United States
Environmental Protection
Agency

Office of Water
Washington, DC 20460

EPA–823-R-07-008
September 2007

# Proceedings of the 2007 National Forum on Contaminants in Fish

All sections of the 2007 Proceedings are available from our web site at:
http://www.epa.gov/waterscience/fish/forum/2007/

# Section II-C
# Biomonitoring

**Moderator:**

*Amy D. Kyle, University of California, Berkeley*

### Biomonitoring Session Introduction: Content and Context

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### Risk Assessment at the Biomonitoring Crossroads – Summary of NRC Report

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*Henry Anderson, Wisconsin Department of Health and Human Services*

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# Biomonitoring Session Introduction: Content and Context

*Amy D. Kyle, University of California, Berkeley*

## Biosketch

Dr. Amy D. Kyle (Ph.D., M.P.H.) holds research and teaching appointments at the School of Public Health at the University of California Berkeley, where she is Director of Research Translation for an interdisciplinary research program in environmental heath sciences and technology, founder of the Project on Science and Policy for Health and Environment, and Co-Investigator in the Center for Excellence in Environmental Public Health Tracking. She has been active in the development of legislation authorizing a biomonitoring program for the State of California and has conducted workshops to foster discussion about how to best use biomonitoring for environmental health policy and surveillance.

Dr. Kyle's research is about how science is interpreted in policy, translation of scientific results and knowledge for policy and stakeholder audiences, use of analytic-deliberative processes in policy-relevant assessments, and children's environmental health. She is currently working on the development of approaches to reduce risk of exposure to contaminants in biota in the San Francisco Bay System, methods to address cumulative impacts in communities, issues of administrative implementation for chemicals policy reform, the role of indicators in an environmental health protection system, and the design of state programs for biomonitoring. She teaches science students about public policy and how to participate in discussions that involve non-technical audiences. She works with a wide array of community-based organizations, non-governmental organizations, executive and legislative agencies, academic partners, and with individuals in many state environmental protection and public health agencies.

Previously, Dr. Kyle served for 5 years as Deputy Commissioner for the Alaska Department of Environmental Conservation. Prior to that she worked for three governors on a variety of environmental, health, and natural resources issues. She received an M.P.H. degree and a Ph.D. in Environmental Health Sciences and Policy from the University of California Berkeley, and she earned a B.A. degree in Environmental Sciences from Harvard College. She was elected as Councilor to the Environment Section of the American Public Health Association and serves as Co-Chair of the California Breast Cancer Research Council.

## Biomonitoring Session Introduction: Content and Context

Amy D. Kyle
University of California Berkeley

## Content of Presentations

- Looking at “good” and “bad” compounds in fish
- National Academy of Sciences’ review of uses of biomonitoring
- Results of analyses that use biomonitoring
  - Alaska
  - New York City
  - Washington State
  - British Columbia
  - Wisconsin

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## Everybody is doing it

- States, Cities
  - Healthy Californians Biomonitoring Act (incorporates “right to know”)
- Researchers
- Non-governmental organizations
  - celebrity biomonitoring
  - Intended to make chemical exposure more immediate to people and influence chemicals policy

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## Related to Venues for Action on “Your” Chemicals

- Same states looking at chemicals policy
  - Chemical bans or phase out of uses
    - Mercury (many)
    - PBDEs (CA, WA, ME)
  - Toxic use reductions
  - Data to identify good and bad actors
- International efforts in Canada and European Union
  - Target persistent and bioaccumulative compounds

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## Fish biomonitoring

- Monitoring of fish is “biomonitoring”
- Consider in light of system as a whole
  - lakes and rivers, sediments, humans
- Integrated picture for PBT pollutants
- This is what is making a case to address sources → chemicals policy

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# Methylmercury and Omega-3 Fatty Acids: Co-occurrence of Dietary Sources and the Role of Fish

*Kathryn R. Mahaffey, U.S. EPA*

## Biosketch

Dr. Kathryn Mahaffey's (Ph.D.) professional career is in exposure assessment and toxicology of metals. She has worked extensively in the area of food safety. Following graduate training in Nutritional Biochemistry and Physiology at Rutgers University, she completed postdoctoral training in neuro-endocrinology at the University of North Carolina at Chapel Hill's School of Medicine. Her research has focused on susceptibility to lead toxicity with greatest focus on age and nutritional factors, which resulted in more than 100 publications. During her long career with the U.S. Government she has been influential in lowering lead exposures for the U.S. population through actions to remove lead from foods and beverages and from gasoline additives during the 1970s and 1980s.

During the past 10 years, Dr. Mahaffey has been actively involved in risk assessments for mercury and assessments of human exposure to methylmercury. She was the author of the NIH Report to Congress on Mercury and a primary author of EPA's *Mercury Study Report to Congress*. Dr. Mahaffey was one of the primary developers of EPA's *Mercury Research Strategy*, which was released in late 2000. Along with other team members, she was responsible for the 2001 EPA/FDA national advisory on fish consumption. Dr. Mahaffey was one of a group of three EPA health scientists who revised the basis for EPA's Reference Dose for Methylmercury, which was used in developing the Methylmercury Water Quality Human Health Criterion. Most recently, she has been evaluating and publishing national estimates of exposures to methylmercury in the U.S. population as shown in the 1999–2000 National Health and Nutrition Examination Survey. In 2006, a scientific volume, co-edited with Dr. Nicola Pirrone, on *Dynamics of Mercury Pollution on Regional and Global Scales*, was published by Springer and is now in its second printing.

In 2002, Dr. Mahaffey received EPA's Science Achievement Award in Health Sciences for this work. This is EPA's highest health sciences award and is presented in conjunction with the Society of Toxicology. Dr. Mahaffey received the Society of Toxicology's Arnold Lehman Award for regulatory toxicology and risk assessment in 2006. This award was presented for her work on regulatory toxicology and risk assessment for lead and methylmercury. The award is one of the top awards given by this society, which is the leading international professional organization of toxicologists.

Dr. Mahaffey served as the Director of the Division of Exposure Assessment, Coordination and Policy within the Office of Science Coordination and Policy, the Office of Prevention, Pesticides, and Toxic Substances, EPA between 2000 and 2006. This division runs EPA's Endocrine Disruptor Screening and Validation Program. Currently, she is developing analytical strategies for use of biological monitoring data to assess the impact of exposure to environmental chemicals on thyroid status in humans. Such data will be useful in economic assessments. Dr. Mahaffey remains active in research and assessing EPA's policies on methylmercury.

## Abstract

Despite many claims of broad benefits, especially for *in utero* development, derived from the consumption of fish as a source of omega-3 fatty acids, individual species of fish and shellfish provide substantially varied levels of these fatty acids. Likewise, fish and shellfish species differ by greater than an order of magnitude in their average concentrations of methylmercury (MeHg) even if within-species variability is not assessed. Exposures to both MeHg and to the omega-3 fatty acids reflect dietary choices, including species consumed, frequency of consumption, and portion size. In view of these sources of

variability, data on dietary patterns and blood Hg (µg/L) among women of child-bearing age (e.g., 16 through 49 years) provided an indication of exposures in the United States. Using data from the National Health and Nutrition Examination Survey (NHANES) for survey years 1999 through 2002, calculated consumption of MeHg and omega-3 fatty acids from fish and shellfish have been estimated based on results from 3,614 women who provided 30-day dietary recall and 24-hour records. These data reinforce how to select individual fish and shellfish species that are higher in omega-3 content and low in MeHg concentrations. This more refined dietary approach contrasts with generic recommendations that simply advise increasing fish consumption as a path toward improving cardiovascular health and providing benefits for *in utero* development. Risk communication in this circumstance is complex, in that the same food source contains both important nutrients and significant contaminants. Alternatives to fish as a source of omega-3s will also be discussed.

* NOTE: Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

Methylmercury and Omega-3 Fatty Acids: Co-occurrence of Dietary Sources and the Role of Fish

***Fish Forum - 2007***

Kathryn R. Mahaffey, Ph.D.
Washington, D.C.

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The Findings and Conclusions in This Presentation Have Not Been Formally Disseminated by US EPA and Should Not Be Construed to Represent Any Agency Determination or Policy

2

- Robert Clickner, Westat Corporation, Rockville, Maryland.
- Rebecca Jeffries, Westat Corporation, Rockville, Maryland.

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## Essential Fatty Acids

Sources – Diet and Pills




Mahaffey - 2007

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## *What are the essential fatty acids and what's important about fish?*

Fish is an extremely important source of two essential fatty acids: eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).


*As are additional food sources including eggs, chicken, pastas, orange juice, etc.*

Also pharmaceuticals/nutraceuticals.

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*Mahaffey - 2007*

## Why are the essential fatty acids important metabolically?

- **Growth**
- **Neurological and visual development.**
- **Immune function**
- **Gene expression**
- **Structural lipids of the nervous system**
- **Platelet aggregation**
- **Vessel wall constriction**
- **Maintain membrane fluidity and confirmation**
- **Cell signaling pathways.**
- **Synthesis of physiologically important chemicals, e.g. prostaglandins.**

- Mahaffey - 2007

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## What Are Omega-3 or Essential Fatty Acids?

- Fatty acids that cannot be synthesized by humans in sufficient quantity to meet nutritional needs.

*Mahaffey - 2007*

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- **Dietary α-linolenic acid is converted metabolically into EPA and DHA.**
- **Synthesis variable.** **Depends on amount of preformed EPA and DHA, levels of omega-6s in the diet, and other factors. Conversion is typically low ~ 15% in adults males (Emken et al, 1994). Females may have a higher rate of synthesis (Burdge and Calder, 2005). Endogenous synthesis of EPA and DHA from α linolenic acid during pregnancy is higher among pregnant than non-pregnant women (Burdge and Calder, 2005).**
- Mahaffey - 2007

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## Omega-3 Fatty Acids

- **α-linolenic acid comes from dietary oils – predominantly soybean oil and flax seed oil.**
- **EPA and DHA synthesized from the precursor α-linolenic acid *or* supplied preformed from the diet.**
- **Changes in supplementation of non-fish sources with EPA and DHA from fish oil and micro-algae provides preformed omega-3 fatty acids in non-fish sources.**
- **Mahaffey - 2007**

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## NHANES 1999-2002
## Non-Fish Sources of Omega-3s

- **Omega-3 intake from supplements was low.**

  **0.43% of examinees reporting use of a dietary supplement containing omega-3 fatty acids with a mean intake of 271 mg/day for those individuals taking supplements.**
- ***Have not estimated omega-3s from chicken. Use of fish meal in chicken feed has not yet been calculated. Also adds mercury intake to the diet.***
- **Omega-3 containing eggs were not specified in the NHANES food intake questionnaires. Use of "designer eggs" is reported to be 5% of total eggs sold in about 2003 (Burns-Whitmore, 2003).**
- **Mahaffey - 2007**

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## ***Turning to Fish, Omega-3s & Mercury***

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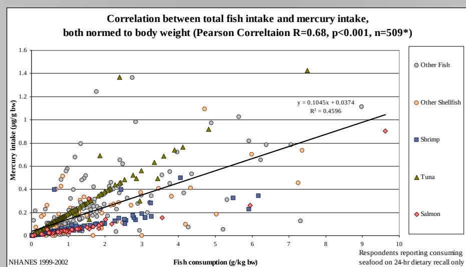
**NHANES 1999-2002 Data on Mercury Exposure and Dietary Intake of the Omega-3 Fatty Acids EPA (20:5) and DHA (22:6)**

- **Data from examinees who participated in the National Health and Nutrition Examination Survey between 1999 and 2002 in the United States.**
- **Dietary information (24-hour dietary recall and 30-day fish intake history) and blood mercury and organic mercury concentrations.**
- **Number of subjects differs with the particular measurement. 24-hour dietary recall data is from 18,725 examinees and blood mercury analyses on a subset of 3,614 examinees.**

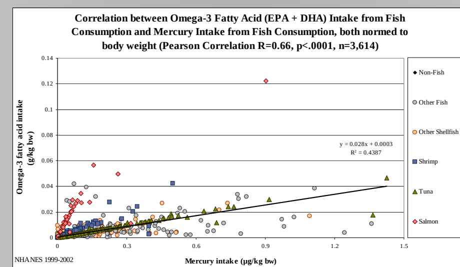
12

Correlation between total fish intake and mercury intake normed to body weight.




