentage of the population with a net adverse impact, but that is only a small percentage increase. (Spiller)

A. As FDA's risk assessment modeler, he clarified that FDA actually used two models. The sigmoidal slope was only one modeling approach. (Carrington)

A. Thank you for providing clarification on FDA's modeling approach. I always bring my risk assessor when I make a presentation. (Spiller)

Q. In Alaska, they decided that consuming fish seems to be associated with so many cardiovascular and other health benefits, that those benefits may sometimes be higher than the adverse effect of mercury. Although Alaska has a small population overall, 17% are Native Americans who are susceptible to loss of health benefits from eating fish. Subsistence fishing is a major part of the diet of many Native Americans, who may potentially be consuming large amounts of fish and thus subject to losing significant health benefits if they reduce fish consumption. How do we address cardiovascular benefits when updating fish consumption advisories? Do we develop endpoints based on clinically significant results (like drug trials) or just based on statistical effects? (Hamade)

A. The State of California published a paper with a policy regarding the drop in IQ from neurotoxicity effects that was considered a de minimis value. When you look at that de minimis value, the IQ drop with mercury exposure is significant by comparison. (Ginsberg)

A. We could consider a semi-quantitative approach to provide more specific advice to consumers. (Bhavsar)

Q. He liked the graph in FDA's presentation with the blue curve, but he questioned whether selenium would affect the slope. The slope of the net benefits may vary based on whether people might have poor or rich selenium sources. (Ralston)

A. The slide in his presentation was very generalized. FDA used fish very high in mercury and fish very low in mercury. FDA did not take selenium into account. You need to look at FDA's report in the appendix for the details and to see how the slopes vary among different fish species in a significant way. (Spiller)

Q. This question was for Gary Ginsberg. For Connecticut's new risk/benefit model, it seemed that there was a lot of "curve fitting." Given the uncertainty, why did you adjust risk and benefit slopes instead of diet? (Stern)

A. Their results matched Dr. Emily Oken's results closely. Because he thought they were close to being on target, they adjusted slopes instead of diet. (Ginsberg)

Q. The fish advisories in New York are very complicated and vary by region, etc. They also try to steer people to choosing fish with low mercury concentrations and low concentrations of contaminants in lipids. However, one of the key messages that people actually get from New York's advice is the "trimming and skinning" message. People say they understand the message in New York's fish advice that if they remove all the fat and skin from fish that they will reduce *their exposure to contaminants. If people are removing all the fat and all the skin from fish, will they get beneficial fatty acids? (Mukasa)*

A. He gets this question on a regular basis. Their management wants to simplify their fish advisories in Ontario instead of issuing advisories individually lake-by-lake. For any two different lakes, the fish advisory can be very different. All of the data in his presentation were for skin-removed fillets. There is a possibility of losing some of the Omega 3 benefit, but the remaining fillet has enough DHA to meet basic dietary guidelines. (Bhavsar)

A. In terms of endpoints, his work on the updated risk/benefit model in Connecticut was more about mercury and neurodevelopment. Mercury contamination will be in the fillet, so he would say remove the skin but keep the fat in fish advice about mercury. For polychlorinated biphenyl (PCB) contamination, he would say definitely trim the fat to reduce PCB exposure. (Ginsberg)

Comment: In New York's fish advice, it is the visual message about "trimming and skinning" fish that helps make it a "take home" message for people. (Mukasa)

Comment: We need more research. (Brodberg)

A. We are trying to brainstorm on how to craft the best message that people will understand and remember. We advise people to remove the skin from fish. The Great Lakes areas have PCBs, so for those locations it may be best to remove the fat from fish. (Bhavsar)

SECTION II-G SESSION 6: COMMUNICATIONS TO THE PUBLIC

Introduction

Moderator:
Barbara Knuth, Cornell University, Department of Natural Resources

Biosketch
Dr. Barbara Knuth is Vice Provost and Dean of the Graduate School at Cornell University. She is also a Professor of Natural Resource Policy and Associate Director of the Human Dimensions Research Unit in the Department of Natural Resources. Dr. Knuth's research focuses on the human dimensions of fisheries and wildlife management and policy, and she is known particularly for her work on risk perception, communication, and management associated with chemical contaminants in fish. She has served on National Academy of Sciences and Institute of Medicine committees, including those focused on improving the collection, management, and use of marine fisheries data and recreational fisheries survey methods, and on dioxins in the food supply. She served on the Ocean Studies Board of the National Research Council (NRC) and on the NRC Committee on the Effects of the Deepwater Horizon Oil Spill on Ecosystem Services in the Gulf of Mexico. Dr. Knuth has served on numerous scientific panels and advisory boards, including the international Board of Technical Experts of the Great Lakes Fishery Commission, and the Great Lakes Science Advisory Board of the International Joint Commission. She is a Past-President of the American Fisheries Society, and served as Vice President of the Executive Board of the World Council of Fisheries Societies.

Presentations
Dissemination of Information about FDA's Seafood-Associated Rhabdomyolysis, Puffer Fish Poisoning and Ciguatera Fish Poisoning Research Project
Karen Swajian, U.S. Food and Drug Administration

Consumer Understanding of the Benefits and Risks of Fish Consumption During Pregnancy
Amy Lando, U.S. Food and Drug Administration

Improving Communication of Fish Advisories: Providing Benefits and Risk Information to Increase Consumer Knowledge
Mario Teisl, University of Maine

Communicating Fish Advisory Information to Women of Childbearing Age
Nancy Connelly, Cornell University

Urban Anglers' Fish Consumption and Response to Advisory Messages
Bruce Lauber, Cornell University

Fish Advisory Outreach to Urban and Rural Alaska Stakeholders
Ali Hamade, Alaska Section of Epidemiology

Engaging Healthcare in Environmental Exposure Risk Reduction
Michael Hatcher, U.S. Agency for Toxic Substances and Disease Registry

Fish Consumption for Clinicians: Increasing Knowledge of the Risks and Benefits of Fish and Evaluating Clinical Screening for Mercury
Susan Buchanan, University of Illinois – Chicago

Communicating Information to Reduce Mercury Exposures in Women of Childbearing Age
Pat McCann, Minnesota Department of Health

Dissemination of Information about FDA's Seafood-Associated Rhabdomyolysis, Puffer Fish Poisoning and Ciguatera Fish Poisoning Research Project

Karen Swajian, U.S. Food and Drug Administration

Biosketch

Karen A. Swajian has worked with the U.S. Food and Drug Administration (FDA) as a Consumer Safety Officer (CSO) in the Seafood Processing and Technology Policy Branch, Division of Seafood Safety, Office of Food Safety since 2008. Ms. Swajian is subject matter expert for natural marine toxins as well as allergenic and food intolerance substances. As such she oversees, and writes policy and guidance to industry regarding natural marine toxins in finfish. She also works with the International Affairs Staff at the Center for Food Safety and Applied Nutrition (CFSAN) auditing Foreign Competent Authorities for Comparability. Prior to August 2008, Ms. Swajian was employed as a CSO with the CFSAN Office of Compliance / Compliance Information Branch and Field Programs Branch. She is also a rehire to FDA previously being employed from 2001-2003 working in the Office of Compliance with allergens as her primary responsibility in the Field Programs Branch. Ms. Swajian graduated from Mount Ida College with a B.S. in Veterinary Technology. She received a M.S. in Clinical Laboratory Science with a major in Microbiology and a minor in Adult Education from the University of Rhode Island. She has worked as a clinical microbiologist at Tufts University School of Veterinary Medicine and Faulkner Hospital. She has worked in industrial microbiology at CASCO-NERL Diagnostics. Ms. Swajian comes from academia as well having taught Veterinary Microbiology at the graduate and undergraduate level with Tufts University and Mount Ida College, respectively. She has also taught Honors Chemistry, Algebra II Honors, Analysis, General Biology, and Advanced Placement Biology at the secondary level. Ms. Swajian has also worked in the dairy industry as the Regional Quality Systems Specialist with Dean Foods where she conducted system audits of the regional dairies, their co-packers and suppliers as well as organized and oversaw customer audits.

Abstract

FDA is undertaking a research project to identify the causative agent of seafood-associated Rhabdomyolysis (sometimes referred to as Haff disease), frequently associated with buffalo fish, as well as collecting epidemiological and meal remnants pertaining to puffer fish poisoning and ciguatera fish poisoning. FDA is including federal agencies as well as state and local officials and other stakeholders in our communications to ensure, among other items, cooperation with the dissemination of information to enable us to reduce future occurrences of these illnesses, and cooperation with acquiring samples and epidemiological information from the health care providers and patients directly involved. This presentation will discuss the outreach developed to assist FDA with this endeavor.

SESSION 6: COMMUNICATIONS TO THE PUBLIC
Dissemination of Information about FDA's Seafood-Associated Rhabdomyolysis, Puffer Fish Poisoning and Ciguatera Fish Poisoning Research Project – Karen Swajian

Dissemination of Information about FDA's Seafood-Associated Rhabdomyolysis, Puffer Fish Poisoning and Ciguatera Fish Poisoning Research Project

Karen A. Swajian
Division of Seafood Safety/ Office of Food Safety/ Center for Food Safety and Applied Nutrition
September 24, 2014

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Objective

- Background of
  - Puffer Fish Poisoning (PFP)
  - Ciguatera Fish Poisoning (CFP)
  - Seafood-Associated Rhabdomyolysis
- Project Goals
- Outreach

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Puffer Fish Poisoning (PFP)

- Severe, potentially life-threatening illness from certain fish belonging to family Tetraodontidae
- Typically caused by the alkaloid toxin tetrodotoxin
- A small amount of toxin (2 -3mg) can be lethal
- Regulation of puffer fish
  - Importation
  - Domestic

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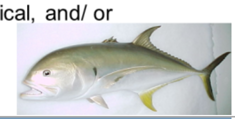
Ciguatera Fish Poisoning (CFP)

- Foodborne illness caused by the consumption of reef-associated fish that have accumulated the toxin from the marine food web
- CFP occurs in tropical and semi-tropical regions worldwide
- Illness occur from the consumption of the meat of large predatory species and are categorized as gastrointestinal, neurological, and/ or cardiovascular



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Seafood-Associated Rhabdomyolysis

- a.k.a. Haff Disease or Buffalo Fish Poisoning
- Haff Disease is a syndrome of unexplained rhabdomyolysis following consumption of certain types of fish
- Causative agent(s) – currently unknown

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Outreach

- Target Audience
- Workgroup Deliverables
  - Background document
  - Internal media Q&A
  - Internal and external sample collection SOP
  - Epidemiological questionnaires
- Information Sharing
- Epi-X posting of the information

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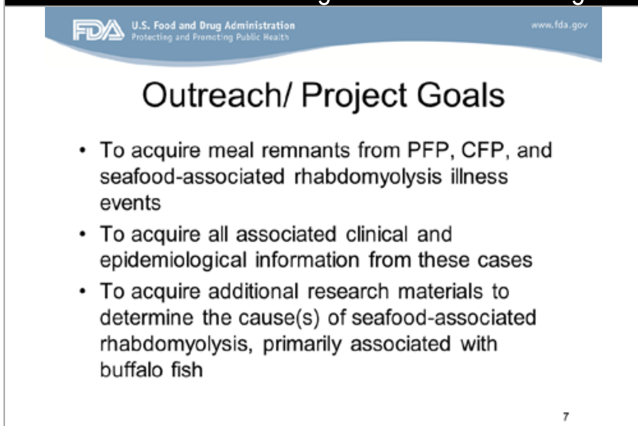
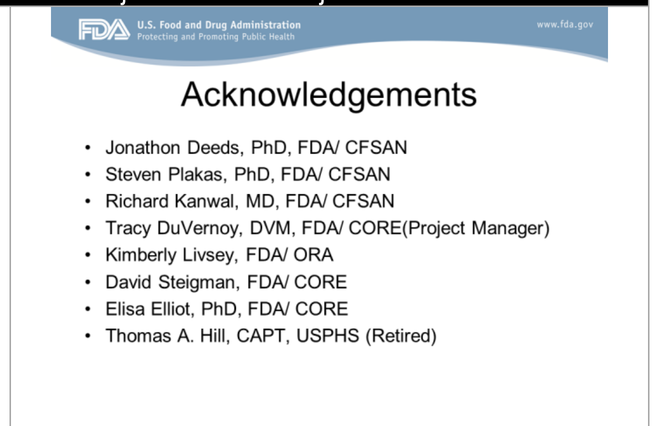
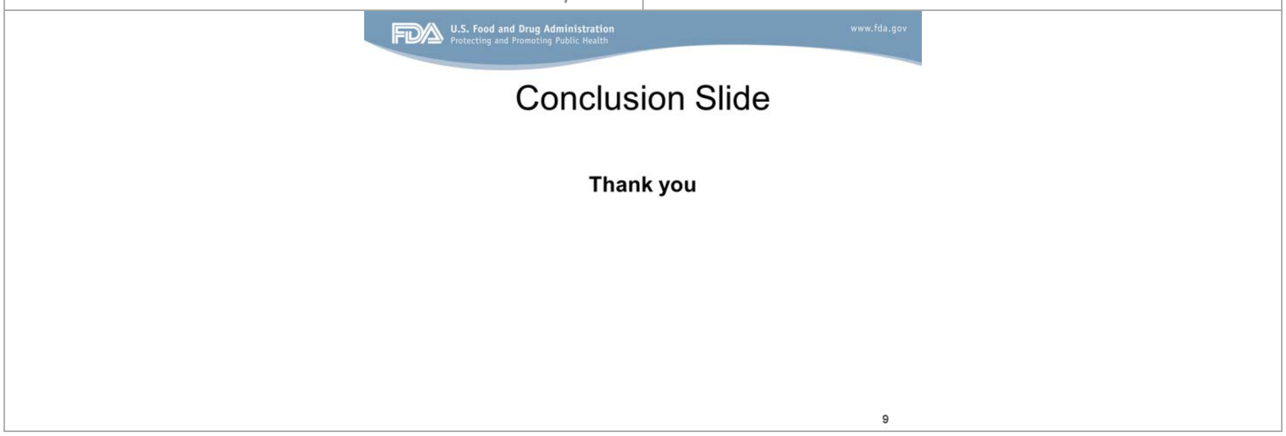
SESSION 6: COMMUNICATIONS TO THE PUBLIC

Dissemination of Information about FDA's Seafood-Associated Rhabdomyolysis, Puffer Fish Poisoning and Ciguatera Fish Poisoning Research Project – Karen Swajian







Questions and Answers

Q. *He has never seen Haff disease and rarely sees ciguatera fish poisoning cases at his clinic. However, he often sees scombroid food poisoning or toxin cases, almost every year. Why isn't FDA looking at scombroid toxin? Is it too common for FDA's agenda? (Gochfeld)*

A. Scombroid toxin is associated with decomposition or decayed fish. Because scombroid is not associated with a specific toxin, FDA is not looking at it.

Q. *The Centers for Disease Control and Prevention (CDC) has a Foodborne Outbreak Online Database where they list some of the toxins that FDA is looking at. This database is part of CDC's National Outbreak Reporting System (NORS). How much has FDA used this CDC database and how often does FDA notify CDC about outbreaks or illnesses that are reported to FDA? (Fisher)*

A. FDA has a CDC liaison, who will inform CDC about an outbreak or illness if it reaches the level where CDC needs to be notified. FDA has worked with their CDC liaison on this research project as well.

Q. *The CDC database reports even to the level of one person or outcome. What level of outbreak requires reporting to CDC? (Fisher)*

A. For Haff disease or puffer fish poisoning or ciguatera fish poisoning, FDA considers that one person is an illness outbreak because these are illnesses specifically related to food.

Q. *It would be interesting to look at the CDC database and NORS system to see if it includes any of the illnesses that are part of FDA's research project. (Fisher)*

A. Karen Swajian agreed that FDA should look at the CDC database.

Consumer Understanding of the Benefits and Risks of Fish Consumption During Pregnancy

Amy Lando, U.S. Food and Drug Administration

Biosketch

Amy M. Lando has been a member of the Consumer Studies team at the Center for Food Safety and Applied Nutrition, U.S. Food and Drug Administration since 2001. She attended Duke University where she received a B.A. in Public Policy with a minor in Chemistry. Upon graduation from Duke University, Ms. Lando attended Georgetown University and completed her Master's in Public Policy with an emphasis on food and nutrition policy. Ms. Lando is the project director of the Food Safety Survey, a national telephone survey of consumers' food safety attitudes and behaviors. She has worked on a number of research projects investigating how consumers understand risk and benefit messaging about fish consumption.

Abstract

Fish consumption during pregnancy is one important area of dietary advice; yet, the message is not simple or easy to communicate because it involves both risks and benefits. The federal government first issued national consumption advice to minimize the risk to the developing fetus from methylmercury in fish in the 1990s. This advice was updated in 2001 and again in 2004 and extends to protecting young children as well as the fetus from harm from methylmercury. Since 2004, a significant body of research indicates that fish consumption during pregnancy can benefit fetal neurodevelopment even though the fish contain methylmercury. Consistent with this approach, the *Dietary Guidelines for Americans, 2010* recommends that to optimize the health benefits associated with lower methylmercury seafood, pregnant and breastfeeding women consume 8 to 12 ounces/week of such seafood. Overall, the literature suggests that consumers, including pregnant women, are generally aware of problems related to mercury contamination in fish, but many do not know the specifics of the advice. Consumption data suggests that all women, including pregnant and postpartum women, are eating less than the recommended amounts of fish and shellfish. In the summer of 2014, FDA conducted a series of 12 focus groups with pregnant and postpartum women and women who may become pregnant to learn about their understanding of the risks and benefits of eating fish and their fish consumption habits. Preliminary results of these focus groups will be discussed in the presentation.

SESSION 6: COMMUNICATIONS TO THE PUBLIC

Consumer Understanding of the Benefits and Risks of Fish Consumption During Pregnancy – Amy Lando

Consumer Understanding of the Benefits and Risks of Fish Consumption During Pregnancy

Amy Lando, MPP
Serena Lo, PhD
Consumer Studies Team
CFSAN/FDA

National Forum on Contaminants in Fish
September 24, 2014

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Outline

- Current research
  - What do women (pregnant) know about benefits and risks of fish?
  - How much fish are they eating?
  - Where do they get fish consumption advice?
- Challenges for communicating benefits and risks of fish consumption
- Preliminary findings from the 2014 fish focus groups

2

What do women know?

- Different studies have found different levels of awareness about mercury in fish
  - Lando and Zhang (2011) found high awareness
    - 67% in 2001; 80% in 2006
  - Lando, Fein, Choinèire (2012) found high awareness in pregnant, postpartum women, control group (73%; 74%; 59%)
  - Firthsen and Goodnight (2009) found somewhat lower awareness
    - 47% in 2006/2007
- Knowledge of the details is lower
  - Bloomingdale et al (2010)

3

How much fish are women eating?

	Ate fish past month	Median fish consumption (fish eaters)
Pregnant	79%	1.8 oz/wk
Postpartum	79%	2.5 oz/wk
Non pregnant, non postpartum	83%	3.0 oz/wk

(Lando, Fein, Choinière; 2012)

Sources of Information About Diet While Pregnant

- Health care provider (81%)
- Books or videos (62%)
- Newspaper or magazine (55%)
- Relative or friend (53%)
- WIC food program (38%)
- Television or radio (20%)
- Web site (27% non gov; 8% gov)

IFPS II data

Communication Challenges

- Risks and benefits messaging is hard
- Changing message on fish over time
  - Media coverage, prior beliefs
- Audience
  - Risk aversion heightened in pregnant women
  - Non target audience may also respond
- Mercury is not the only fish message

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Focus Groups

- What are women's attitudes and beliefs about fish
  - How does fish fit in their diet?
  - What have they heard about any benefits of fish? Risks from fish?
- How much fish and what types are they eating?
- Test reactions to the FDA/EPA draft update to the mercury in fish message

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Focus Groups cont'd

- 12 groups (8 to 11 women per group)
  - Summer 2014; 6 cities
- 9 groups with pregnant women/ women with small children
- 3 groups with women who plan on becoming pregnant
- Segmented by level of education
  - Mix of race/ethnicity
- All had eaten and fish or shellfish in past year

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Preliminary Findings Benefits of Fish

- Benefits of fish came up spontaneously in most groups
- When benefits were discussed, all groups mentioned "omegas."
  "*The Omega 3s are what is really important especially with salmon and fish like that. The Omega 3s are what you need. It's a good fat and it's good for the baby. It's healthy for its growth.*" (Chicago, Il, higher educ.)

Risks of Fish

- Mercury came up in every group as a risk of eating fish and seafood.
  - *"I think it messes with the baby's development…"* (Denver, higher educ.)
  - Range of concern and knowledge about mercury – a few had given up fish, some limit or avoid tuna
  - Mentions of "larger, predatory fish", swordfish, tuna
- Other risks – raw fish, wild-caught vs. farmed-raised, allergies, pollution, bacteria/parasites

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Sources of Information

- Doctor – often gives out pamphlets about do's and don'ts of what to eat (fish)
- Google (Yahoo, WebMD)
  - "*It's like my best friend, Google.*" (Denver, lower educ.)
- What to Expect When Expecting, BabyCenter
- Monterey Bay Aquarium (San Francisco)
- Some participants said that seeing/hearing consistent information from more than one source suggests that the information is credible.

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Fish Consumption

- A range – special occasions, once or twice a month, once a week – few mentioned eating twice a week or more
- Salmon, shrimp, and crab very popular
  - Mentions of tilapia and tuna
- Influenced by -- cost, cravings, taste, allergies, and preparation (freshness and time to cook it), benefits and risks

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SESSION 6: COMMUNICATIONS TO THE PUBLIC

Consumer Understanding of the Benefits and Risks of Fish Consumption During Pregnancy – Amy Lando

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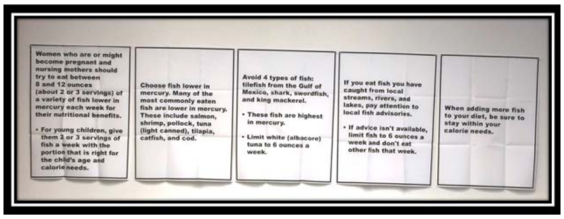
Reaction to messages



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Message 1 – Eat fish

- Already knew that fish had benefits; some suggested explaining what the benefits are
- Amount of fish was new for some, and some considered 8-12 oz/wk to be "a lot" of fish
- Mixed response to message about feeding fish to children
  - Children stop eating "when they're full"
  - Unclear what age to start feeding fish to children

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Message 2 – Lower mercury fish

- Tuna confusion – "light canned"
  - Varied interpretations of "light canned": "diet" tuna, lighter color fish, lighter color can, canned in water
  - "*I thought tuna had a lot of mercury*" (Boston, lower educ.)
- Not familiar with pollock
- Curious about other fish not listed: crab, lobster, other shellfish, trout, snapper

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Message 3 – Avoid 4 fish

- Swordfish and shark were familiar types, whereas tilefish from the Gulf of Mexico and king mackerel were not
- Participants did not anticipate difficulty in avoiding these fish since most never or rarely ate these types

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Message 3 – Limit white (albacore)

- Tuna confusion part 2
  - "*To me it never occurred to me until you just showed this – to me tuna is tuna*" (Denver, lower educ.)
  - "*And I actually thought that the white albacore was the safe one to eat, so I've been buying that.*" (San Fran, higher educ.)
- Participants had heard mixed messages about tuna in the past; this message confirmed for some that there is a problem with tuna, although confusion appeared to persist for many.

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Message 4 – Locally caught fish

- Most participants did not fish or consume fish from local streams, rivers, or lakes
- Confusion about local fish advisories: "*Like when there is a red tide, is that like a fish advisory?*" (Tampa, higher educ.)
- Questions about locally caught commercial fish: "*Are they talking about if you eat fish you have caught local, that means you physically caught and you're about to fry it on a grill? Or are they talking about like fisheries?...*" (Chicago, lower educ.)

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Message 5 -- Calories

- Generally, this message was not useful or helpful.
  - *"I think that's sort of funny, though, because fish are supposed to be better for you and typically it's going to help you stay within your calorie goal and not go over unless they're eating, you know, tons of crab dipped in tons of butter or like a heavy sauce but again, I guess it just depends on how you cook it."* (Denver, lower educ.)

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Overall takeaways

- Women are generally aware about benefits and risks from fish
- Other than Message 1, the rest of the draft updated advice is "cautionary"
- Consistent information, multiple sources = trustworthy
- Confusion and questions about details of the current draft advice
  - What specifically are the benefits of eating so much fish?
  - General confusion about tuna

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FDA Risk Communication Advisory Committee Meeting

- November 4th and 5th
- FDA's White Oak Campus
- FR Notice available at: FR-2014-08-28
- Open to the public

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Thank You!

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Questions and Answers

Q. He wanted to call attention to what Dr. Emily Oken said yesterday that women are confused by so many different messages from different and often credible sources. He thinks the federal government has a unique opportunity now to set a high standard for proper and consistent messages about risks of fish consumption. Since the FDA message published recently, two other groups have published different messages. How can we all get on the same page? Women are the most confused about what fish they should choose for consumption. (Groth)

A. The moderator mentioned that this was a great comment that could be discussed further later in this session, instead of a question to answer now.

Improving Communication of Fish Advisories: Providing Benefits and Risk Information to Increase Consumer Knowledge

Mario Teisl, University of Maine

Biosketch

Dr. Mario Teisl is a Professor and Director of the School of Economics, University of Maine. He received his Ph.D. in Agricultural and Resource Economics from the University of Maryland. Dr. Teisl has years of experience examining people's knowledge, practices, and attitudes related to nutrition, food and water safety, and health information. His health-related work has been funded by the U.S. and Maine Centers for Disease Control and Prevention, the U.S. Food and Drug Administration (FDA), the U.S. Department of Agriculture, and the National Science Foundation. In 2006, the U.S. Centers for Disease Control and Prevention presented him with the S. Teutsch Prevention Effectiveness Program Appreciation Award. Before his current position at the University of Maine, Mario was employed in FDA's Consumer Studies Branch. He also served as Chair of the Food Safety and Nutrition Section, American Agricultural Economists Association.

Abstract

Humans exposed to methylmercury (MeHg) can suffer from adverse neurological impacts. Because eating fish is the primary mechanism of MeHg exposure, federal and state agencies issue fish consumption advisories to inform the public about the risks of eating contaminated fish. However, fish is also a good source of Omega 3 fish oils that promote infants' neurological development. An advisory's purpose is to provide information so consumers can make better choices; however, the difficulty in communicating both the risks and benefits of eating fish leads readers of advisories to over-restrict their fish consumption. In evaluating the effectiveness of Maine's fish advisory, we find it successfully increased women's knowledge of both the benefits and risks of consuming fish while pregnant. It also increased their ability to differentiate fish by their MeHg content, knowledge of both low and high-MeHg fish, and knowledge of detailed attributes of seemingly substitutable goods, such as white and light tuna. Non-readers could not identify fish that provide health benefits like Omega 3 fatty acids or health risks like MeHg. Readers increased ability to make substitutions to minimize risk while maintaining the benefits of eating fish suggests the advisory may reduce MeHg-related health risks while avoiding the drop in fish consumption shown in other studies.

SESSION 6: COMMUNICATIONS TO THE PUBLIC

Improving Communication of Fish Advisories: Providing Benefits and Risk Information to Increase Consumer Knowledge – Mario Teisl

Improving communication of fish advisories: Providing benefits & risk information to increase consumer knowledge

M. Teisl, H. Engelberth, A. Smith, E.Frohmberg, K. Bell, K. Butts, S. Stableford & C. Ogun

Department of Health and Human Services — Maine People Living Safe, Healthy and Productive Lives — Paul R. LePage, Governor — Mary C. Mayhew, Commissioner

NSF — MAINE EPSCoR — 1865 THE UNIVERSITY OF MAINE School of Economics

Literature: Effective communication

- Include information about specific risks and benefits - difficult to communicate/complex
- Encouraging "switch" is ideal
- Emphasis on benefits is critical
- Examples of safe fish next to fish to be avoided
- Emphasis on commercial fish

Maine's Approach: The Pilot

- Distribute safe eating guidelines brochure to healthcare providers and WIC offices
- Given to pregnant women at first prenatal visit

Maine's Approach II: The Sequel

- Distribute safe eating guidelines brochure to healthcare providers and WIC offices
- Given to pregnant women at first prenatal visit

Find the Facts Fast

For more information:

General information: http://www.maine.gov/dhhs/eohp/fish/

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.
- Sardines and Herring
- Smelt
- Atlantic Mackerel
- Mussels

More Great Choices

Other Seafood Low in Mercury, but Not as High in Omega 3 Fish Oils

- **Light** Canned Tuna
- Scallops and Clams
- Shrimp – fresh, frozen, canned, from Maine and away
- 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 is also a great source of protein, zinc and iron and is low in saturated fat.

Most farm raised fish are safe to eat. See page 9. For farm raised salmon, see page 10.

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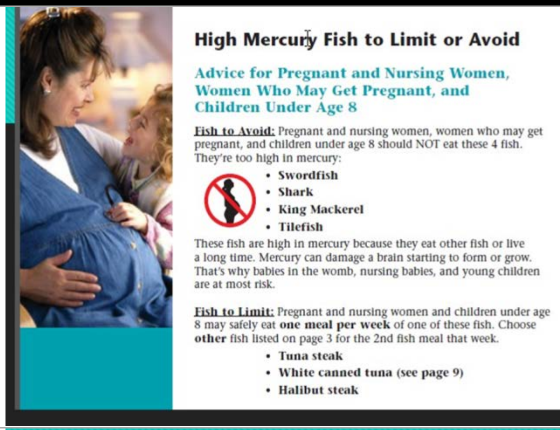

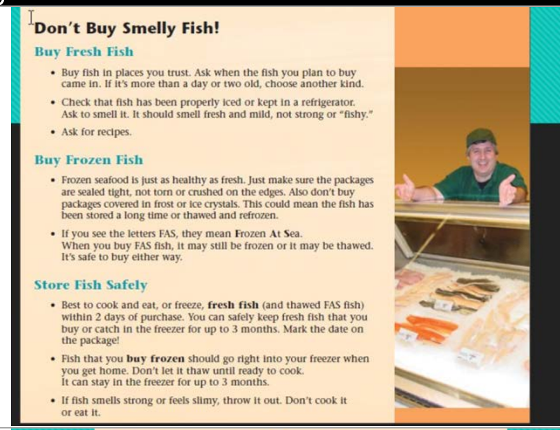

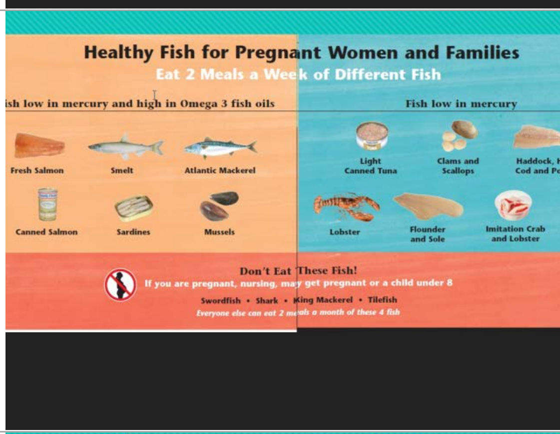

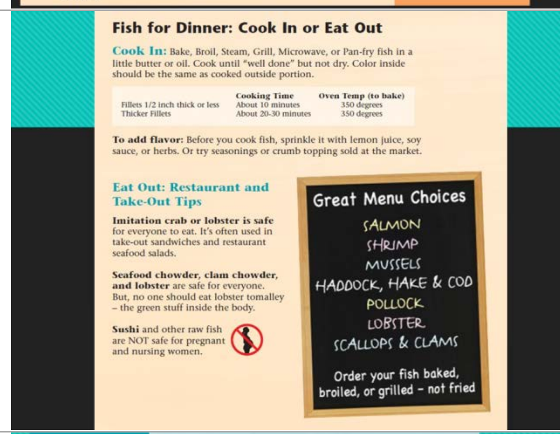

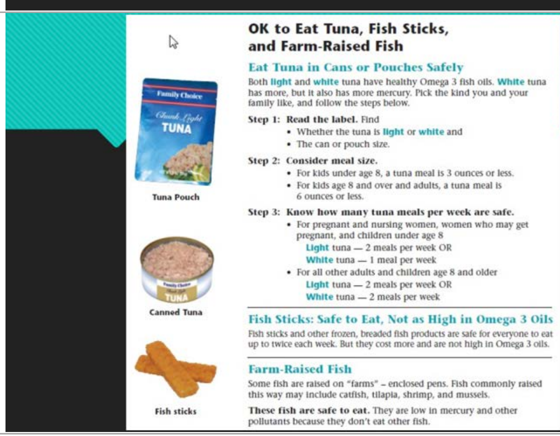

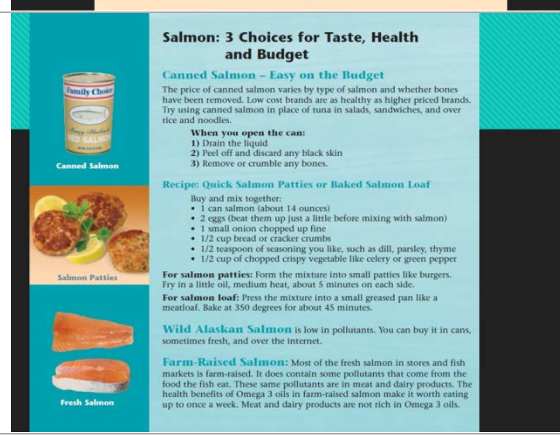

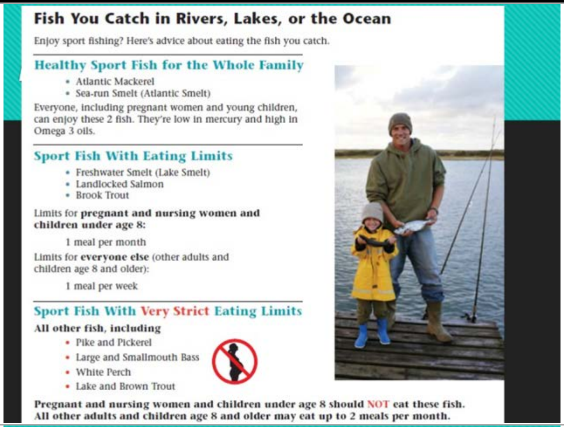

Fish You Catch in Rivers, Lakes, or the Ocean

Enjoy sport fishing? Here's advice about eating the fish you catch.

Healthy Sport Fish for the Whole Family

- Atlantic Mackerel
- Sea-run Smelt (Atlantic Smelt)

Everyone, including pregnant women and young children, can enjoy these 2 fish. They're low in mercury and high in Omega 3 oils.

Sport Fish With Eating Limits

- Freshwater Smelt (Lake Smelt)
- Landlocked Salmon
- Brook Trout

Limits for **pregnant and nursing women and children under age 8:**

1 meal per month

Limits for **everyone else** (other adults and children age 8 and older):

1 meal per week

Sport Fish With Very Strict Eating Limits

All other fish, including

- Pike and Pickerel
- Large and Smallmouth Bass
- White Perch
- Lake and Brown Trout

Pregnant and nursing women and children under age 8 should NOT eat these fish.
All other adults and children age 8 and older may eat up to 2 meals per month.

"Our family eats 2 tasty fish meals each week on a budget."

Sample Fish Meals For a Month

Week 1
- Canned light tuna for lunch on Tuesday
- Frozen shrimp stir-fry for dinner on Friday

Week 2
- Salmon for dinner on Monday (salmon on sale)
- Fish chowder at a public supper on Saturday night

Week 3
- Sandwich with imitation crab for lunch on Tuesday
- Canned light tuna for lunch on Friday

Week 4
- Haddock sandwich for lunch on Wednesday
- Salmon loaf for dinner on Thursday (see recipe page 10)

How much fish is a fish meal?

A fish meal for those age 8 and over is about 4 ounces of fish—the size of a deck of cards. Younger children will eat less. It's best to eat a variety of fish instead of just one kind.

Want to know more?
Give us a call at the Maine CDC
formerly the Maine Bureau of Health
Tollfree: 866-292-3474

Methods

- 2,000 pregnant women
- Mixed-mode survey, both summer and winter
- Response rate of 43%, N=808
- Questions about:
  - Before, during and after pregnancy
  - Fish and other eating (more/less, meals/month)
  - Information sources, including advisory
  - General and specific knowledge test

When it's most important to eat omega-3 fish oils

	R	N
Before Pregnancy	24.3	21.7
During Pregnancy (TRUE)	67.0	52.3***
After Pregnancy	13.2	15.2
Don't Know	13.9	32.4***

What benefits/risks do you/baby get from eating fish while pregnant?

	Mother		Baby	
	R	N	R	N
Omega-3s	86.0	69.6***	84.5	64.1***
Don't Know	11.9	23.9***	12.3	30.7***
Mercury	93.7	87.2***	96.1	87.8***
Don't Know	5.6	13.0***	4.9	12.8***

Which statements are TRUE about "Light" and "White" Tuna?

	R	N
Both contain MeHg (TRUE)	51.0	37.8***
Both contain Omega-3 fish oils (TRUE)	50.7	34.7***
White (Albacore) Tuna contains more MeHg (TRUE)	39.9	20.7***
Light Tuna contains more MeHg (FALSE)	4.9	5.8
Both are not safe to eat (FALSE)	4.5	3.3
Don't Know	29.0	46.0***

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Which fish are low in mercury?

	R	N
Fresh Salmon (TRUE)	58.4	33.3***
Pre-Packaged Salmon (TRUE)	32.2	17.9***
Fish Sticks or Sandwiches (TRUE)	32.5	20.7***
Swordfish (FALSE)	2.1	2.5
Atlantic Mackerel (TRUE)	8.4	5.5
Light Pre-Packed tuna (TRUE)	50.4	29.4***
White Pre-Packed Tuna (FALSE)	19.6	17.7
Don't Know	23.1	48.2***

Which should you avoid?

	R	N
Shark (TRUE)	86.8	55.5***
Fish Sticks/Sandwiches (FALSE)	10.1	10.0
Tilefish (TRUE)	62.8	39.0***
Swordfish (TRUE)	84.4	54.7***
Haddock (FALSE)	2.1	6.9***
King Mackerel (TRUE)	70.5	46.7***
Pre-Packaged Salmon (FALSE)	12.2	15.7
Don't Know	11.5	39.8***

New preliminary results on changes in consumption

Eating change due to pregnancy?

	Pre		During		Post	
	R	N	R	N	R	N
% eating fish	95.8	82.7***	92.0	73.7***	92.0	74.4***
Pre-during			*	***		
Pre-post					*	***

Of eaters, how did the amount of fish change?

	Pre-during	
	R	N
Ate less	44.1	50.7
Same	45.7	42.0
Ate more	10.2	7.4

Why ate less?

	Pre-during	
	R	N
Fish taste worse while pregnant	19.7	19.7
Some fish are unhealthy for me	25.8	25.4
Some fish are unhealthy for baby	66.7	67.4
Some fish are high in mercury	69.1	73.6

Why ate more?

	Pre-during	
	R	N
Fish taste better while pregnant	39.3	35.8
Some fish are healthy for me	60.7	25.8***
Some fish are a healthy for baby	71.4	32.3***
O-3s important during pregnancy	71.4	45.2**
Fish is a lean protein	42.8	32.3

Change in meals/month

	Pre-during		Pre-Post	
	R	N	R	N
Cod	-0.25	-0.26	-0.15	-0.18
White tuna	-0.65	-0.73	-0.38	-0.49
Light tuna	0.04	-0.10	0.08	-0.06
Packed salmon	0.08	-0.09***	0.06	-0.04**
Fresh salmon	-0.12	-0.25**	-0.16	-0.16
Shrimp	-0.26	-0.36	-0.13	-0.25*

Change in other eating

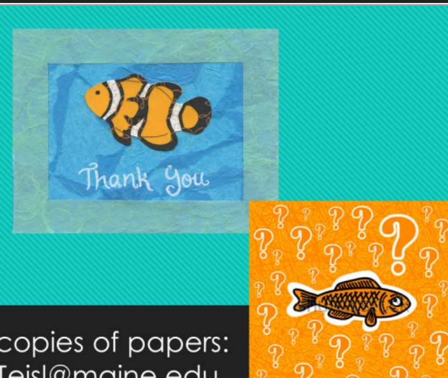
	Pre-during	
	R	N
Eat low-mercury fish	9.8**	0.9
Fish high in O-3	4.0	-5.8**
O-3 supplements	0.3	-0.7
Herbal supplements	-4.0*	-1.2
Prenatals with O-3	26.2***	25.2***
Multi. Vits with O-3	-6.5***	-5.0***
Foods with O-3	5.9	1.3
Lean protein	-1.8	-0.5

A better sequel: what we did

- Emphasis on:
  - Commercial fish
  - Pre-packaged salmon as substitute for "white" tuna
  - Benefits of fish consumption (Omega 3)
- Detailed information on:
  - Low-mercury & high-Omega 3 fish
  - Fish to completely avoid during pregnancy

A better sequel: what we saw

- Well-designed advisories can educate at-risk groups about healthy decisions and induce appropriate changes
  - Increased knowledge
  - Increased consumption of low-mercury, high-Omega 3 fish (pre-packaged salmon)
  - Decreased consumption of high-mercury "white" tuna



copies of papers:
Teisl@maine.edu

Questions and Answers

Q. Why did you choose the term "white tuna" instead of "albacore"? (Murphy)

A. Their survey said both "white" or "albacore" tuna, with "albacore" in parenthesis. He had to shorten his slides so he just had "white tuna" on his slide.

Communicating Fish Advisory Information to Women of Childbearing Age

Nancy Connelly, Cornell University

Biosketch

Nancy A. Connelly (M.S., Natural Resources, Cornell University) is a research specialist in the Human Dimensions Research Unit at Cornell University, with over 30 years of experience conducting primarily applied research involving different types of recreationists in New York and throughout the Northeast and Great Lakes regions. She began work on the topic of angler awareness of fish consumption advisories back in the early 1990s with Dr. Barbara Knuth. Her risk communication research has continued, and now includes work with the Great Lakes Consortium for Fish Advisories focusing on both anglers and women of childbearing age.

Abstract

Women of childbearing age have been identified from the beginning as a special audience for fish consumption advisories because of the health risks to unborn and breastfeeding children. Over time, research has shown both important health risks and benefits that this group of women need to consider when making decisions about fish consumption. Communicating this complex information is a challenge for state, federal, and tribal agencies and organizations. This presentation will summarize the current literature pertaining to risk communication with women of childbearing age, insights from practitioners working in the Great Lakes states, and the results of recent research conducted with women of childbearing age and new mothers at Cornell University.