13

Correlation between omega-3 fatty acids (EPA + DHA) intake from fish consumption and mercury intake from fish consumption, both normed to body weight.

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## Fish Species, EPA/DHA, and Mercury

- Wide species-to-species variation in concentration of essential fatty acids and mercury in fish.
- DHA is an essential fatty acid especially found in seafood.
- Possible to select fish species that are good sources of DHA and low in mercury.
- Mahaffey - 2007

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Dietary Sources of Fish & Shellfish Vary Widely
Virtually All Contain Methylmercury

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The Balance for Fish Consumption, Methylmercury Exposure, and POPs Exposures

- **<u>Good news:</u> Can maintain low mercury exposures and adequate EPA/DHA intakes because methylmercury binds to proteins in tissues and EPA/DHA concentrates in lipoprotein membranes.**
- **<u>Bad news:</u> Likely to be very difficult to have adequate EPA/DHA intake and low exposures to POPs – because of close association of both in tissue lipids**.
- Mahaffey - 2007

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## Nutritional Recommendations

- Nutritionists recommend a 4-fold increase in fish consumption would be required to attain the proposed recommended combined EPA and DHA intake of 0.65 g/day (Kris-Etherton et al., 2000).
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Mercury (Low= 0.1 ppm; Medium = 0.3 to 0.5 ppm; High = 1.0 + ppm) and Omega-3 Fatty Acids (EPA & DHA: low 0.05-0.3; Med 0.31-0.97; High 1.0g/100g) in Fish and Shellfish

| Low EPA & DHA: | Med EPA & DHA: | High EPA & DHA: |
|---|---|---|
| Sole, Flounder, Cod, Skipjack | Clams, Oysters, Shrimp, Scallops Trout | Eel Mackerel Salmon Herring |
| Northern Pike, Grouper | Albacore Tuna Red Snapper Halibut | |
| Shark, King Mackerel | Tilefish Swordfish | |

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Dietary Sources of Fish & Shellfish Vary Widely Virtually All Contain Methylmercury

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### Fish Species, Omega-3 Fatty Acids, and Mercury

- Wide species-to-species variation in concentration of essential fatty acids and mercury in fish.
- *DHA and EPA are essential fatty acids especially found in seafood.*
- Possible to select fish species that are good sources of ω-3 fatty acids, and are low in mercury.

*Mahaffey - 2007*

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## Risk Communication

- Risk communication message aims to reach different groups with high methylmercury exposures:
- *Women of childbearing age because of risk to fetal neurological development.*
- Highly exposed including affluent people with food choices aimed at health promotion, fisher people and their families, subsistence fish consuming groups.

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## Message Conflict

- Simple statements such as "eat fish as a source of essential fatty acids".
- Two sources of over simplification:

**Generalization and over emphasis of the benefits of fish as a source of the specific "essential" fatty acids EPA and DHA.**

**No distinction between quantities of EPA and DHA in different fish species.**

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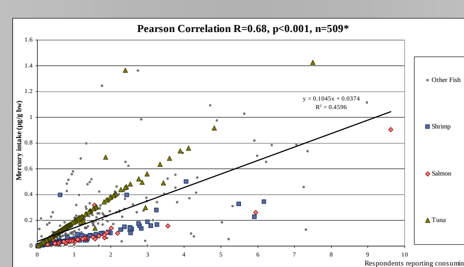
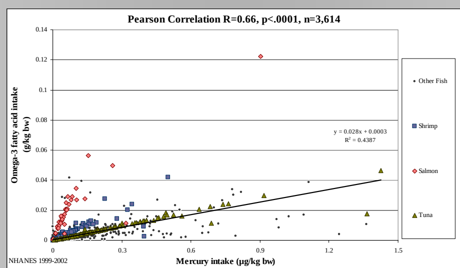
Correlation between total fish intake and mercury intake normed to body weight.




24

Correlation between omega-3 fatty acids (EPA + DHA) intake from fish consumption and mercury intake from fish consumption (normed to body weight)

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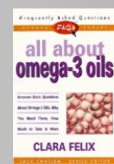
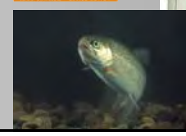
## What are the Message Conflicts?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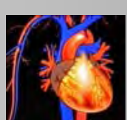
## Risk Communication

## *Challenge*

- **Fish consumption is often recommended to promote *health*.**
- **Specifically for cardiovascular and "wellness" messages.**
- **Fish is also contaminated with methylmercury and organics such as PCBs, and dioxin.**

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The Balance for Fish Consumption, Methylmercury Exposure, and POPs Exposures

- Good news: Can maintain low mercury exposures and adequate EPA/DHA intake because methylmercury binds to proteins in tissues and EPA/DHA concentrates in lipoprotein membranes.
- Bad news: Likely to be very difficult to have adequate EPA/DHA intake and low exposures to POP – because of close association of both in tissue lipids.

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## Future Dietary Changes

- Public concerns about contaminants in fish.
- Alternate non-fish sources of EPA and DHA.
- Greater use of eggs and alternate meats containing higher levels of omega-3 fatty acids.
- Grain sources - "Omega Puffs"

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## Omega-3 Fatty Acids in Eggs

- **Hens fed a special diet containing flaxseed, canola oil, sea algae or other omega-3 rich products.**
- **One egg provides 100 mg to 660 mg (Christopher Eggs) compared with ~ 40 mg/egg in traditional eggs.**
- **Yearly per capita egg consumption of eggs in 2001 was 252 eggs (Pickering, 2003) in the United States.**
- **"Designer" eggs are ~ 5% of the egg market (Hander, 2001) in the United States.**

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Omega-3s in "Designer Eggs"
Compared with Omega-3s in Fish
(mgs/100 gms food)

- One enriched egg contains up to 650 mg/50 gram egg. Or 1300 mg/100 gms
- Cod contains ~ 150 mg EPA + DHA
- Shark contains ~700 mg EPA + DHA
- Tuna (canned light) contains ~ 750 mg EPA + DHA
- Salmon contains ~ 1500 mg EPA + DHA

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Orange Juice (for example, Tropicana) with Added EPA and DHA

- http://www.tropicana.com/TRP_ProductInformation/Detail.cfm?ProductID=55&Packge.
- Contains 50mg of EPA and DHA combined per serving, which is 30% of the 160mg Daily Value for a combination of EPA and DHA based on statements from the institute of medicine. Serving Size: 8 fluid ounces or ~ 250 grams.
- Levels are low compared with fish, but orange juice is a much more frequently consumed food.

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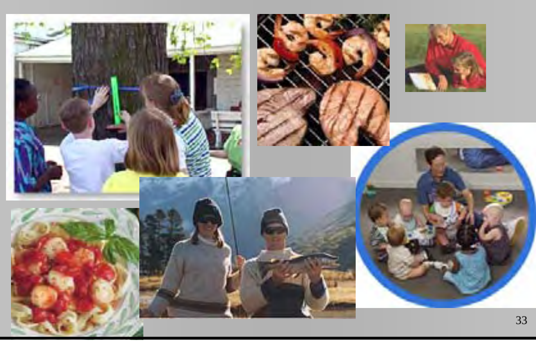
*mahaffey.kate@epa.gov*



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## Questions and Answers

*Q. Have you looked at cardiovascular effects to see if essential fatty acids are causing attenuation of fish consumption benefits at high mercury levels? (Sekerke)*

A. We have not investigated this angle; however, it would be an interesting study.

*Q. Is it possible to run the same types of analyses for PCBs [polychlorinated biphenyls] and dioxins? (Frohmberg)*

A. Your suggestion would be an excellent corollary study.

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# Risk Assessment at the Biomonitoring Crossroads: Summary of NRC Report

*Gary Ginsberg, Connecticut Department of Public Health*

## Biosketch

Dr. Gary Ginsberg is a Toxicologist at the Connecticut Department of Public Health within the Division of Environmental and Occupational Health Assessment. He is responsible for human health risk assessments conducted in the state. Dr. Ginsberg serves as adjunct faculty at the Yale School of Medicine and is an Assistant Clinical Professor at the University of Connecticut School of Medicine. He recently finished serving on the NAS Panel on Biomonitoring, and he currently serves on the NAS Panel that is evaluating EPA risk methods. He has been invited to testify at Congressional hearings on toxics issues on many occasions. He received a Ph.D. in Toxicology from the University of Connecticut (Storrs) and was a Postdoctoral Fellow in carcinogenesis/ mutagenesis at the Coriell Institute for Medical Research. Dr. Ginsberg's toxicology experience has involved a variety of settings, including basic research, teaching, working within the pesticide and consulting industries, and now working in public health. He has published in the areas of toxicology, carcinogenesis, physiologically based pharmacokinetic modeling, inter-individual variability and children's risk assessment. He has also co-authored a book on toxics for the lay public, What's Toxic, What's Not, published by Berkley Books in December 2006.