Presentation Outline

- Recent literature on risk communication
- Insights from practitioners in the Great Lakes region
- Results of recent studies at Cornell

Recent Literature
Are women getting the information?

- Many women do not know much about advisory recommendations (Anderson et al. 2004, Karouna-Renier et al. 2008, Katner et al. 2011, Knobeloch et al. 2005)
- Many women do know about mercury (Lando and Zhang 2011)
- Some women do know a little about advisory recommendations (MDH 2012)

Communicating Fish Advisory Information to Women of Childbearing Age

Nancy Connelly, Bruce Lauber, Jeff Niederdeppe, and Barbara Knuth

Human Dimensions Research Unit
Cornell University

Women of Childbearing Age (WCBA)

- Special audience / sensitive population
- Health risks
- Health benefits
- Communicating the risks and benefits

Recent Literature
Communication Methods

- Personal interaction - Classroom lesson better than brochure (Burger et al. 2003), Face-to-face communication improved efficacy of fact sheet (Burger and Waishwell 2001)
- Women get health risk info from TV news and newspapers (Knobeloch et al. 2005), maybe good way to reach women with lower incomes
- Pregnant women get advice from health professionals (Bradbard 2007, MDH 2012)

Recent Literature
Risks versus Benefits

- Women are getting risk message but not benefit message (Lando et al. 2012)
  - Maybe risk message overwhelms benefit message. Benefits before risks (Knuth et al. 2003)
  - Women as protectors, so risks become most important (Vardeman and Aldoory 2008)
- Need balanced risk/benefit advisory (Teisl et al. 2011)

SESSION 6: COMMUNICATIONS TO THE PUBLIC

Communicating Fish Advisory Information to Women of Childbearing Age – Nancy Connelly

Insights from Practitioners in the Great Lakes Region

- Expertise in fish consumption advisory communication
- Used Delphi method
- Insights on which $\geq$ 90% of Consortium members agreed

How Should Advisory Material be Distributed?

- Sources trusted by target audiences
- Sources currently utilized by target audiences
- In response to requests
- WIC clinics
- Multiple partner agencies and organizations

What Are Effective Advisory Messages?

- Communicate balanced information about the health risks and health benefits of fish consumption
- Emphasize the positive rather than the negative

What Are Important Specific Messages?

- Eating fish is good for your health
- Following the advisories allows people to consume fish safely
- Choices about fish consumption can maximize benefits and minimize risks

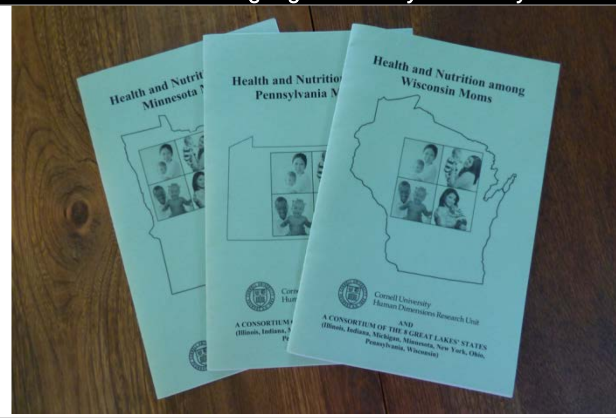
Recent Studies at Cornell

- Past research (Oken et al. 2003, Frithsen and Goodnight 2009, Lando et al. 2012) has shown that women, especially pregnant women, eat less than recommended
- Our objective: To understand further what might be done to encourage WCBA to consume more fish to be closer to (but not exceed) USDA guidelines

Study Area

Methods

- Two-parts
  - Mail survey of new mothers in MN, WI, and PA
    - Factors associated with suppressed consumption
    - 1,000 women per state
    - Non-respondent telephone follow-up (n=130)
  - Focus groups with WCBA throughout Great Lakes region
    - Exposure to information about health benefits and risks
    - Test messages intended to increase consumption of low-risk fish
    - Six focus groups (3 per topic, 64 participants)



Mail Survey Response Rate

- 30% overall
  - range: 25-33%
- 875 useable responses
  - range: 236-313 per state

Changes in Fish Consumption

Changes in consumption	During pregnancy	After pregnancy
Did not eat before, during, or after	13	13
Ate more	7	30
Ate the same	29	44
Ate less	45	11
Stopped eating	6	2

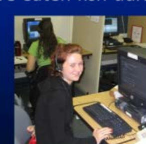
Fish Consumption During Pregnancy

Frequency of Meals	Percent
None	16
Less than 1 meal a month	22
1 to 3 meals a month	43
At least 1 meal per week	15
At least 2 meals per week	4

Non-respondent Telephone Follow-up

Non-respondent Telephone Follow-up

- Respondents more likely to have received information about eating purchased fish
- Respondents more likely to have changed their fish consumption and eaten less fish during pregnancy
- Respondents more likely to have eaten fish during pregnancy



SESSION 6: COMMUNICATIONS TO THE PUBLIC
Communicating Fish Advisory Information to Women of Childbearing Age – Nancy Connelly

Relationship Between Receiving Information During Pregnancy and Changing Consumption

Change in consumption	Received sport-caught fish information		Received purchased fish information	
	No	Yes	No	Yes
Did not eat before, during, or after	16	7	25	5
Ate more	8	6	5	8
Ate the same	31	29	32	28
Ate less	38	53	30	53
Stopped eating	7	5	8	6

Correlations with Education

- More educated women (compared to less educated women):
  - Ate more fish during pregnancy, BUT
  - Were more likely to eat less during pregnancy than before, AND
  - Were more likely to say they had received information

Received Information about Fish Consumption

When was information received?	Sport-caught fish information	Purchased fish information
Before I got pregnant	27	37
During pregnancy	45	66
After giving birth	7	11
At some point	61	77

Belief Statements with Strongest Correlations with Intention to Follow the Recommendations

- Eating fish when I am pregnant is good for my baby
- I received enough information to decide what types and how much fish to eat during pregnancy

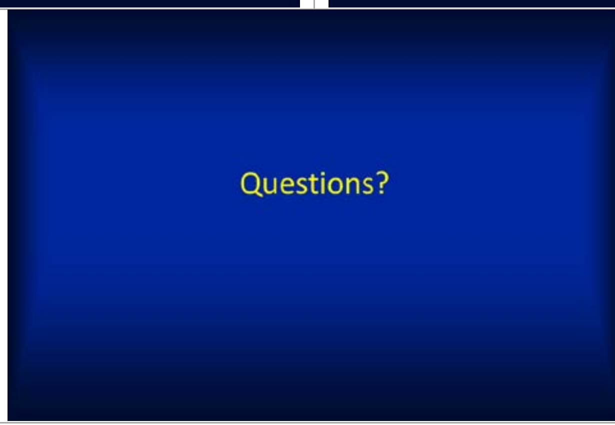
Focus Group Results
Exposure to Information about Health Benefits and Risks

- Many women described themselves as having some information but little depth of understanding
- Had more access to information and paid more attention when pregnant
- Remembered only a few specific messages
- Most commonly remembered message was to avoid or minimize consumption

Focus Group Results
Message Testing

- Be succinct
- Describe positive characteristics of fish that were not shared by many other foods
- Focus on health benefits that could be attributed to omega-3 fatty acids
- Describe relevance to women and their life circumstances

SESSION 6: COMMUNICATIONS TO THE PUBLIC
Communicating Fish Advisory Information to Women of Childbearing Age – Nancy Connelly



Questions and Answers

Note: No questions were asked.

Urban Anglers' Fish Consumption and Response to Advisory Messages

Bruce Lauber, Cornell University

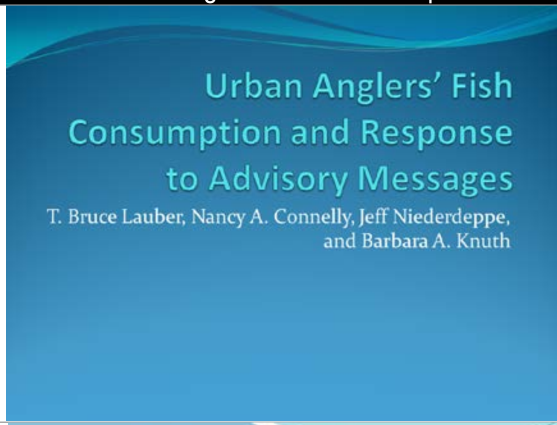
Biosketch

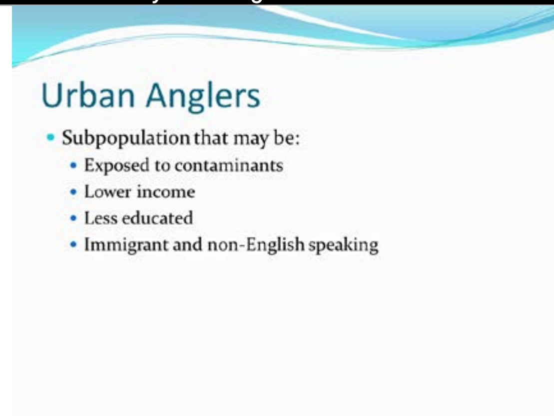
Dr. Bruce Lauber is a Senior Research Associate with the Human Dimensions Research Unit in the Department of Natural Resources at Cornell University, where he has worked as a researcher for the last 18 years. He received his B.A. in Chemistry from Williams College in 1982, his M.S. in Wildlife Management from the University of Maine in 1991, and his Ph.D. in Natural Resources in 1996. Dr. Lauber has worked closely with the Great Lakes Consortium for Fish Consumption Advisories since 2010 on a series of social science studies designed to contribute to more effective advisories.

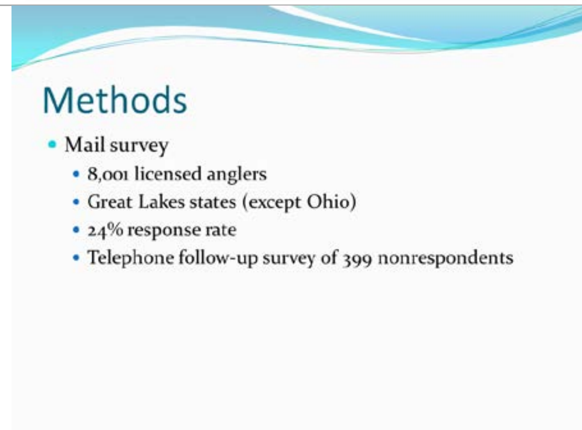
Abstract

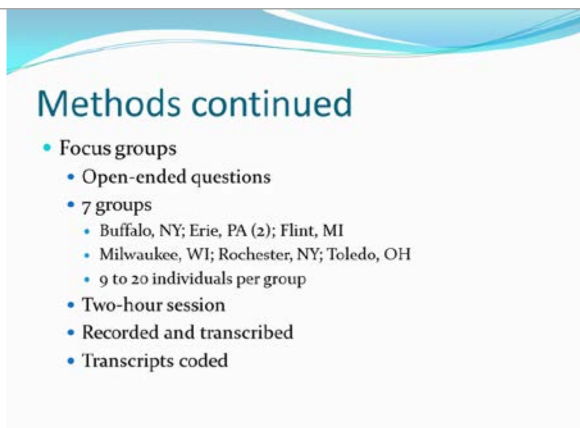
Urban anglers have been identified by many states as a target audience for fish consumption advisories because they are potentially at greater risk from consuming contaminated fish. We studied the characteristics of urban anglers in the Great Lakes region. Between 2011 and 2013, we conducted a series of six focus groups of Great Lakes urban anglers and a survey of licensed anglers living in Great Lakes states. We will describe the demographic characteristics and fish consumption patterns of Great Lakes urban anglers, discuss factors that influence their fish consumption, and identify advisory characteristics that have the potential to increase their adherence to fish consumption advisories. The results suggest ways to improve advisories targeting urban anglers.

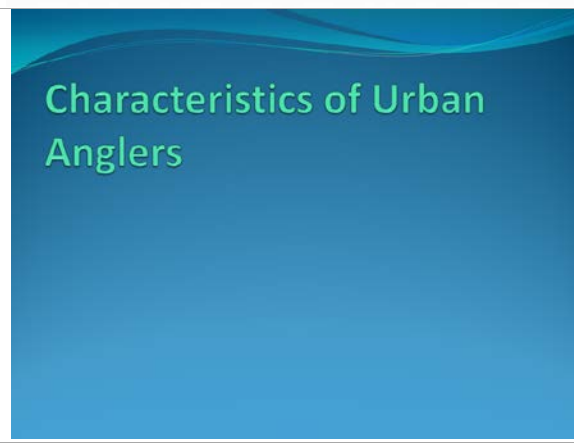
SESSION 6: COMMUNICATIONS TO THE PUBLIC
Urban Anglers' Fish Consumption and Response to Advisory Messages – Bruce Lauber











Primary Residence

Residence	Percent of Respondents
Urban	15%
Suburban	38%
Rural	48%

Income

	Urban	Suburban	Rural
<$25,000	15%	6%	11%
$25,000-$49,999	24%	20%	32%
$50,000-$99,999	42%	42%	41%
$100,000-$199,999	17%	27%	14%
$200,000 or more	3%	5%	2%

Education

	Urban	Suburban	Rural
High School or Less	33%	19%	32%
Some College	34%	39%	44%
College or More	33%	42%	24%

Race: % White

- 92% urban
- 94% suburban
- 97% rural

- 86% nationally

Urban Anglers' Fish Consumption

Fishing and Fish Consumption

- 89% fished
- 68% ate sport-caught fish
  - 5.4 meals/year
- 75% ate purchased fish
  - 12.5 meals/year
  - Less than suburban (17.1 meals)
- 7% ate fish more than once a week

Species	Percentage
Tuna (purchased)	69%
Salmon (purchased)	55%
Bluegill	50%
Walleye	47%
Crappie	35%
Bass	26%
Yellow Perch	24%
Pike	22%
Salmon (sport caught)	22%
Catfish	18%
Trout	13%
Lake Trout	11%
Swordfish (purchased)	9%

Species Eaten More than Suburban Anglers

- Bluegill (50% vs. 36%)
- Crappie (35% vs. 25%)
- Catfish (18% vs. 12%)

Species Eaten Less than Suburban Anglers

- Swordfish (9% vs. 14%)

Species Eaten Less than Rural Anglers

- Bass (26% vs. 34%)

Factors Influencing Fish Consumption

Need for Food

- ***R:*** *I know that there are a couple down there right now that that is their only means of food ... that fish out of that river ... They don't have a choice whether it's healthy or good for them or not. That's what they're doing to survive.*
- ***R1:*** *Especially with the way that the economy has been ... we're seeing more and more people come down there that's fishing for food.*
- ***R2:*** *I see families come down here. I don't know what country they were from. They were white people like myself, but they were speaking some foreign language.*

Diverse Fish Consumption Norms

- ***R:*** *The Asian people, they eat a lot of fish, you know. Any type of fish they prepare differently, different seasoning. They can grill, fry, make soup... So they eat a lot more fish... They make it taste good... Any type of fish they catch, they eat.*

Access to Fishing Sites

- ***R:*** *Right down here where the dam's at... That's the only place really that I can take them fishing because everywhere else, they don't have access to the water.*

Health Risks and Benefits

- Both excessive consumption and unnecessary restrictions
- Misconceptions about judging fish safety

Response to Advisories

Advisory Awareness

- 42% aware of specific advice
- 54% generally or vaguely aware
- 5% not at all aware

Response to Advisory Information

- Lack of awareness of available information
- Desired information on which fish are safe

Response

- ***R:** I would like them to tell me: "Don't eat carp. Don't eat ... bullhead out of here. But bass are okay, or bluegills are okay..." Instead they just say "Don't eat this."*

Preferred Messages

- Succinct
- Clear description of health outcomes
- Information about things they can't observe
- Statements of widespread relevance

Conclusions

- Urban anglers have many similarities to other licensed anglers, but subpopulation may be:
  - Lower income, less educated, and immigrant populations
  - More dependent on fish they catch for food
  - Hard to reach effectively
- Health risks/benefits and advisory messages can be misunderstood

Recommendations

- Utilize community-based communication programs
- Communicate risk-reduction strategies
- Incorporate positive advisory messages
- Target misconceptions
- Adopt preferred message characteristics
- List sources of additional information

Questions and Answers

Q. What did they learn from the 399 non-respondents to the survey of licensed anglers living in the Great Lakes states? (Gochfeld)

A. The non-respondents were less likely to go fishing, and were less aware of fish advisories, so they were less likely to have information to provide in the survey.

Q. In South Carolina, no license is required for fishing with cane poles, which he understands is mostly fishing by lower income people. Also senior citizens are exempt from obtaining a fishing license in South Carolina. In the survey, did they consider that some states may exempt some people from fishing licenses? (Glover)

A. For urban anglers, it is known that many people in urban areas will fish without a license. This is especially common with immigrant groups.

General Question and Answer Session

Q. *This question was for Bruce Lauber. A lot of fishing is recreational and intentionally catch-and-release. Some people just enjoy fishing. The "eat more fish" message can conflict with fisheries management and conservation. People intentionally catch-and-release to put fish back into the water to protect the fishery resource and maintain the recreational opportunity. We need to consider other societal and government goals. (Richter)*

A. Some respondents in the survey and participants in the focus groups said they enjoy catch-and-release fishing. (Lauber)

Q. *This question was for Bruce Lauber. The National Rivers and Streams Assessment compared urban and non-urban rivers and streams for a range of contaminants, and found contaminants such as mercury and organics. Among the organics, PCBs, PBDE, and DDT were significantly elevated in urban locations. (Wathen)*

A. This is good information to follow up on. (Lauber)

Q. *Some women do not eat much fish because they do not know how to cook it. He wanted to ask Mario Teisl—Did providing recipes help? Also he wanted to ask Amy Lando and Nancy Connelly—Has this issue come up in the focus groups? (Groth)*

A. Recipes were provided to help incorporate fish in their diet. There is no data about whether providing recipes helped, but they did hear about this issue in their focus groups. (Teisl)

Q. *This question was for Bruce Lauber. They are doing surveys with anglers in North Carolina now, and are concerned about social desirability bias in their results. Although people will say they have the information and know about the fish advisory, when shown the fish advisory itself they say they have never seen it before. Has Cornell University encountered this issue in their research and, if so, how have they addressed it? (Bawden)*

A. They have seen this social desirability bias and are also concerned about this type of bias in the research on urban anglers in the Great Lakes states. In addition, they have information on specific beliefs related to advisories. (Lauber)

A. A mail survey allows people to be more honest versus a face-to-face research setting, which can lead to this social desirability bias. (Connelly)

Q. *In research on women, we often look at women as one big homogenous group, but actually there are differences among women. Nancy Connelly's work separated women into those with lower and higher levels of education. Are you looking into disparities in activities and behavior among targeted groups of women? (Bawden)*

A. In New York, with the current diary survey, they have education and income as important variables. They hope to look at changes in behavior related to education and income. However, because their sample is licensed anglers they cannot look at race or ethnicity although that would be important too. (Connelly)

A. People that read advisories generally have higher education and income, and will access more sources of information. He only presented descriptive statistics in his PowerPoint presentation. For their published articles, in their regression analyses they controlled for education and the sources of other information that people got. It would be interesting to do additional segmentation of data. (Teisl)

A. They did some segmentation for their focus groups. She cannot remember exactly, but she thinks the cut-off was some college versus no college. They have not had time to do the detailed analysis yet. (Lando)

Q. Can anyone discuss how to expand the distribution of information to incorporate messages into more than printed materials, such as through websites or social media? For example, would the opportunity to have information on a smartphone help disseminate messages? Has anyone done that? (Murphy)

A. CDC has brochure information on their website. He knows there is some discussion of a smartphone App for people to have something available at the grocery store when shopping. This App would help shoppers choose between high versus low mercury fish or high versus low Omega 3 fish. (Teisl)

A. In her research results, the percentage of people who say they have looked at websites has increased over time. They expect to ask more questions about smartphones in future research. (Connelly)

Q. This question was for Amy Lando. Given that the mean concentrations of mercury in purchased fish range by two orders of magnitude, how would that affect different advice for different types of fish with different amounts of mercury? She thinks different information needs to be provided for fish with different mercury levels. (McCann)

A. This would be a good topic to bring to FDA's Risk Communication Advisory Committee meeting in November. (Lando)

Q. Why aren't there more targeted programs to reach anglers who do not have fishing licenses? After you find out what they want to know or do not know, and later give information to them too they want it. Why not ask more about what people do with the information and how they are using it? We are not always researching the people with a lack of education who need to fish for food. She has used undergraduate students to distribute information on the river to these people. They are finding out what people know and do not know. People without licenses really want to know information. Their students had to read that information to the non-readers. (Burger)

A. The panelists are all researchers who do not communicate with the public. Are there any others working on this issue of distributing information? (Knuth)

A. Researchers need to think about this. (Lando)

Q. This question was for Karen Swajian. Is she referring to the buffalo fish family? Also are you suggesting that people avoid them? (Michl)

A. Yes, but FDA is not prepared yet to issue an advisory or to say do not eat buffalo fish, because FDA does not know what the toxin or causative agent is yet. FDA has the same situation with ciguatera fish poisoning, where they say avoid reefs with ciguatera but continue to fish. (Swajian)

Q. When working with focus groups and using terms about tuna, why not use the verbiage that is on the cans of tuna purchased in the store? For example, "chunk light tuna" for "light" and "solid white tuna" for "albacore." Was there confusion among women in the focus groups about "light" tuna and the difference between water-packed versus oil-packed tuna? Do the health benefits differ? (Cunningham)

A. Using the terminology on the tuna cans is a good idea to consider for future research. There was some confusion among the women in the focus groups about water-packed versus oil-packed tuna. She does not have an answer about whether there is any difference in health benefits. (Lando)

Q. In New Jersey, for the North Bay Complex they issued a ban on crabs and have signs in seven different languages and also are using media campaigns. They found that using local community organizations is very helpful for getting the word out. They found that immigrants often get the opposite message that the government is trying to prevent them from fishing in order to save the fishery resource for rich people. (Gary Buchanan)

A. They did not see that reaction from immigrants in his research, but that is a very interesting issue to consider in future research. (Teisl)

Comment: Getting out into the community more is a good point. (Knuth)

Q. This conference has not focused on the nutritional and physiological benefits of Omega 3 to women and their own health. Fish consumption may especially benefit women when breastfeeding. The best source of Omega 3 for the baby is from the mother's brain. The Omega 3 goes from the mother's brain into the baby's brain. If all of the Omega 3 in the mother's brain is going to the baby, the mother is not getting health benefits from Omega 3. If we consider this, we might see less postpartum depression in the United States, which is less common in other countries. (Ralston)

A. There were no responses or comments from any of the panelists.

Q. In Colorado, they have the QR code for smartphones on all of their new signs and materials. This QR code allows smartphone users to read their fish tissue website, which has the fish advisories and interactive maps for fishing areas. Also their website is Google-based so they have the ability to translate the advisories into any language that people need. (Richardson)

A. There were no responses or comments from any of the panelists.

Fish Advisory Outreach to Urban and Rural Alaska Stakeholders

Ali Hamade, Alaska Section of Epidemiology

Biosketch

Dr. Ali Hamade currently serves as the Environmental Public Health Program Manager in the Alaska Section of Epidemiology. The program works with state, federal, and tribal partners to assess and educate about the health hazards of chemical exposure, and to develop intervention strategies to reduce or eliminate chemical exposure from air, water, soil, and food. Dr. Hamade received his Ph.D. in Environmental Toxicology from the University of California, Irvine. Subsequently, he performed air quality health effects research at Johns Hopkins University, where he also trained in the risk sciences. He then transitioned to work on human health risk assessment and hazard identification of chemical contaminants at a consulting company, before joining the State of Alaska in 2012. Since 2012, his work has included a collaborative Alaska state-wide effort to assess the potential risks associated with contaminants in Alaska seafood. Dr. Hamade has also provided health education and outreach about contaminants in fish at community meetings, to health care providers, and at conferences. He is a Diplomate of the American Board of Toxicology.

Abstract

Alaskans, particularly Alaska Natives, likely consume more fish per capita than most other U.S. populations. The Alaska Section of Epidemiology with members of an advisory board recently issued fish consumption guidelines that provide Alaskans, particularly women of childbearing age and children, with advice on fish consumption choices. These guidelines take a risk-benefit-based approach to fish consumption and health. In addition to mercury and persistent organic pollutants, since 2011, Alaskans have been concerned about the safety of consuming fish in the wake of the nuclear accident in Fukushima. The Alaska Section of Epidemiology is informing stakeholders of both the recent fish consumption guidelines and Fukushima-related updates via several channels. These channels include health care providers; environmental, tribal, and medical conferences; community visits; conference calls; and social media. This outreach is of paramount importance in Alaska as a large proportion of the population, particularly that including Alaska Natives, relies on fish and marine mammals for subsistence. This presentation will highlight past, current, and planned outreach efforts to inform Alaska stakeholders of fish advisories and other news related to contaminants in seafood.

SESSION 6: COMMUNICATIONS TO THE PUBLIC
Fish Advisory Outreach to Urban and Rural Alaska Stakeholders – Ali Hamade

THE STATE of ALASKA
GOVERNOR SEAN PARNELL

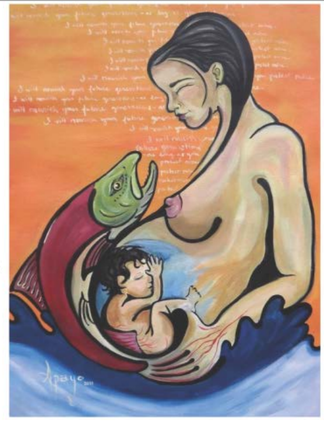
Fish Advisory Outreach to Urban and Rural Alaska Stakeholders

Ali Hamade
Environmental Public Health Program
Section of Epidemiology
Division of Public Health

September 24, 2014
EPA Forum on Contaminants in Fish

Our Agreement:
I will nourish your future generations - as long as you protect mine.

Apayo Moore, Alaska Artist and Fisherwoman



Alaska Fish Consumption Guidelines

- In 2014 updated the Acceptable Daily Intake for mercury in fish (Seychelles cohort)
  - 7,900+ fish monitoring data points
  - Review of recent studies on neurodevelopmental, diabetes, and cardiovascular endpoints
- Recognized the importance of fish for nutrition, economics, sports, culture, community, religion, and identity
- Large amounts of fish consumed by Alaskans

Message Considerations

- Guidelines are ONLY for children and women who are pregnant, or plan on becoming pregnant
- Stress benefits, but communicate some caution from small number of fish (*e.g.*, large halibut, shark)
- Communicate supporting programs
  - Hair mercury biomonitoring
  - Fish monitoring

Stakeholders

- Alaskans (native and non-native)
- Alaska Depts. of Health, Environmental Conservation, and Fish and Game; University of Alaska; US Fish and Wildlife Service
- Alaska Native Tribal Health Consortium (ANTHC)
- Commercial fishers
- Alaska Seafood Marketing Institute, International Pacific Halibut Commission
- Health care providers and public health practitioners

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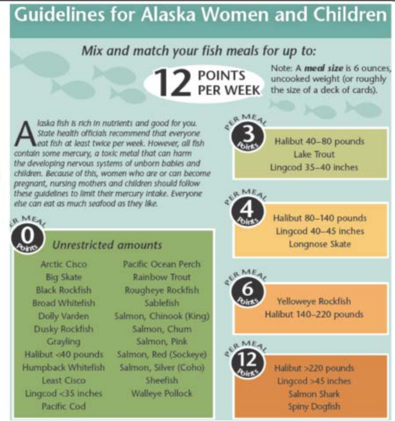
Fish Advisory Outreach to Urban and Rural Alaska Stakeholders – Ali Hamade

Repeated Widespread Message to Stakeholders

- Epidemiology Bulletin, media interviews, press releases
- Conference Calls: Tribal and interagency
- Conferences: Tribal representatives, public and environmental health professionals
- Health Care Providers
- Community Meetings
- Social media

Statewide guidelines incorporate fish species consumed by most Alaskans



Alaska Dispatch News

www.adn.com

Report: Eat all the salmon you want, but leave sharks off the menu

By KYLE HOPKINS
Alaska Dispatch News

The species of Alaska fish that are considered safe to eat every day, even by pregnant women and small children, has more than doubled based on expanded research by the state Division of Public Health.

All five species of Alaska salmon, halibut weighing 40 pounds or less when caught and the countless Alaska pollock sold as frozen fish sticks all have relatively low amounts of mercury, according to new and ongoing state research. The Health Department published updated guidelines for safe levels of fish consumption Monday.

The state began testing samples of seafood for mercury and other risky contaminants in 2001 and started testing for traces of the toxic metal in Alaska women of childbearing age in 2002. As of March, 1,145 women from 148 Alaska communities had shared hair samples with an Anchorage-based lab for analysis. Only four of the women, 0.3 percent, showed mercury levels that the Section of Epidemiology considers a health concern.

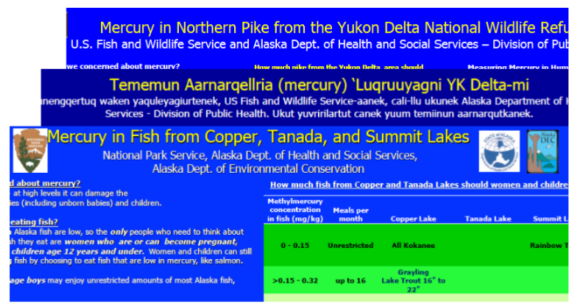
In 2007, the state listed 11 species of fish that were safe to eat in any amount for women and children. This week, that number expanded to 22 species, based on growing efforts to sample fish across the state. The fish aren't necessarily safer than they were seven years ago, but state health experts know more about the impact of eat-

See Back Page, MERCURY

Adolph Pleasant, 34, of Quinhagak caught this 7-foot, 4-inch salmon shark in 2009 while halibut fishing in Kuskokwim Bay.

ZIPPING THROUGH THE TREES IN SEWARD

Targeted Mid Kuskokwim River Advisory (English and Yu'pik)



Mid Kuskokwim Village Community Meeting

March, 2014
Lower Kalskag, AK

March, 2014
Crooked Creek, AK

SESSION 6: COMMUNICATIONS TO THE PUBLIC

Fish Advisory Outreach to Urban and Rural Alaska Stakeholders – Ali Hamade

March, 2014
Red Devil, AK

Mode of
Transportation

March, 2014
Snow Barn
Red Devil, AK

Cs-134

Emergency Steps – Fukushima

- Concerns of fish contaminated with Fukushima related radiation
  - Calls to state agencies
  - Tribal concerns over safety of traditional foods
- State and federal agencies in Alaska issued joint press release indicating safety of wild foods
- Websites
  - communicated safety of fish and other media

Sr-90

I-131

Cs-137

Fukushima

- Initiated an interagency call with all Pacific states, Canada, federal agencies, tribal agencies, and academics
  - Compile public concerns
  - Compare biota and other media for radionuclides
- Worked with the FDA to test Alaska fish for radionuclides
- Communicated information via press releases, tribal calls, and citizen calls
- Continue to communicate information at conferences and conference calls

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Sean Parnell
Governor
P.O. Box 110001
Juneau, AK 99811-0001
gov.state.ak.us

STATE OF ALASKA

JOINT RELEASE

FOR IMMEDIATE RELEASE: July 31, 2014

Contact: Dr. Bob Gerlach, Department of Environmental Conservation, 907-375-8214, bob.gerlach@alaska.gov
Dr. Ali Hamade, Department of Health and Social Services, 907-269-8086, ali.hamade@alaska.gov

Further analyses confirms Alaska seafood is safe from Fukushima radiation

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Future Steps

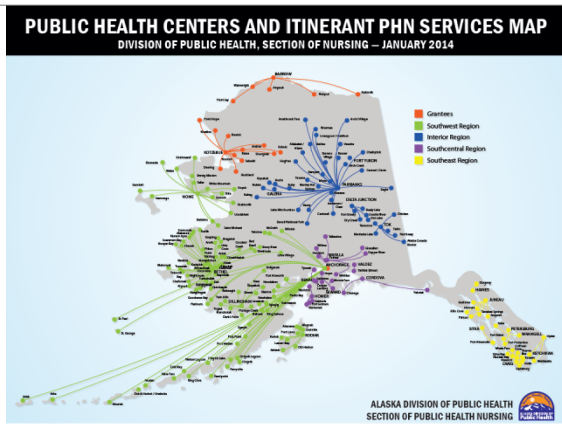
- Regional Immersion to Engage Community
  - In health clinics
  - With itinerant nurses
  - In community meetings
- Collaborate with Partners
  - Alaska Native Tribal Health Consortium
  - Public Health Nursing
  - Audiovisual educational materials
- Social media
  - Facebook, Twitter, partner pages

SESSION 6: COMMUNICATIONS TO THE PUBLIC
Fish Advisory Outreach to Urban and Rural Alaska Stakeholders – Ali Hamade

Statewide Initiative by the Alaska Native Tribal Health Consortium

Help from Public Health Centers

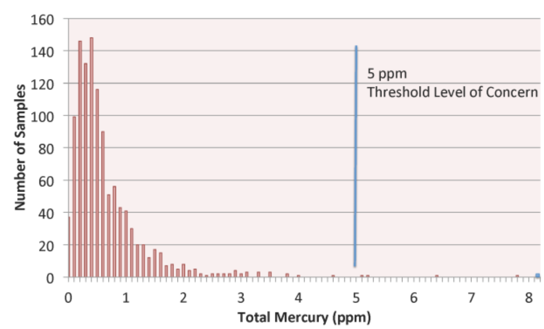
- 24 centers
- Itinerant nurses travel to surrounding locations
- Training videos
  - Importance of fish consumption
  - Importance of advisories
  - Fish monitoring program
  - Hair mercury biomonitoring
- Could also be used for health care providers, tribal officers, health aides, and environmental aides



Acknowledgements

- ✓ Alaskans
- ✓ Alaska Scientific Advisory Committee for Fish Consumption
  - Jim Berner – ANTHC
  - Bob Gerlach – AK Dept. Environmental Conservation
  - Angela Matz – US FWS
  - Joseph McLaughlin – AK Division of Public Health
  - Todd O'Hara – University of Alaska, Fairbanks
  - Chris Siddon – AK Dept. Fish and Game
- ✓ EPA
- ✓ Fish Consumption Guidelines Comments (partial and full)
  - Jeff Bigler and Lon Kissinger - EPA
  - Phil Davidson and Gary Myers - Rochester
  - Sandrine Deglin – AK Division of Public Health
  - Dariush Mozaffarian – Tufts
  - John Risher and Joe Sarcone – ATSDR
  - Phil Spiller - FDA

Hair Mercury Concentrations among Women (age, 15-45 y) — 2002–2014



Questions and Answers

Note: There were no questions because the moderator asked that any questions be held until the general Q&A session at the end of this panel.

Engaging Healthcare in Environmental Exposure Risk Reduction

Michael Hatcher, U.S. Agency for Toxic Substances and Disease Registry

Biosketch

Not provided.

Abstract

Not provided.

SESSION 6: COMMUNICATIONS TO THE PUBLIC
Engaging Healthcare in Environmental Exposure Risk Reduction – Michael Hatcher

Engaging Healthcare in Environmental Exposure Risk Reduction

Michael T. Hatcher, DrPH
Chief, Environmental Medicine Branch
Division of Toxicology and Human Health Sciences
Agency for Toxic Substances and Disease Registry

Disclaimer: The findings and conclusions in this presentation have not been formally disseminated by the Agency for Toxic Substances and Disease Registry and should not be construed to represent any agency determination or policy.

Agency for Toxic Substances and Disease Registry
Division of Toxicology and Human Health Sciences

ATSDR

Presentation Overview

- Challenges for clinicians to address environmental health
- Meeting clinician outreach challenges
- Engaging healthcare systems to promote environmental exposure assessment and risk reduction counseling

Challenges for Clinicians to Address Environmental Health

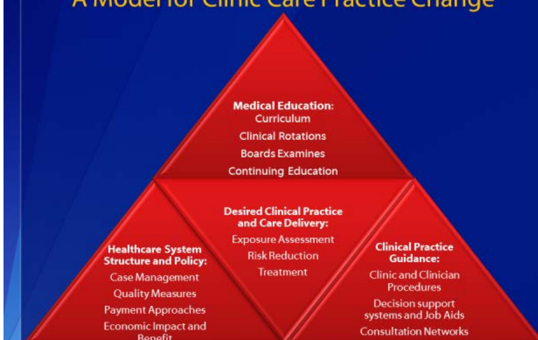
- Lack of
  - Clinic time
  - Reimbursement
  - Perceived importance
  - Clinician knowledge

Meeting Clinician Outreach Challenges

- Public health advisories on fish contamination
- Public health education and communication promoting advisory guidelines adoption
- Clinician education
  - Pre-service medical and nursing school curriculum on mercury and fish
  - In-service medical and nursing education on healthy fish choices

Community and Health Systems Model

A Model for Clinic Care Practice Change



SESSION 6: COMMUNICATIONS TO THE PUBLIC
Engaging Healthcare in Environmental Exposure Risk Reduction – Michael Hatcher

Healthcare Structure Opportunities to Build Environmental Medicine Practice

- Health plans
- Health care provider organizations
- Professional medical associations serving primary care providers
- Medical colleges and primary care residency programs
- Federal agencies - influence on health care policy, workforce development, and clinical care practice

Engaging Healthcare in Great Lakes Environmental Exposure Risk Reduction

- Form a Healthcare Advisory Council (HcAC) to
  - Identify healthcare system opportunities to support system level adoption of clinical practice in environmental exposure assessment
  - Identify opportunities to support delivery of risk reduction counseling responsive to patient exposure assessment findings

Engaging Healthcare in Great Lakes Environmental Exposure Risk Reduction

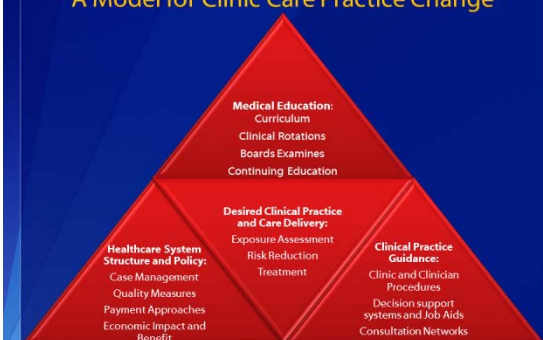
- Develop an eToolkit for healthcare system use
- Hold a symposium to examine environmental exposure risks that Great Lakes contaminants may have on children and women of reproductive age

Committee Opinion: *Exposures to Toxic Environmental Agents*

- Number 575 --- October 2013
- Key Points:
  - Science is robust enough to talk precautionary actions
  - Physicians should:
    - Assess their patient's environmental exposure risk
    - Counsel patient's on lowering their exposure risk

http://www.acog.org/Resources_And_Publications/Committee_Opinions/Committee_on_Health_Care_for_Underserved_Women/Exposure_to_Toxic_Environmental_Agents

A Model for Clinic Care Practice Change



Thank you for the opportunity to speak!

For more information please contact Agency for Toxic Substances and Disease Registry

4770 Buford Highway NE, Chamblee, GA 30341
Telephone: 1-800-CDC-INFO (232-4636)/TTY: 1-888-232-6348
E-mail: cdcinfo@cdc.gov Web: http://www.atsdr.cdc.gov

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Division of Toxicology and Human Health Sciences

Questions and Answers

Note: There were no questions because the moderator moved along to the next speaker on this panel.

Fish Consumption for Clinicians: Increasing Knowledge of the Risks and Benefits of Fish and Evaluating Clinical Screening for Mercury

Susan Buchanan, University of Illinois – Chicago

Biosketch

Dr. Susan Buchanan is Director of the Great Lakes Center for Children's Environmental Health Region 5 Pediatric Environmental Health Specialty Unit (PEHSU) at the University of Illinois at Chicago (UIC) School of Public Health. Dr. Buchanan is board certified in Family Medicine and Occupational and Environmental Medicine. She teaches occupational and environmental medicine including children's and reproductive environmental health topics in the UIC Family Medicine Department, School of Public Health, and Occupational Medicine Residency Program. Her research interests include the occupational health of vulnerable populations, including day laborers, and prenatal exposures to environmental pollutants. Most recently, she has completed research on methylmercury exposure among high-risk groups including pregnant women.

Abstract

This session will present the results of two projects that address the role of the clinician in preventing exposures to contaminants in fish. The first project was the development and evaluation of Healthy Fish Choices, an online continuing education curriculum for healthcare providers on the benefits and risks of fish consumption. The second project involved the testing of a fish consumption screening question to predict elevated blood mercury levels among pregnant women.

SESSION 6: COMMUNICATIONS TO THE PUBLIC
Fish Consumption for Clinicians: Increasing Knowledge of the Risks and Benefits of Fish and Evaluating Clinical Screening for Mercury – Susan Buchanan

Fish Consumption for Clinicians
Increasing Knowledge of the Risks and Benefits of Fish
and
Evaluating Clinical Screening for Mercury

Susan Buchanan, MD, MPH
Great Lakes Center for Children's Environmental Health/R5 PEHSU
University of Illinois at Chicago School of Public Health

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Environmental and Occupational Health Sciences Division

Acknowledgement

FishNet: Internet Curriculum for Healthcare Organizations was funded by EPA Great Lakes National Restoration Initiative grant #GL-00E00536-0.

Testing a Screening Question for Elevated Prenatal Mercury was funded by EPA Great Lakes National Restoration Initiative grant #GL-00E01141-0.

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How to utilize the healthcare provider to decrease exposure to methyl mercury from fish?

A. Educate clinicians about risks and benefits of fish consumption

B. Provide patient education/counseling

C. Implement screening

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Background: Health Behavior Change

- Evidence shows:
  - 50% of the mortality in the US from the 10 leading causes of death are related to lifestyle behaviors
  - Patients look to their primary care providers (PCPs) as sources of prevention recommendations
  - Brief interventions integrated into routine primary care can reduce risk behaviors

Whitlock et al. Am J Prev Med 2002

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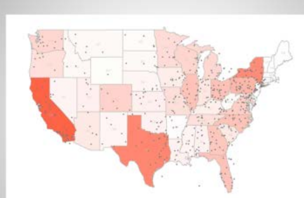
Background: Current clinician knowledge

UCSF ACOG Survey 2011 (N=2,625)



Stotland NE, Sutton P, Trowbridge J, Atchley D, Charlesworth A, Conry J, Trasande L, Gerbert B, Woodruff TJ. Preventing Toxic Prenatal Environmental Exposures: Attitudes, Beliefs and Practices of U.S. Obstetricians (in review)

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78%
of obstetricians surveyed feel that they can reduce patient exposure [to environmental toxicants]

Yet, less than 25% report they take an environmental health history

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Fish Consumption for Clinicians: Increasing Knowledge of the Risks and Benefits of Fish and Evaluating Clinical Screening for Mercury – Susan Buchanan

What Do Obstetricians Ask About?