## Abstract

The 2006 National Academy of Science (NAS) biomonitoring report describes the potential utility and challenges of biomonitoring data such as that reported by the National Health and Nutrition Examination Survey (NHANES)/Centers for Disease Control and Prevention (CDC), the types of biomarkers available, and improved methods for risk assessment and source apportionment. A key challenge is that biomonitoring results are typically blood, hair, or urine concentrations, while risk assessments evaluate exposures in terms of intake dose (mg/kg/d). The National Research Council (NRC) Committee recommended the following three approaches to bridging this gap: 1) pharmacokinetic models, 2) obtain biomonitoring data in animal toxicology studies that can be related to human biomonitoring results, and 3) obtain more biomonitoring data in epidemiology studies so that adverse health outcomes can be analyzed from a biomarker-based dose response perspective. Perchlorate and phthalates are examples of the first approach, perfluorooctanoic acid (PFOA) is an example of the second approach, and lead and mercury are good examples of the third approach. In fact, recent results with perchlorate and phthalates challenge the existing animal-based risk paradigm and suggest that human biomonitoring-based assessments may, in certain cases, lead to more sensitive and relevant dose response information. Broad status and trends biomonitoring programs can be the first signal that there is widespread exposure to underappreciated environmental toxicants, with PBDEs being a leading example. Overall, the report endorses the continued use and expansion of biomonitoring but cautions that care needs to be devoted to analytical, ethical, and risk communication issues.

# Risk Assessment at the Biomonitoring Crossroads: Summary of NRC Report

Gary Ginsberg
Connecticut Dept of Public Health

National Forum on Fish Contaminants
Portland ME July, 2007

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**The Promise**

+ Huge expansion of exposure information
+ ID unknown exposures and risks (PBDEs)
+ Status and trends – evaluate intervention
+ Better epi data – test assocs in humans

**The Problem**

- No d/r for many analytes
- What does a detect mean
  - -Population vs Individual
- Risk assess/Risk comm burden

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ELSEVIER SCIENCE @ DIRECT Regulatory Toxicology and Pharmacology 44 (2006) 249–261 Toxicology and Pharmacology www.elsevier.com/locate/yrtph

Biomonitoring: Is body burden relevant to public health?

Dennis Paustenbach *, David Galbraith

- **Detection doesn't equal risk**
- **Biomonitoring focuses on industrial chemicals and pesticides**
  - **what about natural chemicals?**
- **Why biomonitor if don't know what it means?**

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**HUMAN BIOMONITORING FOR ENVIRONMENTAL CHEMICALS**

**National Research Council**
**Division on Earth and Life Studies**
**Board on Environmental Studies and Toxicology**
**July 2006**

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CDC/NHANES 2005 - 148 Chemicals

- 13 Metals: A …U
  - Not arsenic or Cr
- Tobacco – cotinine
- 22 PAH metabs
- 29 Dioxin/Furan/PCB
- 12 Phthalate metabs
- 6 Phytoestrogens
- 18 organoCl pesticides
- 6 OP metabs – DAPs
- 6 OP metab – specific
- 7 Herbicides
  - 2,4,5-T, 2,4-D, 5others
- 5 Pyrethroid metabs

***CDC/NHANES 2007 Expanding to over 300 Chemicals***

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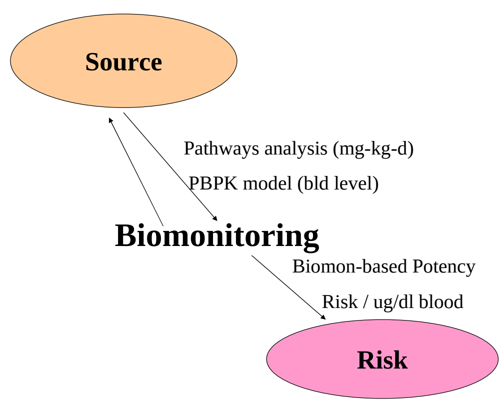
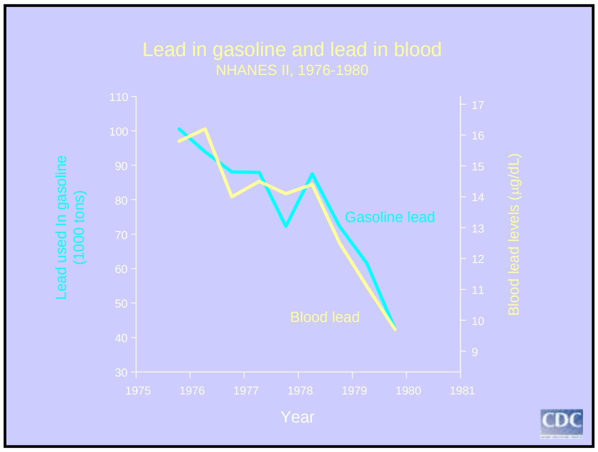




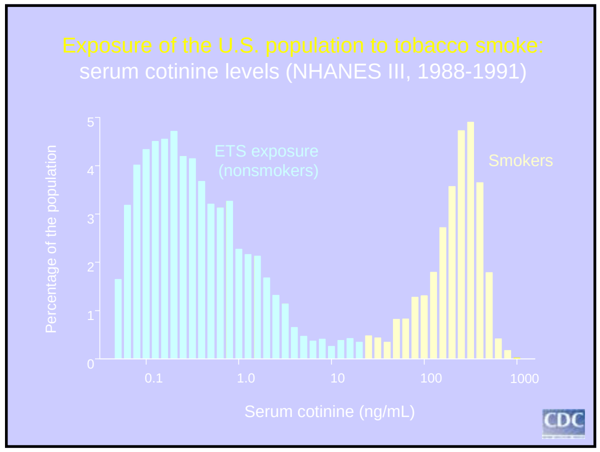




**Table 8. Mercury**

Geometric mean and selected percentiles of blood concentrations (in µg/L) for males and females aged 1 to 5 years and females aged 16 to 49 years in the U.S. population, National Health and Nutrition Examination Survey, 1999-2000.

| | Geometric mean (95% conf. interval) | Selected percentiles (95% confidence interval) 10th | 25th | 50th | 75th | 90th | 95th | Sample size |
|---|---|---|---|---|---|---|---|---|
| **Age group** | | | | | | | | |
| 1-5 years (males and females) | .343 (.299-.393) | < LOD | < LOD | .300 (.200-.300) | .500 (.500-.600) | 1.40 (1.10-2.00) | 2.30 (1.40-3.20) | 705 |
| Males | .317 (.270-.372) | < LOD | < LOD | .200 (.200-.300) | .500 (.500-.600) | 1.10 (.800-1.50) | 2.10 (1.10-3.50) | 387 |
| Females | .377 (.311-.457) | < LOD | < LOD | .200 (.200-.300) | .800 (.500-1.00) | 1.60 (1.20-2.30) | 2.70 (1.80-4.80) | 318 |
| 16-49 years (females) | 1.02 (.860-1.22) | .200 (<LOD-.200) | .400 (.400-.600) | .900 (.800-1.20) | 2.00 (1.60-2.70) | 4.90 (4.00-6.10) | 7.10 (5.60-9.90) | 1709 |
| **Race/ethnicity** (females, 16-49 years) | | | | | | | | |
| Mexican Americans | .820 (.691-.974) | .200 (<LOD-.200) | .400 (.300-.500) | .900 (.700-1.00) | 1.40 (1.20-1.90) | 2.60 (2.10-3.40) | 4.00 (2.70-5.50) | 579 |
| Non-Hispanic blacks | 1.35 (1.11-1.64) | .300 (.200-.500) | .600 (.500-.900) | 1.30 (1.10-1.60) | 2.60 (1.90-3.30) | 4.80 (3.30-6.60) | 5.90 (4.40-10.9) | 370 |
| Non-Hispanic whites | .944 (.765-1.17) | < LOD | .400 (.300-.400) | .900 (.700-1.10) | 1.90 (1.40-2.90) | 5.00 (3.40-6.50) | 6.90 (5.40-10.6) | 588 |

< LOD means less than the limit of detection, which is 0.14 µg/L.

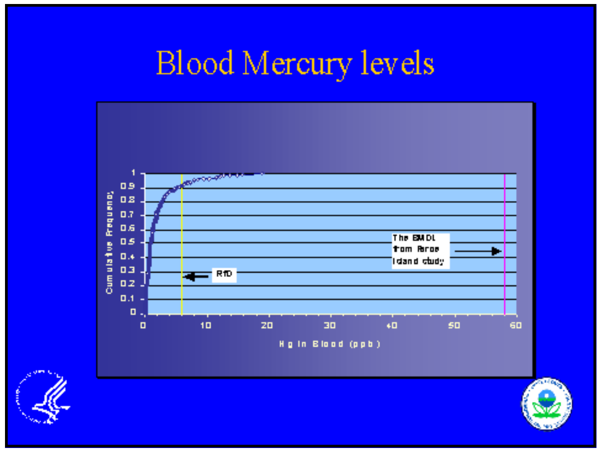



**TABLE 1-1** Numbers of Chemicals in *Third National Report on Human Exposures to Environmental Chemicals* for Which Health-Based Values Are Available

| | |
|---|---|
| 148[a] | Number of chemicals sampled by CDC in third national report |
| 25 | Number of chemicals for which EPA reference values (i.e., RfCs or RfDs) and/or cancer slope factors are established[b] |
| 23 | Number of chemicals for which TLV-TWAs are established |
| 5 | Number of chemicals for which BEIs are established |
| 3 | Number of chemicals for which RfDs/RfCs, TLVs, and BEIs are established |

[a]The CDC measures 148 total analytes; however many are similar compounds that are members of a broader class of chemicals, such as polychlorinated biphenyls, dioxins and furans, organophosphorus pesticides, and heavy metals.
[b]Many of the chemicals do not have specific health-based values, but because many are in similar classes of compounds, alternative approaches to evaluate toxicity, such as toxic equivalency factors, are available.
Source: CDC 2005.

## Major Portions of Biomonitoring Report

- Framework for Characterizing Biomarkers and Uses of Biomonitoring Data.
- Guidelines to ensure the proper conduct of biomonitoring studies – not all studies meet NHANES/CDC rigor
  - Study design, representative sample, collection, storage, analysis
  - Reporting
- Options for interpreting biomonitoring data
- Challenges in communicating results
- Research Agenda
  - Findings and Recommendations

## Framework for Characterizing Biomarkers

**TABLE 3-1** Framework for Grouping Biomarkers of Exposure[a]

| Properties of Biomarkers | | Biomarker Group I | II | III | IV | V | VI | VII |
|---|---|---|---|---|---|---|---|---|
| Reproducible sampling and analytic method | | | R | R | R | R | R | R |
| Known relationship of external dose to [BM] in animals[b] | | | | R | | | | |
| Known relationship of external dose to [BM] in humans[b] | | | | | R | | R | R |
| Known relationship of [BM] to biologic effect in animals | | | | | | | O | |
| Known relationship of [BM] to biologic effect in humans | | | | | | R | | R |
| Known relationship of external dose to response in animals | | | | | | | O | |
| Known relationship of external dose to response in humans | | | | | | | O | |
| Biomarker informs about | Internal dose | | √ | √ | √ | √ | √ | √ |
| | External dose[c] | | | √ | √ | | √ | √ |
| | Biologic effects[d] | | | | | √ | √ | √ |
| | | | | | | Potential for risk assessment | | |

[a]Checkmark in lower portion of table means that biomarkers in group can inform about stated elements of dose and effect.
[b]Implies knowledge of pharmacokinetics of biomarker in relation to exposure to parent chemical.
[c]The relationship between external dose and internal dose may be influenced by metabolic polymorphisms and other factors, including socioeconomic status and racial and ethnic differences.
[d]Biologic effects may include a wide range of observations, from very early biochemical perturbations to clinical signs of alteration of health.
Abbreviations: [BM] = concentration of biomarker; R = required: O = optional (at least one of these is required).

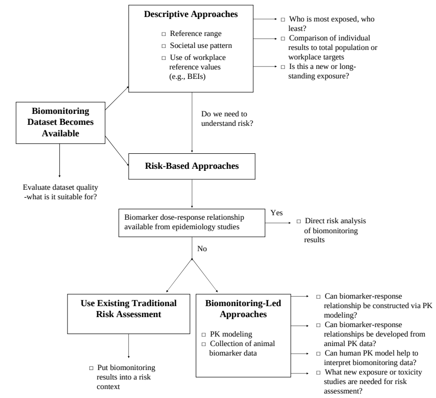



**Figure 5-6.** Conversion of Biomonitoring Data to Daily Dose Based Upon One Compartment (Body Burden) Model

==============================================================

serum level —*Lipid content of serum*→ BM conc in adipose —*Lipid Content of body*→ BM

Total Body Burden —*Elimination rate*→ Whole Body Clearance Rate (mg/d) —*Assume steady state*→

→ **INTAKE RATE (mg/d)**

==============================================================

Where BM stands for biomarker.

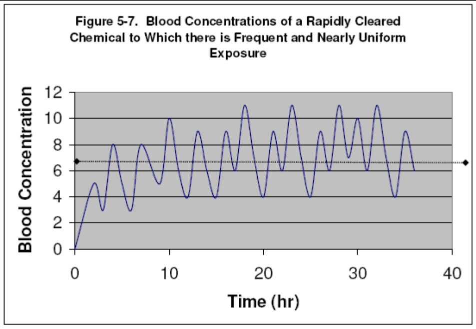
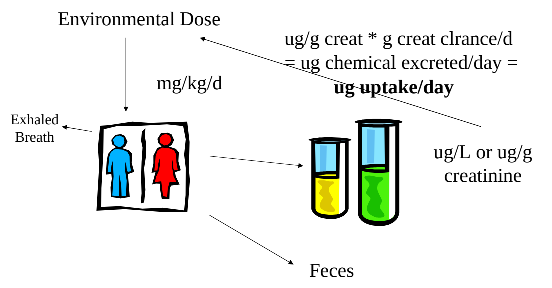



**Figure 5-7.** Highlighted line (♦--♦) is mean blood concentration across all time points. . Under these exposure conditions, biomonitoring will be within two-fold of mean concentration after the first several hours. A simplifying assumption of pseudo-steady state (mean concentration is approximated by the concentration found at any sampling time) may suffice for estimating exposure dose from blood concentration under these circumstances.




# Phthalate Urinary Biomonitoring

(Kohn, et al., 2000)

**Table 2.** Estimated exposures (mg/kg/day) to the general population based on extrapolated intake from urinary metabolites (Equation 1) in 289 individuals measured by Blount et al. (*7*).

| Monoester | Diester | Minimum | Median | 95th percentile | Maximum | CERHR[a] |
|---|---|---|---|---|---|---|
| Ethyl | Diethyl | < LOD | 12 | 110 | 320 | NA |
| *n*-Butyl | Di-*n*-butyl | 0.084 | 1.5 | 7.2 | 110 | 2–10[b] |
| Benzyl | *n*-Butyl benzyl | 0.094 | 0.88 | 4.0 | 29 | 2[c] |
| Cyclohexyl | Dicyclohexyl | < LOD | 0.026 | 0.25 | 2.3 | NA |
| 2-Ethylhexyl | Di(2-ethylhexyl) | < LOD | 0.71 | 3.6 | 46 | 3–30 |
| *n*-Octyl | Di-*n*-octyl | < LOD | 0.0096 | 0.96 | 13 | < 3– < 30[d] |
| *i*-Nonyl | Di-*i*-nonyl | < LOD | < LOD | 1.7 | 22 | < 3– < 30[d] |

[a]The CERHR Phthalates Expert Panel held its third and final meeting on 12–13 July 2000 in Arlington, Virginia; the CERHR final reports on the seven phthalates evaluated, along with a full description of the center and its activities, are available on the CERHR web site (*11*). [b]The upper bound for occupational exposure was estimated as 286 µg/kg/day; the estimate of 2 µg/kg/day is at the 84th percentile of our calculated values. [c]The CERHR estimate for *n*-butyl benzyl phthalate is at the 11th percentile of our calculated values. [d]Di-*n*-octyl and di-*i*-nonyl phthalate estimates from the CERHR were reported as less than for di(2-ethylhexyl) phthalate.

**Decrease in Anogenital Distance among Male Infants with Prenatal Phthalate Exposure**
(Swann, et al., 2005)

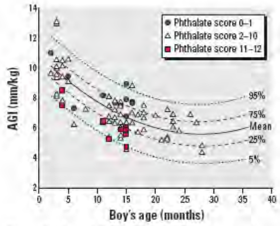


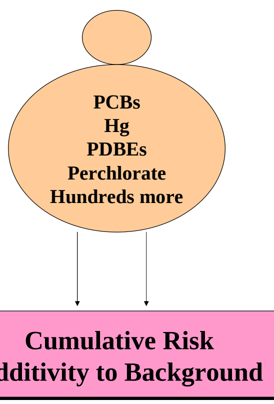

**Figure 1.** Mean AGI (mm/kg) in relation to boys' age at examination (months).

**Biomonitored Phalate Exposures Converted to Daily Intake Dose and Compared to USEPA RfDs (Marsee, et al., 2006)**

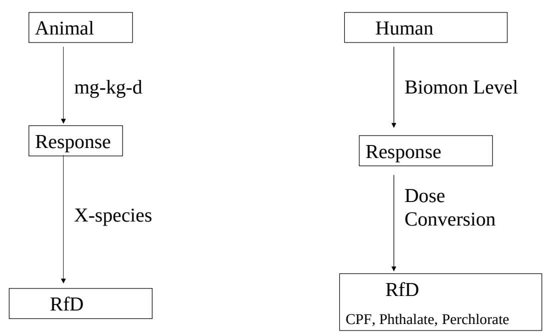
**Table 2.** Estimated phthalate exposure (μg/kg/day), calculated using the Kohn et al. (2000) method, for 214 pregnant women from Swan et al. (2005).

| Monoester | Diester (parent) | 25th percentile | Median | 75th percentile | 95th percentile | Maximum | RfD |
|---|---|---|---|---|---|---|---|
| MEP | DEP | 2.65 | 6.64 | 18.82 | 112.3 | 1,263 | 200 |
| MBzP | BBzP | 0.28 | 0.50 | 0.092 | 2.47 | 15.53 | 200 |
| MBP | DnBP | 0.56 | 0.84 | 1.31 | 2.33 | 5.86 | 100 |
| MiBP | DiBP | NA[a] | 0.12 | 0.21 | 0.41 | 2.90 | |
| MiBP + MBP | DnBP + DiBP | 0.63 | 0.99 | 1.53 | 2.68 | 5.98 | 100 |
| MEHP | DEHP | 0.51 | 1.32 | 3.32 | 9.32 | 41.10 | 20 |

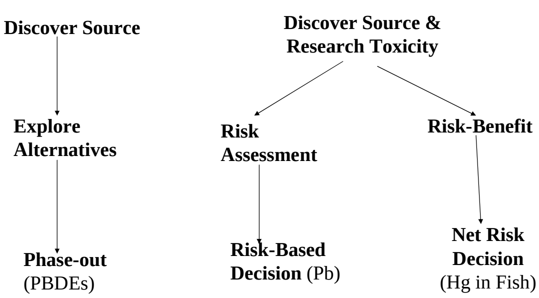
NA, not applicable. The phthalates shown are those that were significantly associated with reduced AGD and AGI (Swan et al. 2005), along with MEHP. Current U.S. EPA RfDs are 100 (DBP), 200 (BBzP), (DEP), and 20 (DEHP) μg/kg/day (U.S. EPA 2005a, 2005b, 2005c, 2005d).
[a]The daily exposure was not estimated when the urinary concentration of the phthalate metabolite was < limit of detection.




**RA at the Biomonitoring Crossroads**




**Biomonitoring Result**
**Options for Action**



## Questions and Answers

*Q. Do you have any comments on the uncertainty in these risk assessments, such the fact that the reference dose is based on cord blood, but the mother's blood is often used?*

A. There is evidence that the mother's blood and cord blood are related. With regard to uncertainty, many individuals have detectable levels of multiple contaminants, and it is critical that the cumulative risk assessment be investigated. In other words, the risk assessments do need to be expanded for a clearer picture of risk.

*Q. Cord blood only represents mercury levels at the end of pregnancy and does not take into account the possible significant effects of high levels of mercury in the first and second trimesters.*

A. The biomonitoring data that were used were the data available and do answer certain questions. More samples may answer whether biomonitoring at certain times during pregnancy is a more effective method of calculating risk.

# Fish Consumption Advice Goes Local: How Human Biomonitoring and Local Risk Management Improve Public Health Policy in Alaska

*Lori Verbrugge, Environmental Public Health Program Manager Alaska DHSS*

## Biosketch

Dr. Lori Verbrugge (Ph.D.) is the Environmental Public Health Program Manager for the Alaska Division of Public Health. She has been working to assess the human health implications of contaminants in Alaska's environment since 1997. Dr. Verbrugge has coordinated the development of analytical chemistry capacity and programs for the Alaska Public Health Laboratory, and she currently works in the Section of Epidemiology to provide expert toxicological support and policy advice to the Division. Dr. Verbrugge oversees various environmental health programs, including human biomonitoring, adult blood lead surveillance, subsistence food safety, environmental health research, and an ATSDR cooperative agreement to assess the public health implications of contaminated sties in Alaska.

Dr. Verbrugge received her Ph.D. in Environmental Toxicology from Michigan State University, where she researched the toxicological effects of PCBs and dioxins on fish-eating birds under the direction of Dr. John Giesy. She also holds an M.S. degree in Fisheries and Wildlife from Michigan State University and a B.S. degree in Environmental Toxicology from the University of California at Davis.