100% | *Less than 20%*

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THE DAILY BEAST POLITICS ENTERTAINMENT WORLD NEWS BUSINESS FASHION TRAVEL ART WOMEN IN THE WORLD

HEALTH

CHANGE TEXT SIZE
AUTHOR
Lenore Skenazy
FOLLOW @THEDAILYBEAST

Medicine Bedevils Pregnant Women With Too Many Warnings About Risk

A well-meaning medical community is worrying pregnant women silly with indiscriminate warnings about environmental hazards, writes Lenore Skenazy.

A recent study showing that breast milk procured online is often tainted has many moms experiencing a familiar emotion: fear. It's part and parcel of modern parenting, and starts the minute the pee stick changes color, basically announcing, "Congratulations! And start worrying!"

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Background: Healthcare provider education

Adult learning techniques that are:

- Interactive
- Sequential
- Held in settings such as workshops, small groups, individual training sessions

WORK BETTER TO CHANGE PROVIDER BEHAVIOR

Whitlock et al. Am J Prev Med 2002

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- On-line CME course
- Six 30-minute modules delivered every 2 weeks
- Repeated short bursts of information, interactive
- Pre-test for each module evaluates knowledge from previous module
- Participants required to make Action Plan for clinical practice
- Actions Plans posted on Discussion Board

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Summary messages

Module 1: the four(five) fish to avoid
Module 2: eat fish twice per week
Module 3: eat a variety of fish
Module 4: advise special populations re: species that are lower in contaminants
Module 5: access local fish advisories for sport anglers
Module 6: balance risks and benefits

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Healthy Fish Choices – *www.healthyfishchoices.org*

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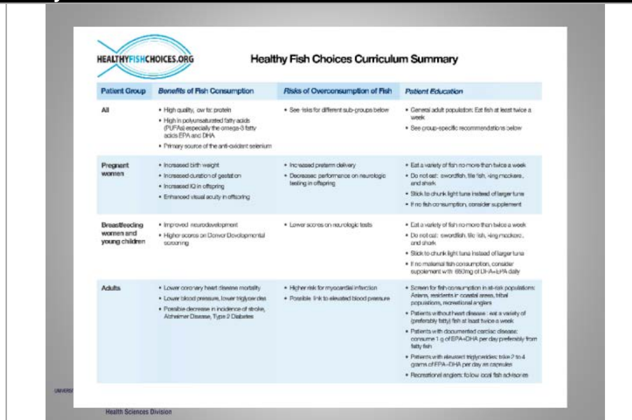
SESSION 6: COMMUNICATIONS TO THE PUBLIC

Fish Consumption for Clinicians: Increasing Knowledge of the Risks and Benefits of Fish and Evaluating Clinical Screening for Mercury – Susan Buchanan

	Knowledge	Behaviors	Tools (Skills)
1	1. How contaminants get into fish-Hg, PCBs, chlordane, DDT. 2. Mercury concentrates in larger fish. 3. Major benefits of PUFAs for fetus/pregnancy/infants: neurodevelopment, etc. 4. Major risks of organic mercury in pregnancy/infants: neurodev, etc. 5. The four fish to avoid.	Ask patients (child's parents) about consumption of the four fish to avoid. Advise against intake of the big four.	Script for asking about the four types of fish to avoid. Advice to avoid them. *Case: pregnant woman craving swordfish*
2	1. Major benefits of PUFAs for adults. 2. Major risks of organic mercury and PCBs in adults. 3. Non-fish sources of PUFAs. 3. A variety of fish, two meals per week.	Ask all patients about frequency of fish consumption. Advise re: eat fish, two meals per week.	Script for asking about freq of fish consumption. Advice re: eat fish twice per week. Access AHA recs. *Case: adult with heart disease – screening for eating enough fish*
3	1. DHA intake recs in pregnancy. 2. Mother-baby pathway (placenta), why children are special pops. 3. Detail on risks and benefits of fish in pregnancy/childhood – expanded from Mod 1.	Ask patients (child's parents) about frequency of fish consumption. Encourage pts. to eat fish, reinforce avoiding the big four, eat a variety twice a week, do not stick to one fish	Script on screening for freq of fish consumption, encouraging to eat fish, reinforce the big four, eat a variety twice a week. *Case: child who eats only tuna sandwiches*
4	Special pops at risk besides pregnant women and babies: Asian pops, tribal pops. Review absorption of mercury, ½ life. Tables of mercury levels in various species.	Know the ethnic groups that may be at higher risk.	Script – Screen high risk populations. Access information on mercury levels in fish. *Case: Asian adult – eating fish often and feeding it to grandchildren*
5	PCBs, pesticides and other contaminants. Great Lakes. Introduction to local fish advisories.	Screen pts about locally caught fish.	How to access local fish advisories. Add consumption of locally caught fish to routine screening. Case: Urban angler
6	Putting it all together into a risk management approach plus Fish oil supplements, other dietary		



Patient Group	Benefits of Fish Consumption	Risks of Overconsumption of Fish	Patient Education
All	• High quality, low fat protein • High in polyunsaturated fatty acids (PUFAs) especially the omega-3 fatty acids EPA and DHA • Primary source of the anti-oxidant selenium	• See risks for different sub-groups below	• General adult population: Eat fish at least twice a week • See group-specific recommendations below
Pregnant women	• Increased birth weight • Increased duration of gestation • Increased IQ in offspring • Enhanced visual acuity in offspring	• Increased preterm delivery • Decreased performance on neurologic testing in offspring	• Eat a variety of fish no more than twice a week • Do not eat: swordfish, tile fish, king mackerel, and shark • Stick to chunk light tuna instead of larger tuna • If no fish consumption, consider supplement
Breastfeeding women and young children	• Improved neurodevelopment • Higher scores on Denver Developmental screening	• Lower scores on neurologic tests	• Eat a variety of fish no more than twice a week • Do not eat: swordfish, tile fish, king mackerel, and shark • Stick to chunk light tuna instead of larger tuna • If no maternal fish consumption, consider supplement with 650mg of DHA+EPA daily
Adults	• Lower coronary heart disease mortality • Lower blood pressure, lower triglycerides • Possible decrease in incidence of stroke, Alzheimer Disease, Type 2 Diabetes	• Higher risk for myocardial infarction • Possible link to elevated blood pressure	• Screen for fish consumption in at-risk populations: Asians, residents in coastal areas, tribal populations, recreational anglers • Patients without heart disease: eat a variety of (preferably fatty) fish at least twice a week • Patients with documented cardiac disease: consume 1 g of EPA+DHA per day preferably from fatty fish • Patients with elevated triglycerides: take 2 to 4 grams of EPA+DHA per day as capsules • Recreational anglers: follow local fish advisories

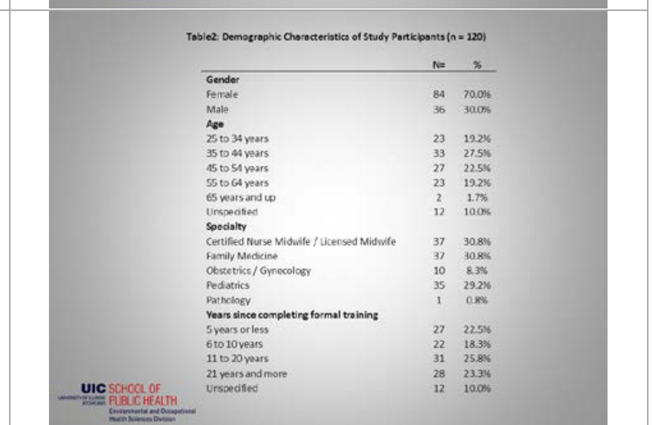


Table2: Demographic Characteristics of Study Participants (n = 120)

	N=	%
Gender		
Female	84	70.0%
Male	36	30.0%
Age		
25 to 34 years	23	19.2%
35 to 44 years	33	27.5%
45 to 54 years	27	22.5%
55 to 64 years	23	19.2%
65 years and up	2	1.7%
Unspecified	12	10.0%
Specialty		
Certified Nurse Midwife / Licensed Midwife	37	30.8%
Family Medicine	37	30.8%
Obstetrics / Gynecology	10	8.3%
Pediatrics	35	29.2%
Pathology	1	0.8%
Years since completing formal training		
5 years or less	27	22.5%
6 to 10 years	22	18.3%
11 to 20 years	31	25.8%
21 years and more	28	23.3%
Unspecified	12	10.0%

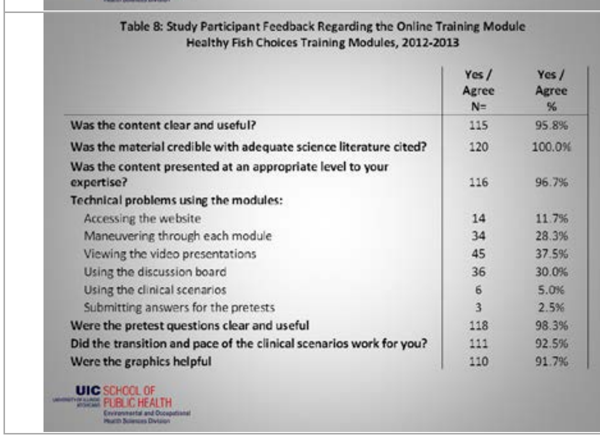
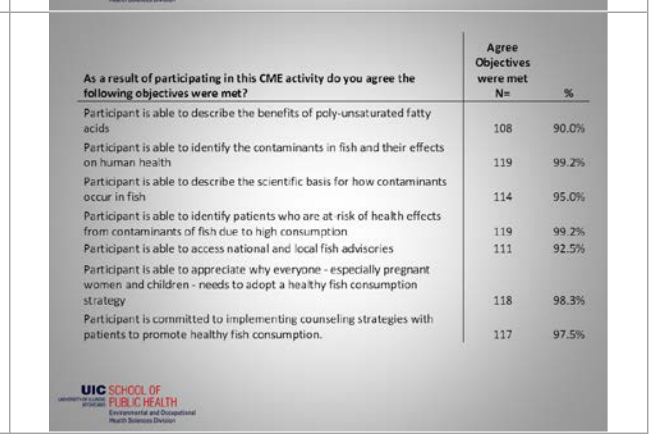


Table 8: Study Participant Feedback Regarding the Online Training Module
Healthy Fish Choices Training Modules, 2012-2013

	Yes / Agree N=	Yes / Agree %
Was the content clear and useful?	115	95.8%
Was the material credible with adequate science literature cited?	120	100.0%
Was the content presented at an appropriate level to your expertise?	116	96.7%
Technical problems using the modules:		
Accessing the website	14	11.7%
Maneuvering through each module	34	28.3%
Viewing the video presentations	45	37.5%
Using the discussion board	36	30.0%
Using the clinical scenarios	6	5.0%
Submitting answers for the pretests	3	2.5%
Were the pretest questions clear and useful	118	98.3%
Did the transition and pace of the clinical scenarios work for you?	111	92.5%
Were the graphics helpful	110	91.7%



As a result of participating in this CME activity do you agree the following objectives were met?	Agree Objectives were met N=	%
Participant is able to describe the benefits of poly-unsaturated fatty acids	108	90.0%
Participant is able to identify the contaminants in fish and their effects on human health	119	99.2%
Participant is able to describe the scientific basis for how contaminants occur in fish	114	95.0%
Participant is able to identify patients who are at-risk of health effects from contaminants of fish due to high consumption	119	99.2%
Participant is able to access national and local fish advisories	111	92.5%
Participant is able to appreciate why everyone - especially pregnant women and children - needs to adopt a healthy fish consumption strategy	118	98.3%
Participant is committed to implementing counseling strategies with patients to promote healthy fish consumption.	117	97.5%

Table 6: Average Pre-test and Post-test Scores by Training Module
Healthy Fish Choices Training Modules, 2012-2013

	Pre-Test			Post-Test				
	N= Questions	Mean Score	SD	N= Questions	Mean Score	SD	Mean Difference Pre to Post-Test*	P-value
le 1	5	53.5%	25.3%	5	84.2%	18.9%	30.7%	<0.001
le 2	7	62.5%	25.6%	6	90.4%	16.0%	27.9%	<0.001
le 3	5	70.5%	26.7%	8	86.8%	13.3%	16.3%	<0.001
le 4	9	63.6%	18.9%	8	83.5%	23.3%	19.9%	<0.001
le 5	7	66.9%	24.3%	9	86.8%	18.4%	19.9%	<0.001
le 6	9	75.6%	20.6%	10	84.4%	11.4%	8.9%	<0.001

*Adjusted for years of practice, specialty, and 5 or more hours CME training in last hour
**Number of questions varied by module and pre/post-test. Some modules contained questions asked in previous modules which randomly selected.

Table 4: Barriers to Integrating Discussions on Nutritional Issues within the Medical Practice of Study Participants
Healthy Fish Choices Training Modules, 2012-2013

	N=	%
What are the main barriers you currently encounter when discussing nutrition and food safety issues with patients?		
Lack of time	85	70.8%
More pressing issues	64	53.3%
Low interest by patient population	38	31.7%
Lack of sufficient knowledge to deal with the issues	30	25.0%
Lack of information on referral sources	23	19.2%
Not my area of expertise	22	18.3%
No resources available for patients	14	11.7%
Other specialists in our practice deal with those issues	6	5.0%

Test scores

- Comparison of the cumulative immediate posttest scores to follow-up scores:
  - 85.9% (sd=10.2) vs 81.5% (sd=12.4)
  - decrease ($p<0.01$) in the percent correct answer
- Persistence of improved knowledge -- comparison of cumulative pretest scores to follow-up scores:
  - 66.2% vs. 81.5%
  - 15.3% points higher ($p<0.001$)

Clinical practice change

- Immediate: **89.2%** stated that they would implement modifications in their practice
- Follow-up: **79.1%** had adopted new practices to enhance their patient care in regards to fish consumption

Qualitative responses re: clinical practice change

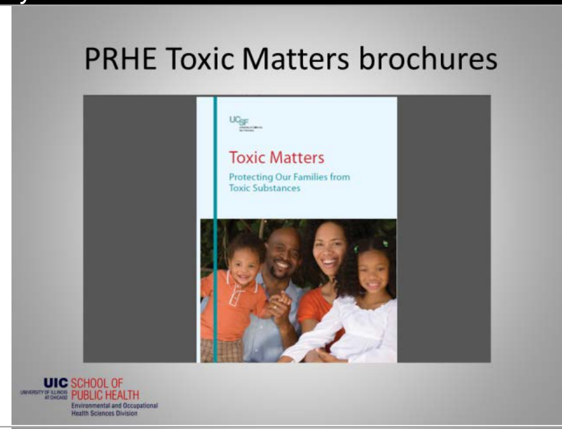
- *Incorporating discussion about fish consumption in the history and physical exam in the initial visit or follow-up visits*
- *Providing lists of fish to avoid and information about adding fish to diet*
- *Improving screening for at-risk groups based on ethnicity and fish consumption levels*
- *Discussing benefits of eating omega 3's and general counseling on appropriate fish intake and risks*
- *Adding questions to electronic medical record screens*
- *Adding smart phrases and smart text that can be printed out for patients on their after visit summary*

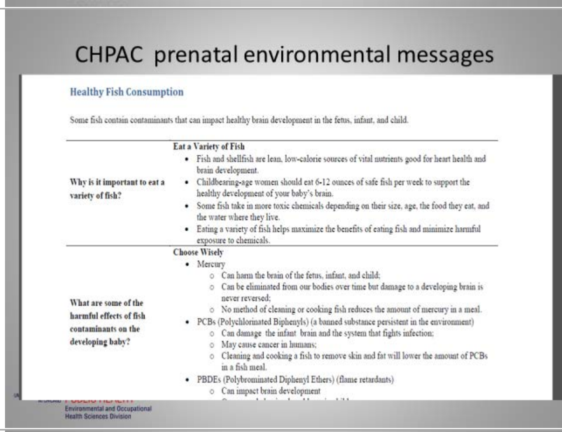
Revisions

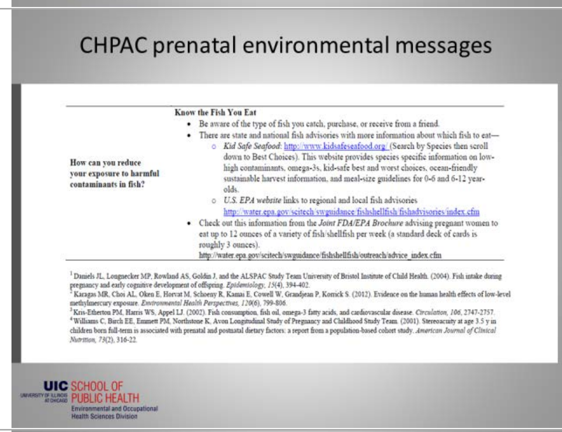
- Reduced required modules
  - Modules 1 and 2 are required for initial CME, 4-6 are for additional CME
- Decreased requirement to post on Discussion Board
- Decreased 2 week interval between Modules
- Size of videos shrunk for faster loading

SESSION 6: COMMUNICATIONS TO THE PUBLIC

Fish Consumption for Clinicians: Increasing Knowledge of the Risks and Benefits of Fish and Evaluating Clinical Screening for Mercury – Susan Buchanan







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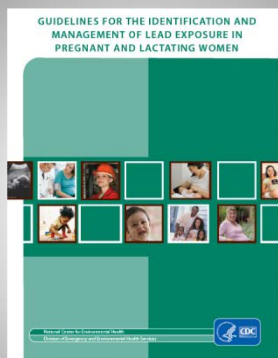

November 2010

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Figure 5-1. New York City Department of Health and Mental Hygiene: Recommended Lead Risk Assessment Questions for Pregnant Women

Health-care providers should use a blood lead test to screen pregnant women if they answer "yes" to any of the following questions:

1. Were you born, or have you spent any time, outside of the United States?
   In NYC, approximately 95% of identified lead-poisoned pregnant women are foreign born. Countries of birth in descending order of frequency include Mexico, India, Bangladesh, Russia, Pakistan, Ecuador, Haiti, Jamaica, Morocco, Dominican Republic, Guatemala, Guyana, El Salvador, Gambia, Ghana, Honduras, Israel, Ivory Coast, Korea, Nepal, Sierra Leone, and Trinidad.
2. During the past 12 months, did you use any imported health remedies, spices, foods, ceramics, or cosmetics?
3. At any time during your pregnancy, did you eat, chew on, or mouth nonfood items such as clay, crushed pottery, soil, or paint chips?
4. In the last 12 months, has there been any renovation or repair work in your home or apartment building?
5. Have you ever had a job or hobby that involved possible lead exposure, such as home renovation or working with glass, ceramics, or jewelry?

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Assessment Questions for Pregnant Women

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Clinical Screening

- Effective screening:

  High sensitivity – those with elevated MeHg have "positive" screen

  High negative predictive value – those with a "negative" screen do not have elevated MeHg

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Testing a Screening Question for Prenatal Mercury Exposure

- Can one screening question identify those with elevated mercury?
- Can prenatal providers implement screening in their clinical practices?
  - identify barriers, successes

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Testing a Screening Question for Prenatal Mercury Exposure

- Recruit prenatal providers from *Healthy Fish Choices* participants
- On first prenatal visit:
  - Administer the screen: "In general, do you eat fish more than twice a week?"
  - Add total blood mercury to prenatal lab panel

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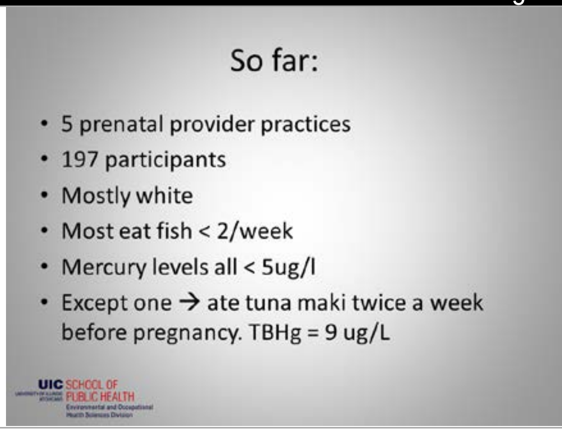
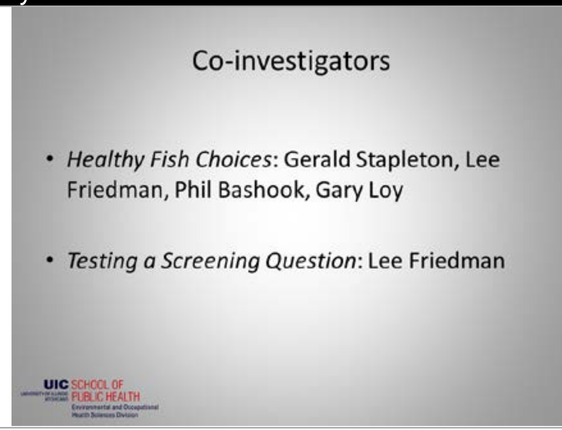
SESSION 6: COMMUNICATIONS TO THE PUBLIC
Fish Consumption for Clinicians: Increasing Knowledge of the Risks and Benefits of Fish and Evaluating Clinical Screening for Mercury – Susan Buchanan





Questions and Answers

Note: There were no questions because the moderator moved along to the next speaker on this panel.