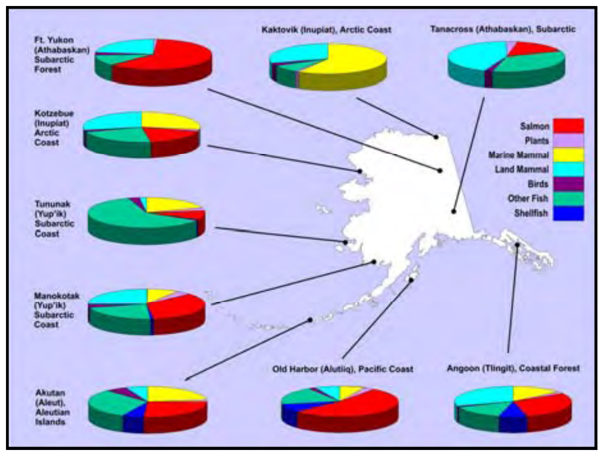
## Abstract

Alaska's natural abundance of traditional foods has supported members of more than 200 Tribes for many generations. Subsistence, with fish as a major component, is the fundamental cornerstone of Alaska Native cultures, providing spiritual, nutritional, medicinal, cultural, and economic well being. As Alaska Native cultures have become more westernized over the past few decades, lifestyle changes have led to increased rates of diabetes, obesity, and heart disease in many communities.

Local risk management is essential to provide appropriate fish consumption advice in Alaska. Potential health risks from contaminants must be weighed against the health benefits of fish consumption and against the risks associated with alternative replacement foods. To reduce uncertainty related to mercury (Hg) exposure estimates, the Alaska Division of Public Health (ADPH) has conducted an on-going Statewide Hair Mercury Biomonitoring Program since 2002. To date, no Hg exposures of health concern related to consumption of Alaska fish have been documented. Through the end of 2006, 359 Alaskan women of child-bearing age have been tested, with a median hair mercury concentration of 0.53 parts per million.

The State of Alaska initiated a Fish Monitoring Program in 2001. With contaminant data on more than 2,200 fish from 23 species, an Alaska Scientific Advisory Committee for Fish Consumption was established to develop Alaska-specific guidance. All five wild Alaska salmon species have very low Hg levels and are safe for everyone to eat in unlimited quantities. Recommendations will be made for women of child-bearing age and children to limit consumption of salmon shark, spiny dogfish, yelloweye rockfish, large lingcod, and large halibut (more than 50 pounds) to limit Hg exposure. Our overarching recommendation to the public is to not reduce their fish consumption. Individuals concerned about Hg exposures are advised to choose fish with lower Hg levels, such as wild Alaskan salmon. The ADPH is currently developing new consumption guidelines, which will be released later this summer.






## Drawbacks of Restricted Consumption of Traditional Foods

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

## Benefits and Risks

**Benefits**

- Nutrition
- Taste
- Social-cultural value
- Fitness
- Cost
- Transfer of culture from elders to children
- Ecological knowledge

**Risks**

- Accidents - hunting/fishing
- Health Risks from contaminants
- Risks of not eating traditional foods (Obesity, diabetes, heart disease)

From Dr. Harriet Kuhnlein, CINE

## Past consumption advice from the ADPH

"The Alaska Division of Public Health recommends unrestricted consumption of all fish from Alaska waters."

- Not enough specific data to base fish advisories on
- Human biomonitoring has not revealed exposures of public health concern
- Risk versus benefit judgment call

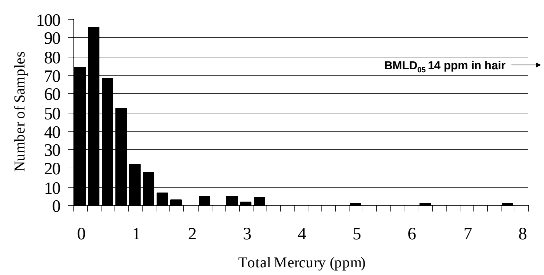
## Data ADPH Uses to Develop Fish Consumption Advice

- Contaminant levels in Alaska fish
- Human biomonitoring data
- Fish consumption patterns in Alaska
- Nutrition-related disease rates and trends in Alaska
- Cultural and socioeconomic factors

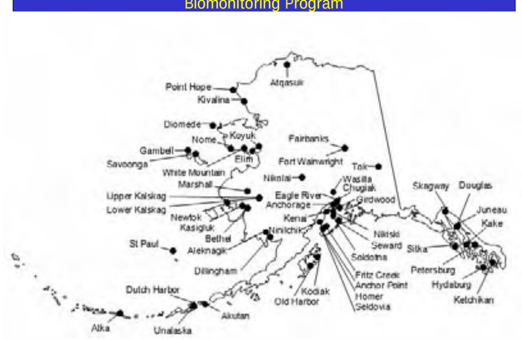
## Statewide Hair Mercury Biomonitoring Program

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

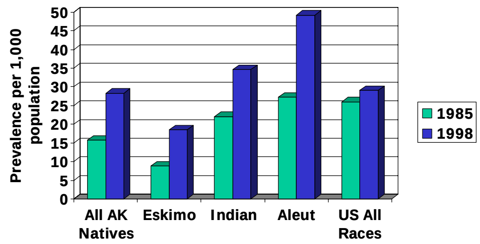
## Hair Mercury Concentrations of Women who Participated in Alaska's Statewide Program July 2002–December 2006 (N=359; Median = 0.53 ppm)




## Locations of Women who Participated in the Alaska Hair Mercury Biomonitoring Program




## Diabetes Prevalence Among Alaska Natives --1985 and 1998

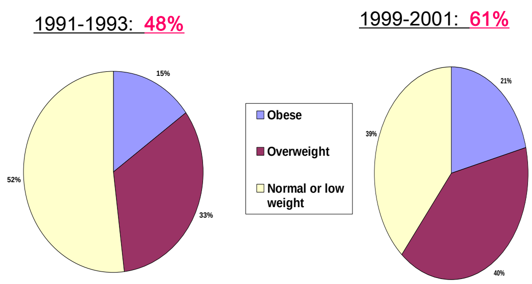



Data from IHS, Alaska Area Profile, 1998

## Non-Insulin Dependent Diabetes Mellitus (NIDDM)

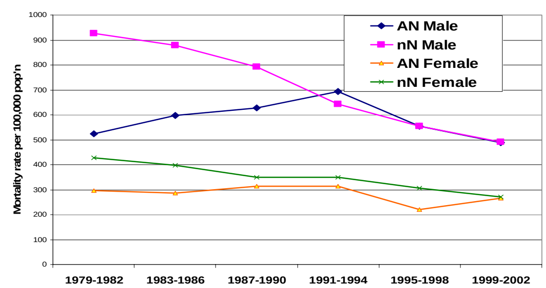
- Etiology complex and multifactoral
- High saturated fat intake increases insulin resistance
- High ω-6 to ω-3 fatty acid ratio a risk factor for development of NIDDM
- Alaska Natives of the Yukon and Kuskokwim: daily consumption of seal oil or salmon decreased risk of NIDDM

## Percent of Alaskan Adults who are Overweight or Obese




State of Alaska Section of Epidemiology

## Coronary Heart Disease Mortality Rates in Alaskans (Age ≥40 y)

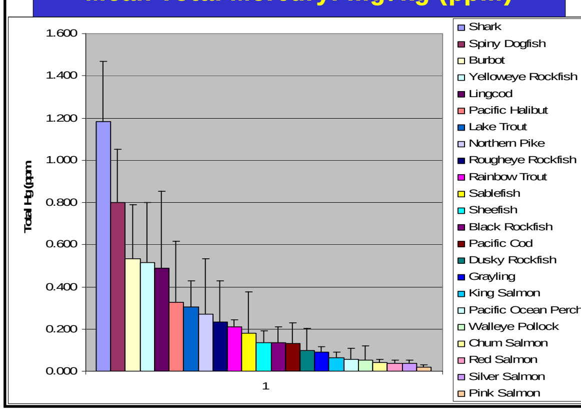



McLaughlin et al, JAMA 2004

## What has Changed?

- For the first time, we have a large data set about contaminants in Alaska fish
- New information about some problematic fish species we didn't have data on before (re: mercury)
- It's time to refine our message. It is possible to enjoy the many benefits of fish consumption while minimizing the risk from mercury

## Mean Total Mercury: mg/kg (ppm)



## What hasn't changed?

- Human biomonitoring still has not detected mercury exposures of health concern from consumption of Alaska fish
- Fish is still a very healthy food – reductions in fish consumption are NOT recommended
- Most fish from Alaska have very low (or non-detectable) levels of contaminants

## Process of Refining Guidelines

- Initial evaluation of data by ADPH – Fall 2006
- Formed Alaska Scientific Advisory Committee for Fish Consumption
- Workshops with Stakeholders
- Finalize guidelines and publish report – Summer 2007

## Alaska Scientific Advisory Committee for Fish Consumption

- Ad hoc group assembled by Alaska DHSS and ADEC
- Met November 30, 2006
  - reached consensus on Alaska-specific risk/benefit balance
  - Alaska-specific Mercury TDI based on ATSDR analysis: 0.4 ug/kg BW/day
- Seven scientific experts from:
  - Alaska DHSS, ADEC, ADF&G
  - Alaska Native Tribal Health Consortium
  - University of Alaska Fairbanks
  - USFWS

## Which Alaska fish have higher mercury levels?

- Salmon shark
- Spiny dogfish
- Yelloweye rockfish
- Large lingcod (over 40 inches)
- Large halibut (over 50 pounds)
  - Commercially caught average 35 pounds
  - Recreationally caught average 23 pounds
  - Subsistence caught average 28 pounds

## Which groups would be most vulnerable?

Women of childbearing age and young children in the following groups:

- Subsistence consumers, because they eat more fish than the general population
- Some recreational consumers
  - Salmon shark
  - Catching a large halibut with a high mercury level
    - divide it into many meals and eat off that one fish all year

## Draft Guidelines for WCBA and children eating Alaska-caught fish

| Fish MeHg Conc, ppm ww | Meals per month | Species; using a. Mean |
|---|---|---|
| 0 - .154 | Unlimited | Pacific Cod<br>Walleye pollock<br>Black rockfish<br>Pacific ocean perch<br>King salmon<br>Chum salmon<br>Pink salmon<br>Red salmon<br>Silver salmon<br>Halibut 0 - 20 pounds<br>Lingcod 0 - 29.9 inches |
| >.154 - .315 | 16 | Sablefish<br>Rougheye rockfish<br>Northern pike<br>Halibut 21 - 40 pounds<br>Lingcod 30 - 39.9 inches |
| >.315 - .416 | 12 | Halibut 41 - 50 pounds |
| >.416 - .640 | 8 | Yelloweye rockfish<br>Halibut 51 - 90 pounds<br>Lingcod 40 - 44.9 inches |
| >.640 - 1.23 | 4 | Salmon shark<br>Spiny dogfish<br>Halibut over 90 pounds<br>Lingcod ≥ 45 inches |

*Calculations performed using 6 oz meal size, and MRL dose of 0.4 ug/kg BW/day established by the Alaska Scientific Advisory Committee for Fish Consumption. Calculations assume a single species diet

## Our Main Advice: Don't Stop Eating Fish!!

- Lean protein source, full of vitamins and healthful omega-3 fatty acids
- Good for Babies: omega-3s important for development of brain and visual cortex
- Good for Adults: omega-3s important for heart health
- Much more healthy than replacement foods loaded with saturated fat, sugar and/or salt
- Important part of Alaska culture and lifestyle

## State of Alaska Public Health Recommendations

- Fish consumption advice should come from local public health officials
- Benefits of Alaska fish outweigh potential adverse effects – for everyone
- Choose fish lower in mercury if you are concerned
  - Wild Alaska salmon
- New guidelines being developed – released in Summer 2007

## Questions and Answers

Q. *Do you envision the recommended advice, unlimited fish consumption, will pose a conflict? (Goshfeld)*

A. We appreciate that some individuals will have additional questions about the safety of fish consumption. Wherever possible, we inform them to eat fish that are low in mercury and, if they are concerned, that a hair-mercury test is available to them.

Q. *Is the Seychelles study of 0.4 µg/kg applicable to Alaska?*

A. The safety factor in the Seychelles study is different. In Alaska, it is appropriate to have a lower safety factor because of the increased risks associated with decreased fish consumption.

Q. *Alaska appears to be meeting EPA's reference doses. Why change the state advice?*

A. Since our data are not taken from a random sampling, we are not aware if our biomonitoring captures those individuals eating shark and we want to be proactive. Additionally, we have the smallest amount of data on urban Alaska consumers; we want more data on that.

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# Blood Mercury Levels in New York City Adults

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

## Biosketch

Dr. Wendy McKelvey (Ph.D.) received her master's degree and Ph.D. in Epidemiology from the University of California in the areas of Nutrition and Cancer. She then transitioned to conducting research in environmental exposure assessment as a Postdoctoral Fellow in the Division of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill. She is currently Director of Epidemiology in the Bureau of Environmental Surveillance and Policy at the New York City Department of Health and Mental Hygiene. Her current work is on environmental health issues in the City of New York. She also serves as Epidemiologist for New York City's Centers for Disease Control and Prevention-funded Environmental Public Health Tracking Program, and she teaches epidemiology as an associate adjunct professor in the Urban Public Health Program at Hunter College in New York City. Previously, she worked at Silent Spring Institute, where she conducted epidemiologic research on environmental causes of breast cancer.

## Abstract

BACKGROUND: Mercury (Hg) is known to harm the developing nervous system. Because clinical testing for Hg is generally voluntary and infrequent, little is known about local populations' exposures.

METHODS: We measured blood Hg concentrations in a representative sample of 1,811 New York City (NYC) adults as part of the NYC Health and Nutrition Examination Survey, 2004.

RESULTS: The geometric mean blood Hg concentration was 2.73 µg/L (95% CI: 2.58–2.89). Hg levels were more than three times higher than national levels. An estimated 25% (95% CI: 22%, 28%) of adult New Yorkers had blood Hg concentration at or above the 5 µg/L New York State reportable level. Across racial/ethnic groups, the NYC Asian population and the foreign-born Chinese, in particular, had the highest blood Hg levels. These levels were elevated 39% in the highest relative to the lowest income group (95% CI: 21%–58%). Consuming fish or shellfish 20 times or more in the last 30 days was associated with a 3.7-fold increase in average blood Hg concentration (95% CI: 3.0–4.6) compared to zero times; frequency of consumption explained some of the elevation in Asian and higher income subgroups.

IMPLICATIONS: Higher blood Hg levels in NYC compared to the United States overall indicates a need for more education about how to choose fish and seafood so as to maximize the health benefits while minimizing potential risks from exposure to hg. The relatively high Hg levels in the NYC Asian community suggests a need for more research on Hg content in fish commonly consumed by this group. In response to this need, the NYC Department of Health and Mental Hygiene will be measuring Hg concentrations in samples from 20 fish species commonly sold in Asian markets.

## Blood Mercury Levels in New York City Adults

Wendy McKelvey, Ph.D.

New York City Department of Health and Mental Hygiene

NYC Health

## NYC Health and Nutrition Examination Survey

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

NYC Health

## Why Conduct a Community HANES?

- NHANES does not provide local descriptions of population health
- Objectively measured data is needed to inform local public health programs
- Baseline levels for health indicators and trends (if survey routinely conducted) can be established

NYC Health

## Data Collection

Interview:

- Fish and shellfish consumption in last 30 days
- Smoking
- Demographics

Physical Exam:

- Venipuncture
- Urine collection

NYC Health

## Blood Mercury Levels (µg/L) in NYC Compared to the US

| | No. | GM | 95th %tile |
|---|---|---|---|
| **NYC HANES 2004** Females 20-49 | 755 | 2.64 | 11.54 |
| **NYC HANES 2004** Males 20-49 | 547 | 2.58 | 10.49 |
| **NHANES 2001-02** Females 16-49 | 1928 | 0.83 | 4.60 |

## Elevated Blood Mercury Levels in Study Participants

| Blood Hg | No. | Likely Source |
|---|---|---|
| > 20 µg/L | 27 | 20 fish / 1 cream / 6 unable to contact |

**Blood Mercury Concentrations (µg/L) in NYC Adults**

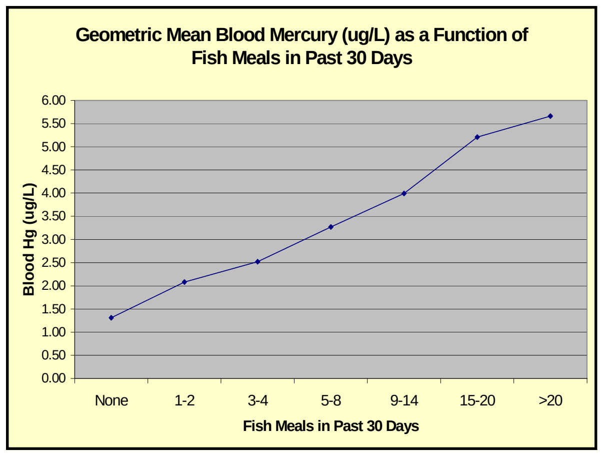
| | No. | Geometric Mean | 95th Percentile |
|---|---|---|---|
| **NYC Total** | 1811 | 2.7 | 11.0 |
| **Race/Ethnicity** | | | |
| White | 529 | 2.8 | 10.9 |
| Black | 390 | 2.6 | 9.3 |
| Asian | 231 | 4.1 | 19.2 |
| Hispanic | 630 | 2.3 | 8.5 |
| Foreign-born Chinese | 93 | 7.26 | 22.5 |

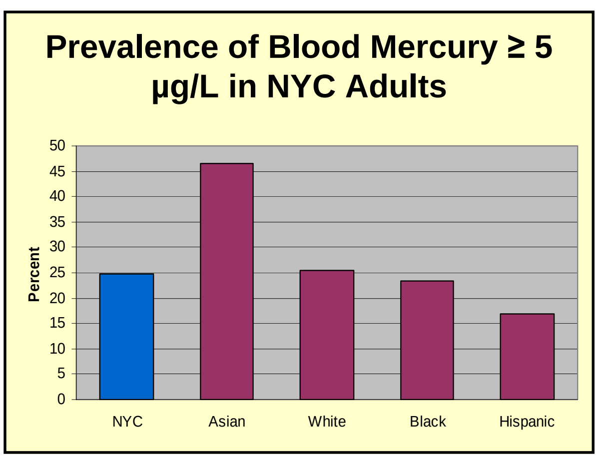
**Blood Mercury Concentrations (µg/L) in NYC Adults**

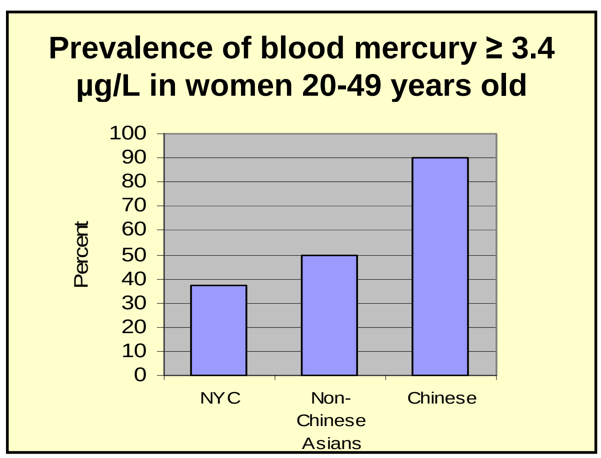
| | No. | Geometric Mean | 95th Percentile |
|---|---|---|---|
| **Family Income** | | | |
| <$20,000 | 610 | 2.4 | 9.8 |
| $20,000-$49,999 | 566 | 2.6 | 9.9 |
| $50,000-$74,999 | 256 | 3.0 | 11.2 |
| $75,000 | 304 | 3.6 | 14.7 |

**Blood Mercury Concentrations (µg/L) in NYC Adults**

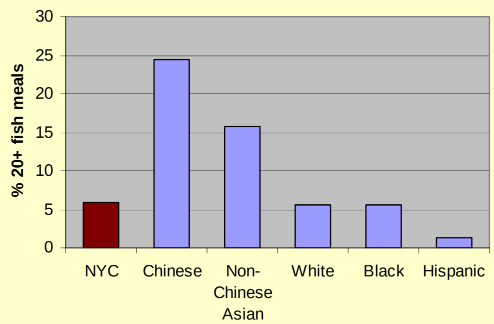
| | No. | Geometric Mean | 95th Percentile |
|---|---|---|---|
| **Fish/Month** | | | |
| Never | 209 | 1.3 | 5.4 |
| Up to 9 times | 1216 | 2.6 | 9.3 |
| 10-19 times | 255 | 4.3 | 19.2 |
| 20+ times | 114 | 5.7 | 18.3 |



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




### Summary

- Blood mercury levels higher in New Yorkers
- Higher blood mercury in frequent fish consumers
- Asians have highest blood mercury levels across broad racial/ethnic groups
- Foreign-born Chinese New Yorkers have even higher levels

NYC Health

### Study Limitations

- Response was 50% (but weighted to correct for potential biases in response)
- Meaningful exposure thresholds not well known
- Questionnaire did not distinguish types of fish eaten
- Subgroups are small

NYC Health

### Public Health Needs

- More information about types of fish eaten by frequent fish consumers
- More data on mercury content of fish species in NYC markets
- Advisories on healthy fish consumption that are relevant to the NYC population
- Targeting of Asian, Chinese and high SES communities