Communicating Information to Reduce Mercury Exposures in Women of Childbearing Age

Pat McCann, Minnesota Department of Health

Biosketch

Pat McCann has managed the Minnesota Department of Health (MDH) Fish Consumption Advisory Program since 1997. She is involved in planning for sampling fish for contaminants, researching health effects of fish contaminants, developing consumption advice and communicating this advice to the public. Ms. McCann holds a M.S. in Environmental Health from the University of Minnesota, School of Public Health, and a B.S. in Chemical Engineering from the University of Minnesota Institute of Technology. She is the co-chair of the Great Lakes Consortium for Fish Advisories and is the Principal Investigator for several on-going Great Lakes Restoration Initiative (GLRI) Grants.

Abstract

Fish in northeastern Minnesota and northern Wisconsin have elevated levels of methylmercury compared to other inland water bodies in these states. Fish consumption is associated with elevated blood levels of methylmercury. The developing nervous system is especially vulnerable to exposure to methylmercury. A recent study funded by EPA found that 10% of newborns tested in the Lake Superior basin region of Minnesota had blood mercury levels indicating maternal exposures above the EPA reference dose (RfD).

Health care providers are sources of credible and efficacious information to their patients. With the support of GLRI 2012 and 2013 funds, partnerships with health care providers are being established to further study fish consumption and mercury exposures in women who may become pregnant, and to develop effective communications with positive messages about health benefits of consumption of fish lower in mercury. Messages about safe fish consumption are complex because fish are a source of beneficial nutrients, and different species of fish have different risk/benefit profiles.

With clinics in Cook County on Minnesota's North Shore, MDH developed a training program for health care providers, and is conducting a study to measure blood levels of mercury and beneficial Omega 3 fatty acids in up to 500 women from 16 to 50 years of age. Women are also asked three simple screening questions to determine if this easily implemented screen will identify women with high mercury in their blood. Women also complete a more detailed questionnaire about fish consumption. Women will be given educational materials about safe fish consumption and blood mercury and fatty acids will be measured six months later in women with blood mercury indicating exposures above the RfD to determine if the educational intervention was successful. Two "control" women will also receive the same follow-up. In a related study, blood mercury is being measured in up to 150 WIC clients in neighboring Lake County. A similar educational intervention will be conducted with these women. Wisconsin is conducting a similar study with women who live on the south shore of Lake Superior. Additionally, MDH is collaborating with Health Partners based in the Twin Cities, and Essential Health based in rural Minnesota, to conduct detailed message testing via surveys and focus groups of their clients who are women of childbearing age. Finally, MDH is supporting Cornell University researchers who are conducting a 2-year diary study and message-testing in Great Lakes States women to measure behavior change between the first and second year. Overall this research program will provide: 1) more information about women's exposures; 2) simple and effective messages to encourage good nutrition for healthy babies; 3) collaborations with

health care providers who can integrate fish consumption advice into clinical practice by instituting a simple, time-efficient screening procedure to identify women who need advice about healthy fish consumption, and providing effective and simple messages and counseling to these women.

SESSION 6: COMMUNICATIONS TO THE PUBLIC
Communicating Information to Reduce Mercury Exposures in Women of Childbearing Age – Pat McCann

COMMUNICATING INFORMATION TO REDUCE MERCURY EXPOSURES IN WOMEN OF CHILDBEARING AGE

September 24, 2014
Pat McCann

Presentation Outline

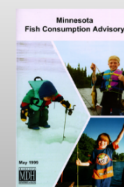
- Communication of Fish Consumption Advice
- Data on mercury exposure in newborns in Lake Superior Basin
- Working with Healthcare Providers
- FISH Project

Fish Consumption Advice Evolution

- 1970's - advice to anglers, mainly men
  - Advice based on risk from exposure to contaminants
- Mid-1990's – targeted communications to women of child-bearing age and other "at-risk" groups
  - Fetus more sensitive to effects from mercury exposure
  - Advice to anglers not necessarily reaching women
- 2000's – more attention to benefits of eating fish
  - Consideration of revised Ginsberg & Toal framework

Communication Methods

- Annual production and distribution of outreach materials
  - Rely on Partners to Distribute:
    State agencies, environmental groups, healthcare providers, businesses, University Extension,…
- Website
- Media Releases – increase awareness
  - Newspaper, Radio, TV
- Presentations to community groups



Distribution of Information to Women

- *A Family Guide to Eating Fish* brochure (English and Spanish)
- WIC
- Maternal Child Health
- Local Public Health Agencies
- Healthcare Providers
  - HMOs
  - Prenatal care

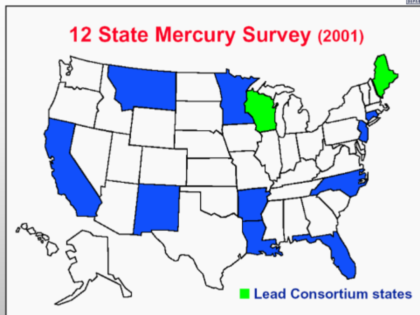
Communication Challenge:

- Talk about mercury without scaring women away from eating fish

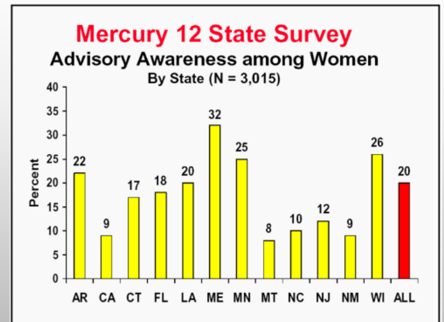
Complicated message:

- Which fish are low in contaminants?
  - Fish are not all the same
    - Salmon = low in mercury
    - Shark = high in mercury
- Who needs to be most careful about exposure?
  - Risks and benefits are different depending on who you are
    - Pregnant women (developing fetus)
    - Adult with CVD

SESSION 6: COMMUNICATIONS TO THE PUBLIC
Communicating Information to Reduce Mercury Exposures in Women of Childbearing Age – Pat McCann



Source: H. Anderson, WDHFS



Source: H. Anderson, WDHFS

2004 Survey of Recent Moms

- Women remember receiving MDH brochure from healthcare providers

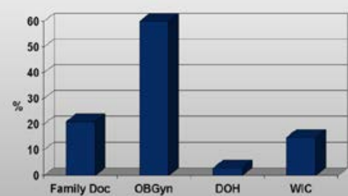


Table 10. Received information about sport-caught or purchased fish consumption before, during, after pregnancy, or at some point (percent checking*), overall and by state of residence.

	Overall	MN	PA	WI
Sport-caught fish information				
Before I got pregnant**	26.6	37.1	18.5	33.1
During pregnancy**	44.6	61.9	34.7	48.0
After giving birth	7.2	9.3	6.8	6.0
At some point**	61.2	79.4	50.9	64.8
Purchased fish information				
Before I got pregnant**	37.3	45.7	32.0	40.2
During pregnancy**	65.5	75.3	62.6	61.6
After giving birth**	10.6	13.4	10.8	7.1
At some point**	77.2	88.0	73.4	74.4

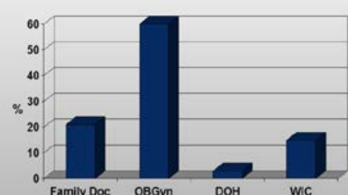
* Percentages do not add to 100% because women could receive information during multiple time periods.

**Statically significant difference between states at P ≤ 0.05 using chi-square test.

Connelly et al. 2013. Factors Affecting Fish Consumption among New Mothers Living in Minnesota, Pennsylvania, and Wisconsin. Human Dimensions Research Unit Department of Natural Resources Cornell University. GLRI 2010 Funded.

2004 Survey of Recent Moms

- Women remember receiving MDH brochure from healthcare providers



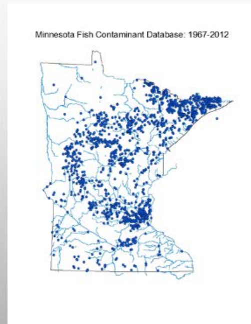
Healthcare Providers

- Limited time with patients
- Typically not trained to assess environmental exposures, several courses developed to help fill that gap
- **Need evidence to prioritize spending time discussing fish consumption**

MDH

Do people in MN eat enough fish to be concerned?

- Data on levels of mercury in fish



MDH

Do people in MN eat enough fish to be concerned?

- Not much regional data on:
  - How much/often people eat fish
  - Levels of mercury in people
- National data on mercury in people (NHANES)
  - Doesn't characterize people who eat locally caught fish
  - A regional analysis of mercury exposure data from NHANES reported that the "Midwest" may have lower mercury exposures than other areas of the U.S.
- Need for regional exposure data

MDH

Mercury Levels in Blood from Newborns in the Lake Superior Basin

MDH

Why Lake Superior Basin?

- Funded by U.S. EPA GLNPO
  - Data needed for subpopulations that may be more exposed
  - Lake Superior Binational Program, Chemical Committee
    - Are there exposures of concern in the Superior Basin?
    - Indicator to track temporal trends?
- Fish in northeastern MN and northern WI have higher levels of Hg

17 MDH

Goals

- Screen to determine range of mercury concentrations in newborns from Lake Superior Basin
  - Are there exposures of concern?
- Assess feasibility of a novel method to analyze mercury in residual dried blood spots from Newborn Screening

MDH

Design

Total mercury measured in residual dried bloodspots from newborns whose mothers were from the US portion of the Lake Superior Basin

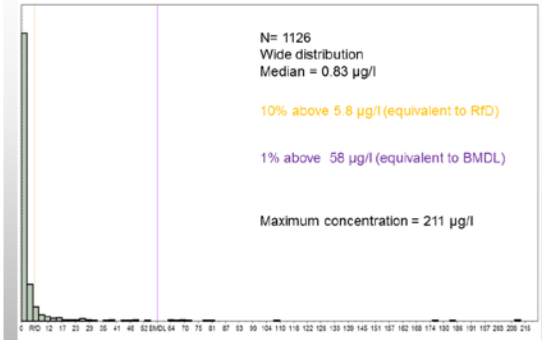
- Births Nov 2008 through May 2010
- 1465 participants from MI, WI, MN
- 1126 from MN (informed consent)
- Number of participants per state based on number of births in basin

- Anonymized design, kept data on:
  - Sex of baby
  - Month of birth
  - State of mother's residence
  - Urban vs. non-urban residence (MN only)

SESSION 6: COMMUNICATIONS TO THE PUBLIC

Communicating Information to Reduce Mercury Exposures in Women of Childbearing Age – Pat McCann

Mercury in Residual Newborn Blood Spots, MN data (µg/l)



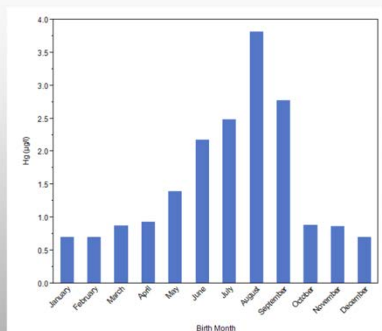
44% below MDL of 0.7 µg/l, most exposures low

Results - covariates

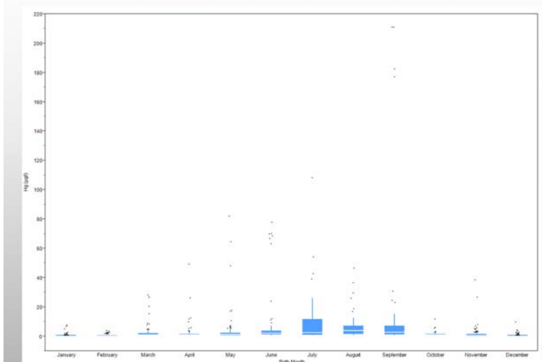
Star Tribune, Feb 15 2010

- No association between mercury concentration and sex or urban versus non-urban residence (MN).
- MN results suggest a seasonal exposure pattern
  - Highest concentrations in summer months

Median Hg vs. Month of Birth, MN Data (ND=0.7µg/l)



Mercury Concentration vs. Month of Birth, MN Data



Sources of mercury exposure

- Total mercury measured in this study
- For most people, exposure to mercury comes from eating fish
- Other exposures are possible:
  - amalgams
  - vaccines
  - broken thermometers/manometers
  - cosmetic uses (skin lightening creams)

Support for Fish Consumption as Source of Exposure

- Seasonal exposure pattern
- Focus groups of women from study area report eating higher mercury fish (walleye) at greater than recommended frequency

SESSION 6: COMMUNICATIONS TO THE PUBLIC
Communicating Information to Reduce Mercury Exposures in Women of Childbearing Age – Pat McCann

Methylmercury/Total mercury (NHANES 1999-2000)

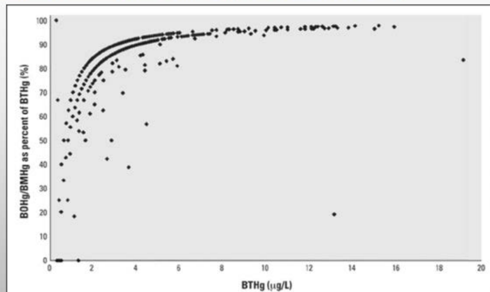


Figure 1. Organic/methyl mercury as percentage of BTHg versus BTHg. Data are from NCHS (2003). This plot is based on 1,733 data points; in many cases, multiple data points have the same values and appear as a single point.

Illustration: Exposure from Fish Consumption

- Case Report - Wisconsin
  - Family ate 2 meals/week of imported sea bass
    - Mercury in seabass ~0.5 µg/g (~ large walleye and northern pike in NE MN)
  - Max blood Hg was 58 µg/l in adult
- Translate to newborn Hg level
  - Umbilical cord blood mercury > maternal blood mercury
    - Mean ratio from multiple studies ~ 1.7
    - 95th percentile of individual ratios reported in one study ~ 6

Estimated potential mercury level in newborn:

- 58 µg/l x **1.7** = **99** µg/l
- 58 µg/l x **6** = **348** µg/l

Conclusions

- **This study provides evidence of mercury exposures in some pregnant women that need to be reduced**
  - 10% of MN babies tested were above EPA RfD for methylmercury
- Results provide fish advisory programs stronger evidence of need to communicate with women of childbearing age about reducing mercury exposure.

Earth Journal: Ron Meador on Environment

After decades of warnings and pollution controls, newborns arrive with a burden of mercury

By Ron Meador | Published Mon, Feb 6 2012

How to utilize the healthcare provider to decrease prenatal exposures?

- Educate clinicians
  - Difficult message given conflicting recommendations about the risks and benefits of eating fish
  - Need to be careful about the message
    - Unintended consequences
  - Promote substitution rather than avoidance
  - Substitution requires knowledge and effort
- Implement screening
- Patient education/counseling

Susan Buchanan, MD, MPH
Great Lakes Center for Children's Environmental Health/R5 PEHSU
University of Illinois at Chicago

Reducing Mercury Exposure in Women of Childbearing Age GLRI 2012 Grant to MDH

Goals: Healthcare providers screen for mercury exposure and integrate fish consumption advice into clinical practice.

Partners:
Sawtooth Mountain Clinic
Grand Portage Health Service
Northshore Cook County Hospital
Grand Portage Trust Lands

SESSION 6: COMMUNICATIONS TO THE PUBLIC
Communicating Information to Reduce Mercury Exposures in Women of Childbearing Age – Pat McCann

Study: 1 in 10 babies in Lake Superior region are born with high levels of mercury
One of every 10 babies born in the Lake Superior region of Minnesota has unsafe levels of toxic mercury in his or her bloodstream, according to a Minnesota Department of Health study released Thursday.
By: John Myers, Duluth News Tribune

High levels of mercury found in North Shore babies
Article by: JOSEPHINE MARCOTTY , Star Tribune
Updated: February 2, 2012 - 11:04 PM
Blood samples showed surprisingly elevated concentrations.

Study: High Mercury Levels In North Shore Babies
February 3, 2012 6:05 PM
MINNEAPOLIS (WCCO)

Design

- In-clinic screening questions for high Hg exposure from fish consumption to be used at intake in EMR (enroll ~450 women)
  - Use biomonitoring for Hg to validate
  - Measure fatty acids to indicate continued fish consumption
- Educational intervention to promote consumption of fish low in Hg and other contaminants
- Detailed Questionnaire
- 6 month follow-up to track change

Healthcare Provider Training
Risks and Benefits of Eating Fish

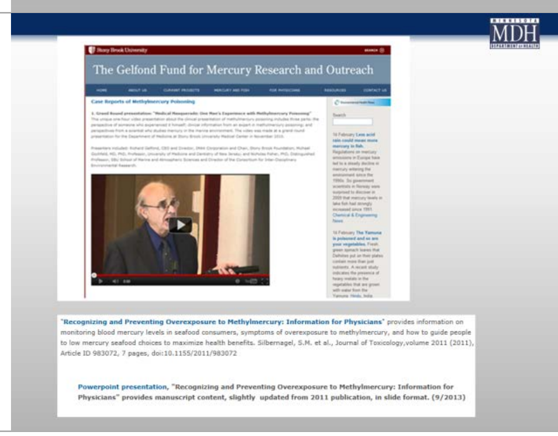
- Several courses developed to help fill gap
  - GLRI funded in 2010
    - UIC
    - MSU
  - University of StonyBrook, Gelfond Fund

Eating Fish

Maximizing Benefits & Minimizing Risks

Kenneth D. Rosenman, M.D.
Professor of Medicine
Michigan State University

Funding - Great Lakes Restoration Initiative EPA GL-00E00461



SESSION 6: COMMUNICATIONS TO THE PUBLIC
Communicating Information to Reduce Mercury Exposures in Women of Childbearing Age – Pat McCann

FISH Project
Provider Training

- Summarize benefits and risks
  - Just the bottom-line, no research
  - Dartmouth video
- Fish consumption guidelines
- Screening and education

Putting Fish on Your Plate
&
Preventing Mercury Exposures in Babies

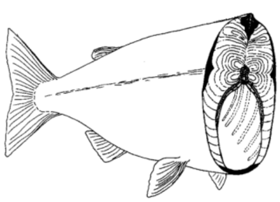
Training for Healthcare Providers

FISH Project
Grand Portage Health Clinic
Sawtooth Mountain Clinic
Cook County North Shore Hospital
Grand Portage Trust Lands
Minnesota Department of Health

Which fish has more mercury?

Which lake has higher levels of mercury in the fish?

Is mercury in the fatty parts of fish or in the fillet?



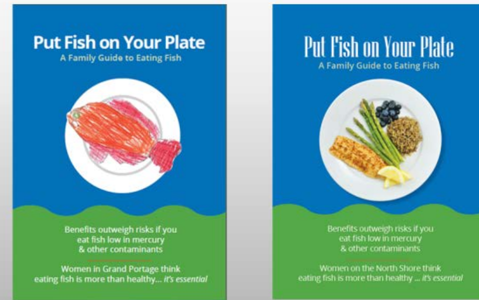
A pregnant women should not eat fish (T/F)

SESSION 6: COMMUNICATIONS TO THE PUBLIC
Communicating Information to Reduce Mercury Exposures in Women of Childbearing Age – Pat McCann

Patient Screening – questions in EMR

- Questions developed with "trained" clinicians
- In the last 2 to 3 months…
  - How many times **per week** did you eat any kind of fish?
  - How many times **per month** did you eat any of these fish? lake trout from Lake Superior, walleye, northern, or bass
  - Did you eat shark or swordfish?

Patient Education/Intervention



A Successful FISH Project…

- Women eat fish low in contaminants
- Screening questions predict mercury exposure and used at clinic intake
- Healthcare providers:
  - Learn about and talk with patients about fish consumption
  - FISH screening model adopted by other healthcare providers

Use of FISH Model

- Lake Superior South Shore, 2013 GLRI Grant to Wisconsin
  - Partnering with Essentia Health in Ashland
  - Using FISH project model
  - FISH Project Risk and Benefit Training
- Lake County MN Public Health WIC - testing mercury screening questions from FISH, 2013 GLRI grant

Prenatal and Preconception Exposures: Prevention in the Exam Room

Susan Buchanan, MD, MPH
Great Lakes Center for Children's Environmental Health/R5 PEHSU
University of Illinois at Chicago

Fish Consumption Screening

In general, do you eat fish more than twice per week?

PEHSU Pediatric Environmental Health Specialty Units

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GLRI 2013 Grant to MDH/Great Lakes Consortium/Cornell

- HealthPartners surveyed 600 women to test reaction to key messages
- Essentia Health further testing key messages in Focus Groups in NE MN
- Cornell incorporating past work and key message testing to conduct a 2 year diary study to measure behavior change

SESSION 6: COMMUNICATIONS TO THE PUBLIC
Communicating Information to Reduce Mercury Exposures in Women of Childbearing Age – Pat McCann

Acknowledgments

- MN Department of Health
  - Newborn Screening Program
  - Public Health Laboratory
  - Environmental Health Tracking and Biomonitoring Program
  - Environmental Health Division
- MI and WI Newborn Screening Programs
- Great Lakes Consortium for Fish Advisories
- Henry Anderson, Michael Gochfeld, Alan Stern
- Human Dimensions Research Unit, Department of Natural Resources Cornell University
- FISH Project Partners
- Funding provided by U.S. EPA GLNPO
- For more information: http://www.health.state.mn.us/fish
- Or contact Pat McCann: patricia.mccann@state.mn.us

Thank you

Questions and Answers

Note: There were no questions because the moderator moved directly into the general Q&A session at the end of this panel.