NYC Health

### New York City Responds:

- Developed brochure in English/Chinese/Spanish:

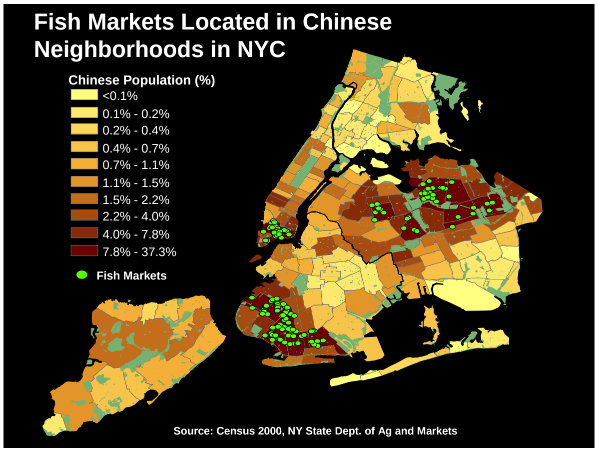
  *"Eat Fish, Choose Wisely"*
- Distributed health care provider advisory letter on mercury in fish (electronically)
- Collecting data on fish species eaten by Chinese New Yorkers
- Sampling 20 species of fish from Chinese markets for mercury and PCB's

NYC Health

### Selecting species in Chinese markets for mercury and PCB testing

- Took inventory of live, on-ice, frozen, salted/dried, and canned products in markets
- Determined species lacking sufficient data on Hg (US FDA, EPA MML) for use in advisories
- Determined species for which existing data might not be representative (e.g., tilapia)

NYC Health




## Proposed list of species to be tested for mercury and PCB's

- Porgy
- "Red" Snapper
- White Pompano
- Tilapia
- Bighead Carp
- Buffalo Carp
- Black Sea Bass
- A Flounder Species
- Whiting
- Atlantic Tilefish
- Blue crab
- Frozen Yellow Croaker
- Canned Eel
- Canned Dace
- Dried Yellow Croaker
- Spanish mackerel
- Live yellow eel
- Grouper

NYC Health

## Fish Market in Chinatown, NYC

## Contributors

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NYC Health

## Questions and Answers

*Q. Why do you believe individuals making higher incomes generally have higher blood mercury levels?*

A. More expensive fish tend to be higher in mercury (i.e., sushi-grade tuna, swordfish, and Chilean sea bass). This group needs to be targeted.

*Q. Have you done any studies as to what parts of the fish are being consumed?*

A. We are in the process of gathering information on this. We aren't going to look at the levels of organs because we don't know how many people eat the organs.

*Comment*: North Carolina has also been working with CDC [Centers for Disease Control and Prevention] to sample blood of subsistence fishermen before the CAMA [Coastal Area Management Act] rule was implemented. *(Williams)*

# Fish Consumption and Mercury Exposure among Washington Residents — Results from the Behavioral Risk Factor Surveillance System (BRFSS) Survey and the Women's Diet Survey

*Denise Laflamme, Washington State Department of Health*

## Biosketch

Ms. Denise Laflamme has been a Toxicologist at the Washington State Department of Health for more than 15 years. Ms. Laflamme has an M.S. degree in Environmental Toxicology and an M.P.H. degree in Epidemiology from the University of Washington, School of Public Health and Community Medicine. Her primary duties include providing toxicological and epidemiological support within the department and to other agencies. Her recent duties include providing technical support around the following topics: PBDE flame retardants, persistent bioaccumulative toxic (PBTs) chemicals, biomonitoring, exposure assessment methods, and risk assessment.

## Abstract

The general public is mainly exposed to methylmercury from eating fish that contains mercury (Hg). To better ascertain fish consumption among the general public in Washington State, the Washington State Department of Health (DOH) included several fish consumption questions on the Centers for Disease Control and Prevention's (CDC's) Behavioral Risk Factor Surveillance System (BRFSS) survey for the years 2002, 2004, and 2005. The BRFSS is an on-going population-based telephone survey of randomly selected non-institutionalized adults age 18 and older. The BRFSS fish consumption questions asked about adult consumption of canned tuna, store-bought fish, and sport fish during the past month; children's consumption of canned tuna; serving size of canned tuna; types of canned tuna and store-bought fish consumed; awareness of fish advisories; sources of information about fish advisories; and attitudes about health and fish consumption.

In 2005 and 2006, DOH conducted a study to assess the validity of the BRFSS fish consumption questions. This study, called the Women's Diet Survey, recruited 800 women ages 18–40 from across Washington State who had completed the BRFSS in 2005 and 2006 and who had agreed to be called back for other health surveys. The Women's Diet Survey collected fish consumption information over the telephone using the BRFSS fish questions and via a mailed food frequency questionnaire. Participants were also asked to provide hair samples for mercury testing.

This work is paid for under the CDC Environmental Public Health Tracking Program, Grant U38/EH000179-01.

## Fish Consumption and Mercury Exposure among Washington Residents

Results from the Behavioral Risk Factor Surveillance System (BRFSS) survey and the Women's Diet Survey

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Division of Environmental Health
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*EPA National Forum on Contaminants in Fish*
*Portland Maine*
*July 23, 2007*

## Outline

- Review available data on mercury exposures in WA
- BRFSS
  - Overview of fish consumption questions
  - Results highlights
- Women's Diet Survey
  - Specific Aims
  - Overview/Methods
  - Results
  - Limitations
- Conclusions
- Use of data/next steps

## Mercury Exposures in Washington

- General public exposure to methylmercury depends on:
  - amount of fish eaten
  - concentration of mercury in fish
- National fish consumption & biomonitoring data
- WA fish consumption data for some populations
  - Native Americans
  - Asian and Pacific Islanders
- No general population biomonitoring data in WA
- Use BRFSS to obtain WA population estimates for fish consumption among the general public

## Behavioral Risk Factors Surveillance System (BRFSS)

- Ongoing telephone survey sponsored by CDC
- Collects information about health behaviors, attitudes and knowledge
- Population based random selection of non-institutionalized adults ≥ 18 years
- Includes core questions asked by all states, optional questions for states to choose from, and state-developed questions
- WA added fish consumption questions in 2002, 2004 and 2005

## BRFSS Fish Consumption Questions

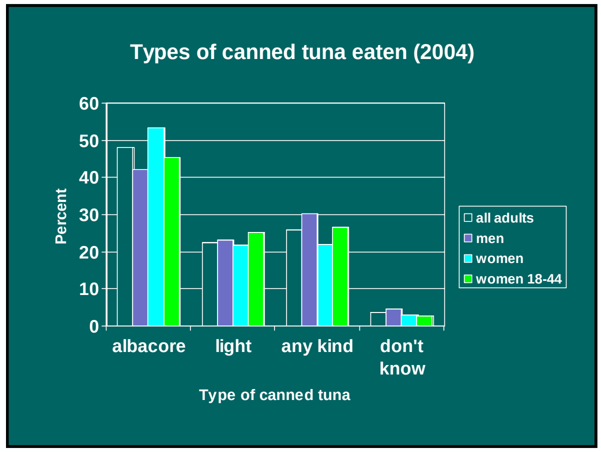
- 2002
  - Canned tuna consumption (adult and child)
  - Store-bought fish consumption (adult and child)
  - Awareness of advice about eating store-bought or sport fish
- 2004
  - Attitudes about healthfulness of eating fish
  - Sport-caught fish consumption in past 30 days
  - Store-bought fish consumption in past 30 days
  - Canned tuna consumption in past 30 days
  - Awareness of health advice about fish and mercury
  - Sources of information about health advice
  - Adherence to health advice
- 2005
  - Types of store-bought fish eaten in past 30 days
  - Store-bought fish consumption in past 30 days

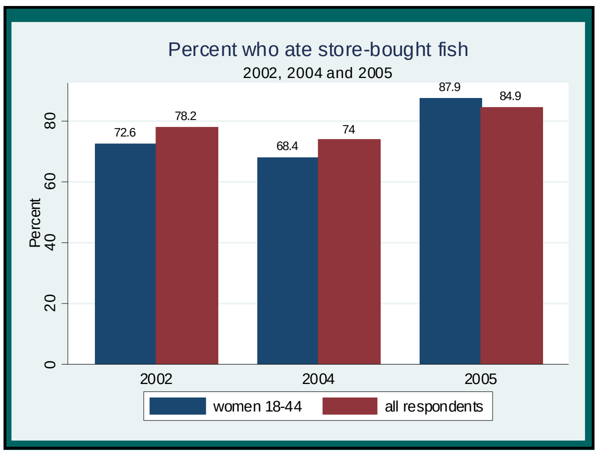
## BRFSS Results (2004) Consumption of different types of fish

| | % who ate fish in past 30 days (all participants) (95% CI) | Mean times per month (consumers) (95% CI) |
|---|---|---|
| **Any fish** | **87.6% (86.6-88.7)** | **6.46 (6.25-6.66)** |
| **Store-bought fish** | **74.0% (72.6-75.3)** | **4.56 (4.41-4.71)** |
| **Sport-caught fish** | **16.8% (15.6-17.9)** | **2.88 (2.48-3.27)** |
| **Canned tuna** | **56.5% (55.0-58.0)** | **3.27 (3.08-3.45)** |
| **All 3 fish types** | **7.6% (6.8-8.4)** | **10.08 (9.32-10.83)** |

## BRFSS Results (2002 and 2004) Consumption of canned tuna

| | 2002 (N=4756) | | 2004 (N=6378) | |
|---|---|---|---|---|
| | % ate any canned tuna (95% CI) | Mean times ate canned tuna (95% CI) (consumers) | % ate any canned tuna in past 30 days (95% CI) | Mean times ate canned tuna in past 30 days (95% CI) (consumers) |
| All adults | 84.2% (82.9-85.5) | 3.15 (2.94-3.37) | 56.6% (55.0-58.0) | 3.27 (3.08 -3.45) |
| Men | 85.3% (83.4-87.1) | 3.48 (3.09-3.87) | 54.1% (51.8-56.5) | 3.22 (2.89-3.57) |
| Women | 83.2% (81.5-84.9) | 2.84 (2.65-3.02) | 58.8% (56.9-60.7) | 3.30 (3.11-3.72) |
| Women (18-44) | 80.0% (77.2-82.8) | 3.14 (2.81-3.47) | 55.1% (52.2-58.1) | 3.42 (3.11-3.72) |
| Pregnant women | 75.8% (63.6-88.1) | 2.12 (1.37-2.87) | 37.1% (23.6-50.6) | 2.55 (1.42-3.67) |