General Question and Answer Session

Q. *This conference has talked a lot about maximizing benefits of Omega 3 and minimizing risks of mercury. In Delaware, they have many urban fisheries that are highly contaminated with organics. This high concentration of organics makes the problem for urban waters much more complex to manage balancing risks and benefits. His second question is whether anyone knows how frequently FDA is testing imported fish and shellfish? Ninety percent of the fish consumed in the United States are imported. Is there a surveillance program in place to track this? (Greene)*

A. The moderator (Knuth) asked whether anyone from FDA could address this, and there was no response from the panelists or the audience.

Q. *In the State of Washington, they have a very involved maternal and child health program in their Health Department who would like any outreach information available from Susan Buchanan. Also they have developed Text4Baby fish messages as outreach for pregnant women and those messages are tailored to their zip code. (Carr)*

A. There were no responses or comments from any of the panelists.

Q. *He gets a lot of push back on evidence-based medicine from the Rutgers medical school faculty. His question is about looking at the example of direct-to-consumer advertising from pharmaceutical companies. The pharmaceutical companies are trying to get patients to ask their doctors about medicines. Could this approach be adapted to get patients to ask their doctors about fish consumption? (Gochfeld)*

A. Their marketing consultant considered similar marketing tools, such as a button for the general public with a message to ask your doctor what they know about fish. (Susan Buchanan)

A. Direct-to-consumer marketing funded by the pharmaceutical companies works or they would not be spending so much money on it. When patients ask their doctors questions about fish consumption, clinicians need information to respond and begin adopting changes in their practice. He believes that it is necessary to have that message out there to drive change in clinical practice, especially for clinicians who have an aptitude to include environmental exposures in their practice. (Hatcher)

Q. *This question was for Susan Buchanan. She is interested in marketing materials, because the Michigan Department of Community Health is trying a similar project. Will Susan Buchanan be willing to share her information for a project in Michigan in federally-funded clinics in Detroit? (Manente)*

A. She will share everything with Michigan. She would also like to help in reaching out to state chapters of professional associations. (Susan Buchanan)

Q. *We do not want to forget about communicating with men because they can get exposed and because in subsistence communities they bring the fish home for their wife to cook and eat. (Burger)*

A. In their educational materials for clinicians, one of their modules has an avatar case that is an older man who fishes for his family. (Susan Buchanan)

Comment: We should also not forget that where incomes are low, one ethnic group may not eat a particular fish species but may share that fish species with another ethnic group. (Burger)

Q. FDA updates their mercury database fairly often. There is nothing like that for organics. He suggested looking at the U.S. Department of Agriculture (USDA) pesticide database for how data can be provided on residues and residue testing. The USDA database has 6000-8000 samples annually for 600 residues. (Groth)

A. There were no responses or comments from any of the panelists.

Q. When planning for the Great Lakes Restoration Initiative (GLRI) and how to use the funding, we wanted to think strategically for the Great Lakes states but also wanted the results to be transferrable to other areas. She encourages everyone to talk with their award recipients and with them at EPA's Great Lakes National Program Office to get information about their GLRI results. Also they are trying to do work internally within the Federal government to get engagement with healthcare providers or clinicians. (Fisher)

A. There were no responses or comments from any of the panelists.

Q. This question was for Susan Buchanan. It is very hard to change clinician behavior. Will the continuing education modules be incorporated into medical schools so they learn this behavior before doctors start practicing? How will the curriculum be updated when the science changes regarding fish consumption advisories? (Mukasa)

A. They are working with the distance education department at the University of Illinois at Chicago to update the modules if any significant changes occur. The Continuing Medical Education (CME) approach was the hook to get the doctors involved, but using a CME approach would not capture medical students. She knows of one person in Detroit who created a PowerPoint presentation to teach medical students and residents about fish. Getting into the medical school curriculum is very difficult. (Susan Buchanan)

Wrap-up: General Forum Moderator

Jeff Bigler, U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology

Biosketch

Jeff Bigler has managed the U.S. Environmental Protection Agency (EPA) National Fish Advisory Program since 1994. The program coordinates activities with states, tribes, and federal agencies on matters related to assessing potential health risks and benefits of fish consumption. He has been responsible for developing and managing all of the National Forums on Contaminants in Fish. Jeff also managed development of the series of national guidance documents titled Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volumes 1-4; led the development of the National Listing of Fish Advisories; and served as EPA's technical lead for the joint 2001, 2004, and 2014 national mercury advisories. Some of the other EPA projects Jeff has managed include the Survey of Chemical Contaminants in Fish, Invertebrates and Plants Collected in the Vicinity of Tyonek, Seldovia, Port Graham and Nanwalek - Cook Inlet, Alaska; the Survey on the Awareness and Effectiveness of the Mississippi Delta Fish Consumption Advisory; Trends in Blood Mercury Concentrations and Fish Consumption Among U.S. Women of Reproductive Age, NHANES, 1999-2010; and the recently published Estimated Fish Consumption Rates for the U.S. Population and Selected Subpopulations (NHANES 2003-2010). Before joining EPA in 1989, Jeff worked for the Virginia Department of Game and Inland Fisheries; Alaska Department of Fish and Game; and the National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Wrap-Up – Jeff Bigler

EPA United States Environmental Protection Agency

THANKS!
Closing
Jeff Bigler,
U.S. Environmental Protection Agency

2014 National Forum on Contaminants in Fish
September 22-24 / Alexandria, Virginia

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2014 National Forum on Contaminants in Fish
September 21-24 / Alexandria, Virginia

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- Pat McCann, Minnesota Department of Health
- Sharee Rusnak, Connecticut Department of Public Health
- Jackie Fisher, USEPA, Great Lakes National Program Office
- Jeffrey Bigler, USEPA, Office of Water

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- Amy D. Kyle, University of California, Berkeley School of Public Health
- RTI, International: Patricia Cunningham, Amy Wesley

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BIG THANKS GO TO:

Moderators

- Rick Greene, Delaware Department of Natural Resources and Environmental Control
- Amy D. Kyle, University of California, Berkeley School of Public Health
- Alan Stern, New Jersey Department of Environmental Protection
- Robert Brodberg, California Office of Environmental Health Hazard Assessment
- Barbara Knuth, Cornell University, Department of Natural Resources

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John Wathen	Cindy Marchand	Tom Hornshaw
Leanne Stahl	Margy Gassel	Lesley V. D'Anglada
Beth Murphy	Sarah Ryan	Joyce Donohue
Tim Fitzgerald	Faith Schottenfeld	Jeff Swartout
Bob Gerlach	Tony David	Geniece Lehmann
Michael Opheim	David Wong	Vince Cogliano
Tracie Merrill	Steve Ridenour	Rebecca Birch

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Ned Groth	Emily Oken	Bruce Lauber
Glen Rice	Phil Spiller	Ali Hamade
Jyrki Virtanen	Satyendra Bhavsar	Michael Hatcher
Meghan Williams	Gary Ginsberg	Susan Buchanan
Henry Anderson	Karen Swajian	Pat McCann
Roxanne Karimi	Amy Lando	
Joanna Burger	Mario Teisl	
Dariush Mozaffarian	Nancy Connelly	

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BIG THANKS GO TO:

EVERYONE WHO PRESENTED A POSTER AS WELL AS TO THE STATES WHO BROUGHT OUTREACH MATERIALS TO DISPLAY

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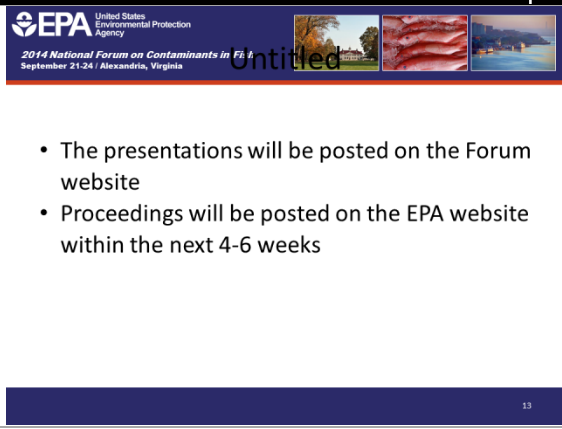
Wrap-Up – Jeff Bigler



SECTION III APPENDICES

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SECTION III APPENDICES

APPENDIX A: FINAL PARTICIPANT LIST

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APPENDIX B: POSTER ABSTRACTS

Evaluating the Effectiveness of Educational Materials on Fish Consumption Advisories around Lake Crabtree, Morrisville, North Carolina

Presenting Author: Kat Bawden
Contributing Authors: Kathleen Gray, Sarah Yelton

Our program seeks to educate recreational anglers and their families about a fish consumption advisory (FCA) on dangerous polychlorinated biphenyl (PCB) levels in fish found in Lake Crabtree County Park and its tributaries, popular fishing sites located near the Ward Transformer Superfund site in Morrisville, North Carolina. While educational materials on PCBs are available to recreational anglers, and there is a catch-and-release policy in place at the park, the lake and its tributaries remain popular fishing sites, and many people take home their catch. FCAs alone are ineffective at reaching recreational anglers and people who eat fish. Even when FCA messages do reach their target audience, people do not always understand, trust, or follow them. This is particularly true among non-English speakers and people with lower levels of education and income. The literature on FCA education and risk communication overwhelmingly supports involving target audience members in the process of crafting and disseminating FCA educational materials. However, this idea remains largely un-tested in the literature.

Our poster will present on the preliminary results from our pilot program to engage community members in the process of creating and disseminating educational material on PCBs risk from Lake Crabtree and surrounding waters. We developed a map of safe fishing sites for recreational anglers, which included a guide to safely consuming locally-caught fish. We involved stakeholders who share information on safe fishing in the process of developing the prototype of this material. Next, we piloted this material with target audience members (particularly Spanish speakers, who are least likely to be aware of the FCA) with four objectives: 1) to understand anglers' perceptions of PCBs risk, 2) to solicit feedback on the material, 3) to evaluate our material's impact on participant knowledge and intent to change behavior, and 4) to identify possible outlets for disseminating the material. This research was an integral step for our process of developing responsive community-based educational programs to disseminate FCA information. This work is supported by the National Institute of Environmental Health Sciences through a grant to the University of North Carolina at Chapel Hill Superfund Research Program (grant number P42ES005948).

Estimated Fish Consumption Rates for the U.S. Population and Selected Subpopulations (NHANES 2003-2010)

Presenting Author: Rebecca Birch

We used data from the National Health and Nutrition Examination Survey (NHANES) to estimate usual fish consumption rates (FCR) for the U.S. population and selected sub-populations. The usual FCR is an estimate of the long-term average FCR. Rates were estimated for 18 fish types (e.g., freshwater, estuarine, marine, shellfish, finfish, and by trophic levels) and for sub-populations such as by race/ethnicity, age, and geographic location. This poster presents the methodology, results, and how the results are being used by the U.S. Environmental Protection Agency for the Human Health Ambient Water Quality Criteria 2014 updates.

Outreach Efforts in a Multilingual Urban Estuary

Presenting Author: Gary Buchanan
Contributing Authors: Terri Tucker, Bruce Ruppel, Kerry Kirk Pflugh, Calliope Alexander

The State of New Jersey's Department of Environmental Protection (NJDEP) and Department of Health (NJDOH) have been conducting advisory outreach efforts since the 1980s. Efforts have focused on reaching out to populations that are non-English speaking for whom English is their second language, since many of these populations consume locally caught seafood as part of their diet. Repeated and recent efforts have been concentrated in the Newark Bay Complex (Complex), which consists of several major tidal waters surrounded by 32 municipalities in northeastern New Jersey. Due to the ethnic diversity, numerous languages are spoken in this area of the state. It is important to reach as many local consumers as possible as New Jersey bans the harvest of blue crabs and has issued fish advisories in the Complex due to dioxin/furan and PCB contamination.

The identification of predominant languages spoken for each municipality was determined from analysis of 2010 census data. The state was able to take advantage of its diverse staff in translating outreach materials into six additional languages at no cost. 2014 outreach activities included reaching out to the mayors, local officials, and constituent groups in the towns surrounding the Complex; distribution of warning signs and informational brochures; a press release with newspaper and TV coverage; as well as release of public service announcements (PSAs). This multimedia effort is used to increase the potential of this public health information reaching the targeted audiences. Past surveys of local anglers/crabbers indicated that these type of multimedia outreach efforts increased comprehension and awareness of fish advisories and the crabbing ban. Due to the population turnover in this urban area, it is necessary to conduct these efforts frequently (e.g., annually) to reach new residents.

Other statewide outreach activities include the distribution of brochures at public events, local departments of health, and public programs for women and children, as well as easily understood "Fish I Catch" and "Waters I Fish" Web pages and periodic updating of the advisory website www.FishSmartEatSmartNJ.org. New Jersey has also developed three additional brochures in multiple languages on how to properly cook and clean blue crabs, carp, and catfish.

Evidence of Resistance to AhR-mediated Effects of PCB-126 in Atlantic Killifish (Fundulus heteroclitus) in the Island End River, Chelsea, Massachusetts

Presenting Author: Kathryn Crawford
Contributing Authors: Wendy Heiger-Bernays, Mark E. Hahn

Efforts to reexamine the consumption advisory for fish caught in the Lower Mystic River Watershed, an urbanized and industrialized watershed near Boston, highlight the need to understand links between ecological and human health impacts of contaminants. Industrial pollutants, including non-ortho polychlorinated biphenyls (PCBs) and some polycyclic aromatic hydrocarbons (PAHs) are known to cause embryotoxicity and altered gene expression in Fundulus heteroclitus through the AhR pathway, a transcription pathway activated by some PCBs and PAHs. Long-term exposure to environmental AhR ligands can cause reduced sensitivity of F. heteroclitus to the toxicological response caused by these pollutants. The human health implications of AhR-mediated resistance to aromatic industrial pollutants in F. heteroclitus are not well understood, but resistance may influence chemical bioaccumulation. To assess whether there is evidence of genetic resistance to aromatic hydrocarbons in Island End River F. heteroclitus, embryos from fish collected from this area and a reference site were exposed to PCB-126 at three time points (4-8 hours post-fertilization (hpf); 48 hpf; and 7 days post-fertilization (dpf)). Analysis of CYP1A mRNA, a biomarker of AhR-mediated responsiveness to aromatic hydrocarbons, by RT-qPCR provides evidence of differential sensitivity to AhR-mediated gene induction between F. heteroclitus from the two sites following embryonic exposure to PCB-126. These results suggest evolved resistance to aromatic compounds in the Island End River and are consistent with results from F. heteroclitus populations inhabiting other contaminated areas along the eastern seaboard. Together, these data provide the framework for asking further questions about how AhR-mediated resistance to aromatic hydrocarbons impacts human health in the Lower Mystic River Watershed. [Supported in part by National Institutes of Health grant P42ES007381]

Total Mercury Levels in Blood and Urine of Frequent Consumers of Detroit River Fish

Presenting Author: Linda D. Dykema

Background: The Detroit River is a popular fishery for urban, shoreline anglers who may be less aware of Michigan's fish consumption guidelines, which are prompted by contaminants such as methylmercury. Consumption of contaminated fish is major route of human exposure to methylmercury.

Description: The Michigan Department of Community Health measured total mercury levels in blood and urine samples collected from shoreline anglers under funding provided by the Agency for Toxic Substances and Disease Registry. Participating anglers were 18 years of age or older who ate at least two meals per month of fish caught from the Detroit River Area of Concern. Information about fish consumption habits, confounding exposures, and demographics were collected by a detailed questionnaire. Participants reported eating an average of 11 meals per month of fish caught from the Detroit River (range = 0.08 to 102 meals per month). Participants' blood and urine results are compared to data from the National Health and Nutrition Examination Survey (NHANES). Total mercury levels in participants' blood were elevated in comparison to NHANES, while urine mercury levels were lower.

Conclusion: Elevated total blood mercury results for Detroit participants suggest increased dietary exposure to organic mercury, particularly methylmercury found in fish.

Pacific Halibut Commission and the Alaska Department of Environmental Conservation

Presenting Author: Claudia Dykstra

The International Pacific Halibut Commission and the Alaska Department of Environmental Conservation have been conducting a project monitoring environmental contaminants in Pacific halibut since 2002 throughout the northeast Pacific Ocean and Bering Sea. Regional results from 2002 to 2014 will be compared along with biological characteristics and temporal trends.

Mercury in Fish from 21 National Parks in the Western United States: Inter- and Intra-park Variation in Concentrations and Ecological Risk

Presenting Author: Colleen M. Flanagan Pritz
Contributing Authors: Collin Eagles-Smith, James Willacker

National parks, protected areas considered to be relatively pristine and removed from environmental contaminants, contained levels of mercury in some fish that exceeded thresholds for potential impacts to fish, birds, and humans. We measured mercury (Hg) in more than 1,400 fish from 86 remote lakes and rivers – spanning 16 fish species and 21 national parks in 10 western states – and compared Hg concentrations in the fish to an array of health benchmarks. Across all parks, sites, and species, fish Hg concentrations ranged from 9.9 to 1,109 ng/g ww with a mean of 77.7 ng/g ww. Fish Hg levels varied greatly both among and within parks, suggesting that patterns of Hg risk are driven by processes occurring at site-specific, local, and global scales. In most parks, Hg concentrations in fish were moderate to low in comparison with similar fish species from other locations in the western U.S. Mercury concentrations were below the U.S. Environmental Protection Agency (EPA) fish tissue criterion for safe human consumption in 96% of the sport fish sampled. However, the average concentration of Hg in sport fish from two sites in Wrangell-St. Elias and Lake Clark (Alaska) national parks exceeded EPA's human health criterion. Mercury levels in individual sport fish at some sites from Lassen Volcanic (California), Mount Rainer (Washington), Rocky Mountain (Colorado), Yellowstone (Wyoming), and Yosemite (California) national parks also exceeded the human health criterion. Mercury concentrations exceeded the most conservative fish toxicity benchmark at 15% of all sites, and the most sensitive health benchmark for fish-eating birds at 52% of all sites. Exposure to high levels of Hg in humans may cause damage to the brain, kidneys, and the developing fetus. In wildlife, elevated Hg levels can result in reduced foraging efficiency, survival, and reproductive success. Much of the mercury found in these mainly high elevation areas is likely the result of air pollution from outside the parks. Future targeted research and monitoring across park habitats would help identify patterns of Hg distribution across the landscape and facilitate informed management decisions aimed at reducing the ecological risk posed by Hg contamination in sensitive ecosystems protected by the National Park Service.

Mercury in Fish and Small-pond Health (MyFISH); a statistical model that provides fish tissue mercury estimates from small freshwater ponds in South Carolina

Presenting Author: Jim Glover

Recreational fishing and fish consumption is important to many South Carolina citizens and small reservoirs and excavated ponds are utilized for this purpose. The goal of MyFISH was to provide statistically valid estimates of mercury (Hg) in the tissue of popular game fish from these ponds. Over a 2-year period, 349 fish were collected from 38 ponds across South Carolina and analyzed for Hg. Using interval censored regression statistical techniques, a predictive model was developed that incorporated hydrologic unit land-use, pond type (impoundment or excavated pond), degree of management (limed and fertilized or unmanaged), fish type (largemouth bass or 'bream'), and fish length. Linear regression between the predicted and observed estimates for each length normalized pond-fish type combination (n=72) indicated that MyFISH explained 73% of the variance in tissue Hg in pond fish. To validate the model, historic fish Hg data (n=108) from North Carolina ponds were used (n=20). Predictions correlated linearly with an r^2 of 0.87. With limited user input, the web-based interface for MyFISH allows pond owners to estimate Hg in popular game fish from small South Carolina ponds.

Perfluorooctane Sulfonate (PFOS) and Other Perfluorinated Chemicals in Michigan Water Bodies

Presenting Author: Jennifer Gray

With the aid of a Great Lakes Restoration Initiative grant from the U.S. Environmental Protection Agency, the Michigan Department of Community Health has been able to test fish samples (edible portions) from reference and potentially historically contaminated locations. Perfluorooctane sulfonate (PFOS) and other perfluorinated chemicals were found in edible portion samples from various water bodies in Michigan. Testing confirms that PFOS is the predominant perfluorinated chemical present in edible portion of fish and that perfluorinated chemical levels are high enough in some locations to warrant issuance of water body-specific fish consumption guidelines.

Toxics in the Saint Jones Watershed: Past, Present, and Future

Presenting Author: Richard Greene
Contributing Authors: John Cargill, Todd Keyser, Upal Ghosh, David Velinsky, Chris Sommerfield

The Saint Jones watershed (233 square kilometers) is located in central Delaware and drains through the state's capital of Dover on its way to the Delaware Bay. Fish consumption advisories have been in place in the watershed since 1988 due to PCBs, dioxins and furans, organochlorine pesticides, and mercury. Polycyclic aromatic hydrocarbon contamination is also significant in sediments. Local sources include NPL and other waste sites, NPDES wastewater discharge (past and present), in-place contaminants in sediments, atmospheric deposition, stormwater runoff, and exchange with the Delaware Bay. Monitoring and special studies have been performed to better understand the status and trends of toxics in this system. This poster highlights selected results from toxics testing of fish, sediment, and water samples collected from the Saint Jones watershed in the fall of 2013. Current conditions are placed into longer-term perspective by presenting data on toxics in radiodated sediment cores collected in fringing tidal wetlands of the Saint Jones watershed. Finally, this poster looks to the future of toxics mitigation in surface waters by presenting details from the Mirror Lake Remediation and Restoration Project. This project involved adding activated carbon to sediments with the intention of sequestering contaminants in place, thereby reducing bioavailability, toxicity, and bioaccumulation.

Architectural Design of the Michigan Fish Consumption Advisory Program

Presenting Author: Kory Groetsch

With support from the U.S. Environmental Protection Agency (EPA), Great Lakes Restoration Initiative, the Michigan Department of Community Health (MDCH) has restructured the assessment and communication methods of the Michigan Fish Consumption Advisory Program. MDCH uses EPA risk assessment methods and ATSDR public health assessment methods to evaluate chemical contaminants found in edible portions of Michigan fish. The communication strategy involves message layering, generating public awareness, and encouraging information seeking behavior by individuals. This poster describes the program's architectural design including the program goal, design specifications, program elements, technical documentation, and communication strategy.

Use of Biomonitoring to Support Alaska's Statewide Mercury Advisory

Presenting Author: Ali Hamade

The Alaska Division of Public Health offers hair mercury testing through its Statewide Hair Mercury Biomonitoring Program to assess exposures to mercury among women of childbearing age. Over 1,000 eligible women have participated in this program. Hair samples are collected by health care providers or the individuals themselves, and analyzed by the Alaska State Public Health Laboratory. This program supports the Alaska Division of Public Health fish consumption recommendations, most recently updated in July 2014. Having their hair tested for mercury enables women to determine their own mercury levels, and learn whether dietary changes are needed to reduce their mercury exposure. The Division of Public health follows up with women whose hair mercury concentrations approach or exceed the state's hair mercury level of concern of 5 parts per million to identify sources of mercury exposure and provide the necessary fish consumption recommendations. This poster will present hair collection and analysis methods, hair monitoring data, and public health implications.

An Examination of Selenium-based Fish Consumption Advisories in the United States and Canada

Presenting Author: Ryan Holem

Selenium (Se) is an essential micronutrient naturally present in varying levels in food and readily available as a dietary supplement owing to its presumptive benefits to human health. Selenium has been shown to accumulate in tissues of fish when present at elevated levels in aquatic systems and as a result, Se-based fish consumption advisories (FCAs) exist at multiple locations in North America. Se-based FCAs have the potential to cause confusion amongst anglers and/or consumers given the existence of advice encouraging dietary intake of Se. Advocates of Se intake often recommend fish as a source of dietary Se, creating the potential for conflicting consumption advice in locations where Se-based FCAs have been issued. The objectives of this poster are to: 1) identify the North American locations where published Se-based FCAs are in effect, 2) compare the methods used to derive trigger levels for Se FCAs and corresponding fish consumption advice, and 3) discuss unique aspects of Se-based FCAs.

State-level Recreational Fishing and Fish Consumption Advisories in the United States: Identifying Opportunities for Improved Risk Communication

Presenting Author: David Love
Contributing Authors: Meagan Hawes, Jamie Harding

Over 30 million U.S. citizens participate in recreational fishing annually, and take about 400 million fishing trips a year to many regions of the United States. Subsistence fishers and their families, and women of childbearing age, infants, and young children, face disproportionate health risks from exposure to environmental chemicals that bioaccumulate in seafood. Recreational fishing is managed by states using public heath-based fish consumption advisories to reduce risks to humans from exposures to pollutants. In addition, states employ natural resource-based management of fish stocks to protect these natural resources. We examined the extent to which state regulatory agencies present recreational fish consumption and catch advisories together. State-level catch and consumption advisories were collected from 50 states in 2011 via the U.S. Environmental Protection Agency "Advisories Where You Live" website, and by searching state agency websites for the most current consumption advisories. Catch and consumption advisories within states were cross-referenced by fish species. State-level catch advisories were strongly predictive of state-level consumption advisories, by species (R2=0.87) or taxonomic family (R2=0.91). Within each state, however, fish catch and consumption advisories were presented together in less than half of fishing guides. Fish advisories are often produced by separate state regulatory agencies, indicating an opportunity for inter-agency collaboration to improve health communication messaging regarding recreational fishing and self-caught fish consumption. Adopting policies that require rigorous state-level inter-agency collaboration before releasing fish advisories to the public could better protect fishers and others from consuming contaminated seafood. These advisories must engage in risk communication that reaches the appropriate audience, in a readable language and literacy level, and with understandable metrics.

Outreach to Urban Anglers: Methods to Inform a Hard-to-Reach Population in Detroit

Presenting Author: Susan Manente
Contributing Author: Donna Kashian

Anglers fishing in Detroit and Saginaw, two impoverished urban areas in Michigan, are less likely to be aware of Michigan's fish advisories and eat more of the most contaminated fish. The Michigan Department of Community Health (MDCH) has provided fish advisory information to residents of Michigan since the 1970s. More recently, studies conducted by MDCH along the Saginaw River and the University of Michigan along the Detroit River (both designated Areas of Concern by the U.S. Environmental Protection Agency) found urban shoreline anglers were more likely to be a minority population, have lower income and education levels, and tend to eat more servings of the most contaminated fish. They are also more likely to be unaware of the fish advisories. MDCH has conducted health education to Detroit and Saginaw area residents using unique methods to reach an urban population including employing River Walkers; men who visit anglers at fishing sites to provide in-person fish advisory information. MDCH has also developed area-specific materials such as signs and brochures with input from local anglers during focus group sessions. An evaluation of these outreach methods as well as an ethnography study profiling fish distribution methods, essentially tracking fish from the "river to the plate," were conducted in Detroit. This MDCH poster will describe the methods used to reach this hard-to-reach population and preliminary results of the evaluation and ethnography study. Providing health education to a unique population is challenging. Reaching out to urban anglers is complex and requires innovation, flexibility, and continued funding.

Mercury Concentrations and Stable Isotopes of C and N in Alaska Pacific Halibut Muscle

Presenting Author: Todd O'Hara
Contributing Authors: Rebecca Bentzen, Margaret Castellini, Bob Gerlach, Claude Dykstra

Pacific Halibut (Hippoglossus stenolepis) are one of the world's largest flatfish, and supports one of the most important commercial fisheries on the west coast of the United States and Canada, as well as popular recreational and subsistence fisheries. Halibut are an excellent source of lean protein, Omega 3 fatty acids, antioxidants, and vitamins. However, concerns about the health risks of mercury (Hg) have prompted many states and several federal agencies to advise the public, in particular women of childbearing age, to limit consumption of halibut since they accumulate monomethyl mercury (MeHg+) in muscle. We measured total Hg concentrations ([THg]) and δ15N and δ13C values in muscle of 693 halibut caught in commercial fisheries around Alaska between 2002 and 2011. The goals of this project were: 1) to evaluate whether δ15N and δ13C values varied with region, age, sex, and length of halibut; and 2) determine whether muscle [THg] varied with the relative trophic position of the halibut (e.g., δ15N and δ13C values) while accounting for sex, size, and region. Variation in [THg] was explained, in part, by feeding ecology of the halibut; [THg] increased with trophic position (increasing δ15N) for many regions sampled. The western Aleutian island region stood out from the rest of Alaska in that halibut were feeding at a lower trophic position (lower δ15N values) but paradoxically had higher [THg] than did halibut in other Alaskan waters. This pattern has been observed in other biota and has been attributed to a northeasterly movement of mercury from Asia.

Status and Trends of Contaminants in Fish from Lake Erie, the Niagara River, Cayuga Creek, and Lake Ontario, New York

Presenting Author: Wayne Richter
Contributing Authors: Xiangrong Li, Lawrence Skinner

We analyzed over 600 individual samples from 16 fish species collected in 2010 through 2012 from the New York State waters of Lake Erie, Cayuga Creek, the Niagara River, and Lake Ontario for contaminants including mercury, polychlorinated biphenyls (PCBs), chlorinated dioxins and furans, organochlorine pesticides, and polybrominated diphenyl ethers (PBDEs). Collections were typically 10 to 15 individuals per species at a site, with species selection dependent upon availability. We examined spatial patterns and compared the current data to historical results as far back as 1970.

Mean mercury concentration over all fish in the current sample was 0.16 ppm (range: 0.029 ppm to 1.09 ppm) with only one fish exceeding 1 ppm. Site and species specific mercury concentrations dropped between 1970 and the next sampling period beginning in 1988, but showed no change in subsequent periods up to the present. PCB and organochlorine pesticide concentrations were generally lower than recorded previously. PCB concentrations ranged from non-detect to 11.0 ppm, with 99% of fish below 2 ppm. DDT and metabolites were detected in most fish, though at low levels (range: non-detect to 0.73 ppm). Mirex concentrations, a primary cause of consumption advisories for the Niagara River and Lake Ontario, dropped considerably with most fish below the detection limit and only a single fish exceeding 0.1 ppm. Other organochlorine pesticides were generally detected in small numbers of fish and at low concentrations. With the exception of Cayuga Creek, all site and species combinations had a dioxin toxic equivalency (TEQ) below health advisory guidelines. PBDEs were found in all fish with an overall mean concentration of 29.0 ppb (range: 1.3 ppb to 122.6 ppb); about two-thirds of 47 analyzed PBDE congeners were detected. Based on the decline of contaminant levels in fish, the New York State Department of Health relaxed specific advisories for several important Lake Ontario and lower Niagara River fish species.

Trophic Ecology and Mercury Sources for Hawaiian Bottomfish

Presenting Author: Dana Sackett
Contributing Authors: Jeffrey C. Drazen, Anela Choy, Brian Popp, Robery Humphrey, Gerald Pitz

In Hawai‘i, some of the most important commercial and recreational fishes are an assemblage of lutjanids and carangids called bottomfish. Despite their importance, we know little about their trophic ecology or where the mercury (Hg) that ultimately resides in their tissue originates. While some have suggested that the source of Hg in marine fish derives from freshwater coastal Hg methylation that is subsequently advected offshore, others have suggested there are major ocean sources of Hg methylation independent of freshwater and coastal ecosystems. Here we investigated these topics by analyzing muscle tissue samples for trace mercury content, nitrogen, carbon, and amino acid specific isotope ratios in five species of bottomfish distributed across different depths from the Northwestern Hawaiian Islands (NWHI) and the Main Hawaiian Islands (MHI). Species had significantly different sources of nitrogen and carbon, particularly shallow water species, which had isotopic values suggesting benthic food sources. High trophic level lutjanids that foraged in deeper water, benthic environments generally had higher Hg levels. These results suggested that benthic Hg methylation is an important source of Hg for shallow benthic feeders, while deepwater sources of methylmercury may be important for those with food derived from the pelagic environment. Despite the lack of freshwater sources of Hg methylation in the NWHI, Hg levels were higher in shallow species in the NWHI. Additionally, the nearly identical models explaining the variation in tissue Hg in the MHI and NWHI suggested Hg methylated in freshwater environments were not a major source of Hg in fish tissue.

Green Tea Increases Blood Concentration of Mercury from Fish

Presenting Author: Charles Santerre
Contributing Authors: Elsa Janle, Chris Manganis, Tzu-Ying Chen, Bruce Craig

Fish provides many health benefits but are also the most common source of dietary mercury, which can be detrimental to the developing brain during the early stages of life. The bioavailability of mercury in fish may be affected by other meal components. In this study, the effect of green tea on the bioavailability of mercury from a fish meal was studied in rats and compared to a control group and a group treated with meso-2,-3-dimercaptosuccinic acid (DMSA), a compound used medically to chelate mercury (n=5/group). Rats were given via gavage a 4g fish meal which delivered 5.24 µg mercury/ kg body weight and one of the treatments: Control (water), green tea powder (357 mg/kg), and DMSA (120 mg/kg). Rats were given access to AIN-93M polyphenol-free chow for 3h at 12h intervals. Rats were dosed with each of the treatments at 12h intervals with each chow meal. Blood samples (5µL) were collected for 95h and analyzed for mercury by thermal decomposition-amalgamation/atomic absorption spectrophotometry. Green tea significantly increased the concentration of total mercury in the blood relative to the control whereas, DMSA significantly decreased mercury concentrations. In addition, meals were accompanied by a slight increase in blood mercury for several meals following the initial dose in all groups. These results suggest that the amount of mercury absorbed from a fish meal depends not only on the mercury content of the fish but also on the meal composition. The results also show that subsequent feedings where mercury was not consumed result in slight increases in blood mercury.

Trends of PCB Concentrations in Lake Michigan Coho and Chinook Salmon, 1975–2010

Presenting Author: Candy Schrank
Contributing Authors: Paul Rasmussen, Meghan Williams

The manufacture and use of polychlorinated biphenyls (PCBs) was banned in the United States in 1977 after it was determined that these compounds adversely affect animals and humans. The Wisconsin Department of Natural Resources has quantified total PCB concentrations in Lake Michigan chinook (n=765) and coho (n=393) salmon (Oncorhynchus tshawytscha and Oncorhynchus kisutch, respectively) filets since 1975. We analyzed these data to estimate trends in PCB concentrations in these fish (1975–2010). We used generalized linear models with a gamma error distribution and log link fit to the untransformed concentrations. Trend patterns were examined using graphical smoothing and generalized additive models. We identified a candidate set of models that included time trend and other predictor variables. Using the Akaike Information Criterion to select among models, we found the best models for both species included piecewise linear time trends, total body length, % lipid, and collection season as predictor variables. The intersection of the two trends was 1985 for chinook salmon and 1984 for coho salmon. PCB concentrations in both species increased with body length and % lipid, and were higher for individuals caught in the fall. Our data reveals a dramatic decline in PCB concentrations of −16.7% and −23.9% per year for chinook and coho, respectively, up until the intersection year, likely reflecting implementation of restrictions on Aroclor-based PCBs. After the intersection year to 2010, PCB concentrations declined at an annual rate of −4.0% (95% CI: −4.4% to −3.6%) and −2.6% (95% CI: −3.3% to −1.9%) for chinook and coho, respectively.

Assessment of Perfluorinated Compounds (PFCs) in Fish from U.S. Rivers and the Great Lakes

Presenting Author: Blaine Snyder
Contributing Authors: Leanne Stahl, John Wathen, Harry McCarty

The chemical structure of perfluorinated compounds (PFCs) gives them unique properties, such as thermal stability and the ability to repel both water and oil, which make them useful components in a wide variety of consumer and industrial products. Their high production volume led to widespread distribution in the environment, particularly in water where they are most readily transported. PFCs have emerged as contaminants of concern because they are broadly distributed, persistent in the environment, and linked to potential health effects. Recent modeling studies estimate that PFC contamination in food may account for most human exposure to perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA), with results from other studies suggesting that fish from contaminated waters may be the primary source of exposure to PFOS. The U.S. Environmental Protection Agency (EPA) Office of Science and Technology (OST) within the Office of Water identified the need for a comprehensive characterization of PFC contamination in U.S. fish. OST conducted a national-scale study of urban rivers and a regional-scale study of the Great Lakes to evaluate the extent of PFC contamination in freshwater fish. Both studies were conducted under the framework of EPA's National Rivers and Streams Assessment and EPA's National Coastal Condition Assessment in the Great Lakes. Fish were collected for PFC analysis from 162 randomly selected urban river locations throughout the lower 48 states (2008 and 2009) and from 157 randomly selected nearshore locations in the five Great Lakes (2010). Fish fillet composites were analyzed for 13 PFCs including PFOA and PFOS. Six PFCs dominated frequency of occurrence in the fillet samples from both studies. PFOA had a low frequency of occurrence (detected in <12% of all samples); however, PFOS was present in 73% and 100% of fish samples collected for the urban river and Great Lakes studies, respectively. Probability-based results indicated that the median concentration of PFOS is 10.7 ppb in fish from U.S. urban rivers and 15.2 ppb in fish from the Great Lakes. The maximum PFOS concentration measured in fillet tissue was 127 ppb in urban rivers and 80 ppb in the Great Lakes.

EPA’s Assessment of Contaminants in Fish from U.S. Rivers

Presenting Author: Leanne Stahl
Contributing Authors: John Wathen, Blaine Snyder, Harry McCarty

The U.S. Environmental Protection Agency (EPA) Office of Water and Office of Research and Development are collaborating to conduct a national study of fish tissue contamination in U.S. rivers. This study provides data for human health applications related to fish consumption, adding to the core ecological assessments EPA is conducting under the statistically designed National Rivers and Streams Assessment (NRSA). Results from the 2008-2009 NRSA fish tissue indicator generated a national baseline for fish contamination data including mercury, PCBs, and contaminants of emerging concern (i.e., perfluorinated compounds and polybrominated diphenyl ethers) in rivers. EPA’s inclusion of fish tissue analysis in the 2013-2014 NRSA will provide the first probability-based national fish contamination trends data for U.S. rivers. Sampling in 2013-2014 will involve the collection of fish tissue at a statistically representative subset of over 400 river locations (5th order or greater) assessed during the 2008-2009 NRSA. This subset provides sufficient sample size to develop national estimates of toxic chemical concentrations in fish with acceptable confidence intervals. Assessment of contaminants in river fish for this human health component involves collecting one fish composite sample from each of the river sites consisting of five similarly sized adult fish of the same species that are commonly consumed by humans. Fillet tissue from each 2013-2014 composite sample will be analyzed for mercury and 13 perfluorinated compounds (PFCs) including perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS). Samples will also be archived for potential future analysis of polybrominated diphenyl ethers (PBDEs) and polychlorinated biphenyls (PCBs). Sample collection is proceeding in 2013 and 2014, fish tissue analysis and data quality review will be completed in 2015, and EPA anticipates having results available to report in 2016.

An Investigation of Mercury Concentration Trends in Fish Tissue in the Ohio River

Presenting Author: Rob Tewes
Contributing Author: Jeff Thomas

The Ohio River Valley Water Sanitation Commission (ORSANCO) is a multi-state pollution control agency formed in 1948 and charged primarily with pollution abatement in the basin, criteria and standard development and issuance, and environmental and biological monitoring. ORSANCO has been collecting fish tissue contaminant data from the Ohio River since the 1980s. The six main stem states (Pennsylvania, Ohio, West Virginia, Kentucky, Indiana, and Illinois) have been using these data to issue risk-based fish consumption advisories since the 1990s.

A comprehensive analysis of mercury trends in fish tissue is warranted at this time as recent air emission regulations could ultimately be responsible for directing more mercury into waterways. Additionally, mixing zones for bioaccumulating contaminants of concern, like mercury, are in the process of being eliminated on the Ohio River, potentially affecting permit renewals for many Ohio River dischargers. In addition to fish tissue contaminant data that ORSANCO has gathered over the last three decades, we have also compiled contaminant data from other agencies from as early as 1972. We conducted a data quality review to qualify all data to be used in comparisons and trend analyses. All data used in this investigation were derived from fillets only (not whole fish), multiple fish composites (unless otherwise noted), taken from fish of average size (within angling regulations unless otherwise noted) and multiple trophic levels, and analyzed using comparable methods with accompanying QAQC documentation.

Data that fell within qualification parameters were analyzed spatially and temporally by species, taxonomic family, trophic level, and size range. We chose to compare mercury concentrations in individual species by river segment and by year to determine if concentrations were increasing or decreasing in any particular species in any river segment over time. Additionally we did a more gross analysis based on trophic level by river segment per year. We were able to determine the frequency and specificity of violations (>0.3 mg/kg) and denote differences in concentrations across species by river segment.

"All Things Fish" Informational Website: Conceptual Design

Presenting Author: Marcella Thompson
Contributing Authors: Amie Parris, Bruce Hooke, Robert Vanderslice

Goal and Objectives

- Create an informational website that provides "one-stop shopping" for recreational and subsistence fishers and their families.
- Provide information about the risks and benefits of eating Rhode Island fish.
- Unite sampling data from state, federal, and tribal agencies as well as research from academic institutions.
- Develop a sustainable and coordinated program for assessing and monitoring contaminants and nutrients in Rhode Island freshwater and saltwater fish.

Background

- Fish tissue analyses of mercury, polychlorinated biphenyls (PCBs), and other environmental contaminants are collected sporadically by state, federal, and tribal agencies as well as academic institutions for research. These efforts are not coordinated nor are the data reviewed in toto.
- Web-based information about fishing and fish advisories are absent, outdated, or not linked. Fish advisories for mercury and for other contaminants such as cyanobacteria are not linked. The benefits of consuming Rhode Island fish have not been addressed.
- There is anecdotal evidence of subsistence fishing by low-income families, immigrants, and Native Americans.
- There is a need to consolidate information, update fish consumption advisories, and create one-stop consumer-oriented website.

Methodology

- Meet with state and federal regulators, tribal councils, and academic researchers to begin dialogue on comprehensive fish advisories. Completed.
- Establish Memoranda of Understanding to share fish tissue analyses data. Consolidate data and update fish advisories statewide. In Process.
- Create user-friendly and useful information for "all things fish." Beta-test among different subgroups.