## BRFSS Results (2002 and 2004) Awareness of advice for fish

| | 2002 (N=4698) % read, seen or heard of any official advice about eating fish. (95% CI) | 2004 (N=6403) % who read, saw or heard advice about fish and mercury in past 12 months (95% CI) |
|---|---|---|
| All adults (N = 6403) | 29.0% (27.5-30.5) | 57.6% (56.1-59.2) |
| Men (N =2560) | 30.1% (27.7-32.4) | 54.4% (52.1-56.8) |
| Women (N =3843) | 27.9% (26.0-29.8) | 60.8% (58.9-62.7) |
| Women (18-44 yrs) (N =1582) | 24.8% (22.0-27.6) | 60.0% (50.0-55.9) |
| Pregnant women (N =60 ) | 19.4% (9.3-29.5) | 61.4% (47.5-75.2) |

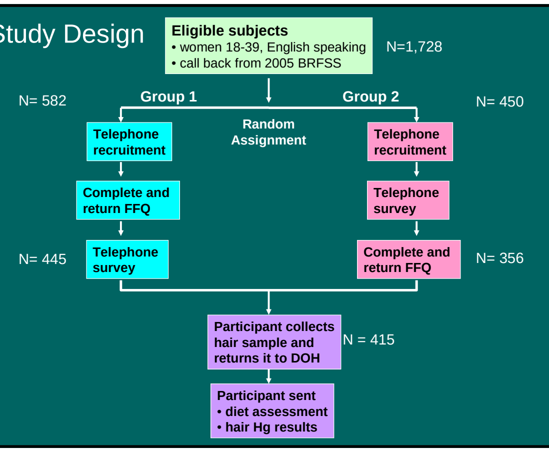
## Women's Diet Survey (WDS)

- Specific Aim: To validate existing BRFSS telephone survey questions on fish consumption.
  - Accurate dietary information is difficult to collect
  - Validity assessed by comparison to a "gold standard"
- Secondary Aim
  - to gather more information to estimate mercury exposures among women ages 18-40 years in Washington

## WDS Methods

- Recruited 800 women ages 18-40 over the phone
  - Had participated in the WA BRFSS
  - agreed to be called back for other health surveys
- English speaking only
- Collected fish consumption information:
  - via a telephone survey, and
  - self-administered food frequency questionnaire (mailed)
- Requested hair sample for mercury analysis
  - Hair questionnaire collected information on hair treatments, amalgam fillings, and workplace

## Study Design




## Food Frequency Questionnaire (FFQ)

- Food intake was collected using an FFQ developed by the Nutrition Assessment Shared Resource of Fred Hutchinson Cancer Research Center
- The self-administered FFQ booklet asks participants to report the frequency of consumption and portion size of approximately 120 line items over a defined period of time (the last month)
- FFQ developed and validated by the Fred Hutchinson Cancer Research Center for use in their epidemiological studies of diet and health


## Participation

- 1742 eligible women
- 1034 women recruited (59%)
- 801 women completed both telephone and diet questionnaire (78%)
- 415 women provided hair samples (52%)
- 22 (5.3%) women with hair samples ≥1 ppm Hg

## Types of fish eaten past 30 days

| | FFQ | Telephone | Sens. | Spec | PPV |
|---|---|---|---|---|---|
| Store-bought | 59.3% (55.8-62.7) | 59.9% (56.6-63.2) | 83.9 | 71.8 | 81.3 |
| Canned tuna | 68.3% (65.1-71.6) | 61.9% (58.7-65.2) | 93.5 | 87.1 | 93.5 |
| Sport-caught | 19.9% (17.1-22.6) | 15.6% (13.2-18.1) | 61.5 | 95.9 | 78.5 |

## Store-bought fresh fish consumed (past 30 days)

| | FFQ | Telephone |
|---|---|---|
| Salmon | 54% | 54% |
| Halibut | 20% | 20% |
| Cod | 15% | 18% |
| Tilapia | 11% | 8% |
| Tuna steaks | 7% | 5% |
| Sole | 4% | 3% |
| Red snapper | 3% | 2% |
| Catfish | 3% | 3% |

## Canned tuna consumed (past 30 days)

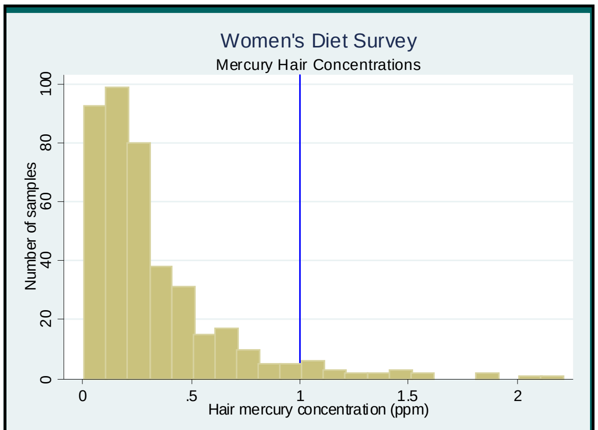
| | FFQ | Telephone |
|---|---|---|
| Albacore (White) | 44.2% (40.0-48.3) | 45.1% (40.8-49.3) |
| Light | 38.9% (34.8-43.0) | 29.1% (25.2-32.9) |
| No particular kind | 14.4% (11.5-17.4) | 24.6% (20.9-28.2) |
| Don't know | 3.6% (2.1 – 5.2) | 1.3% (0.3-2.3) |

## Frequency of consumption (past 30 days)

| | Store-bought | | Canned Tuna | | Sport caught | |
|---|---|---|---|---|---|---|
| Meals/mo | Tel | FFQ | Tel | FFQ | Tel | FFQ |
| None | 41.3 | 40.0 | 32.7 | 38.1 | 83.9 | 84.5 |
| 1 to <2 | 24.7 | 16.2 | 22.2 | 26.1 | 9.4 | 8.1 |
| 2 to <4 | 19.5 | 22.7 | 29.5 | 25.5 | 5.1 | 4.9 |
| 4 to < 8 | 9.7 | 15.0 | 9.5 | 6.7 | 0.8 | 2.1 |
| >=8 | 4.7 | 6.0 | 6.1 | 3.7 | 0.9 | 0.5 |

## Frequency of consumption among consumers

| Type of fish | Mean meals per 30 days | | Pearson correlation coefficient |
|---|---|---|---|
| | FFQ | Telephone | |
| Store-bought | 3.4 (3.2, 3.6) | 2.9 (2.7, 3.2) | 0.58 |
| Canned tuna | 2.8 (2.3, 3.4) | 3.0 (2.7, 3.3) | 0.34 |
| Sport-caught | 2.4 (1.8, 3.0) | 2.0 (1.7, 2.3) | 0.55 |



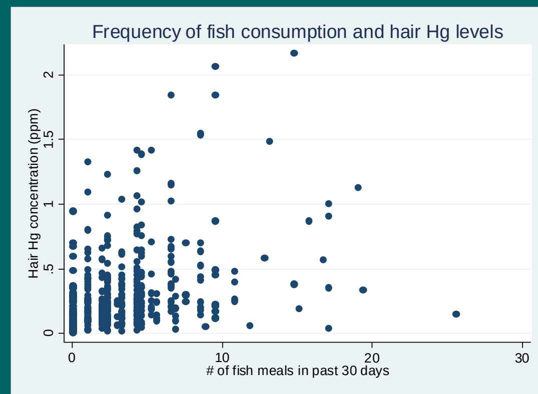

## Hair Sample Respondents/non-respondents

| | Provided hair sample | |
|---|---|---|
| | Yes | No |
| Mean age | 31 | 33 |
| % white | 94% | 87% |
| % < $50,000 income | 48% | 54% |
| % <= HS education | 24% | 31% |
| Mean fish intake | 1.7 | 1.7 |
| Ate fresh fish | 61% | 57% |

## Hair Mercury Results

| | Mean hair Hg concentration (ppm) | % ≥ 1 ppm |
|---|---|---|
| No colors hair | 0.32 (N=157) | 4.7 |
| Yes colors hair | 0.33 (N=246) | 6.0 |
| No perm hair | 0.34 (N=356) | 6.3 |
| Yes perm hair | 0.20* (p=0.002) (N=48) | 0 |
| No work with Hg | 0.33 (N=398) | 5.6 |
| Yes work with Hg | 0.20 (N=5) | 0 |
| No silver fillings | 0.37 (N=107) | 9.2 |
| Yes silver filling | 0.31 (N=282) | 4.4 |
| No amalgams removed | 0.32 (N=359) | 5.3 |
| Yes amalgams removed | 0.36 (N=37) | 8.8 |
| All participants | 0.33 (N=415) | 5.3 |

(Missing questionnaires for 10 hair samples)




## Limitations of WDS

- Lack of perfect match up in timing of telephone and FFQ
- Participation rate low for hair sampling (50%)
- Conducted during fall-spring; less sport fishing and fresh fish consumption?

## Main Conclusions

- Very close overall estimates of proportion of women eating different kinds of fish.
- Good agreement for eating store-bought and sport-caught fish; lower agreement for canned tuna
- Poorer agreement on type of canned tuna; telephone respondents more likely to report ‘no particular kind’; fewer report eating ‘light’ tuna

## Main Conclusions (cont.)

- Lower percentage of women with hair hg > 1 ppm than reported for US or other states
- Lower hair mercury levels among women who reported perming their hair
- Species of fish consumed associated with hair Hg levels; reported frequency not associated.
  - Knowing species consumed may be good indicator of high exposure

## Use of Results/Next Steps

- Use information about main types of fish eaten to fine tune consumer information
- Follow-up with some sushi sampling

## Acknowledgements

- Study participants
- DOH
  - Katrina Wynkoop Simmons, Erin Wallace, Marnie Boardman
- Fred Hutchinson Cancer Research Center, NASR
  - Judi Standley, Eric Meier
- Gilmore Research Group
  - Laurie Burke, Karen Schmit, Amity May
- Frontier Geosciences Lab
  - Frank Colich
- Environmental Quality Institute
  - Richard Maas
- Brad Grimsted

*Funding for this work comes, in part, from CDC's National Environmental Public Health Tracking Program, Grant # U38/EH000179-01*

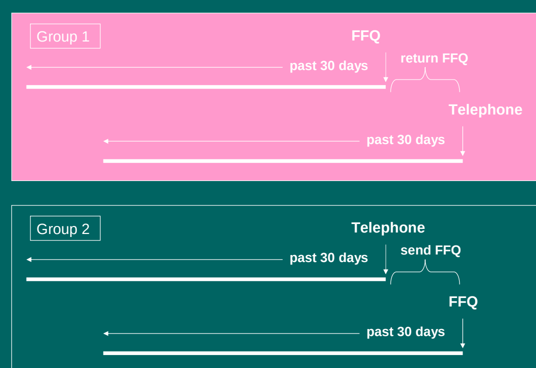
Extra background slides follow, if needed

## Type of fish and hair Hg levels (ppm); linear regression results

| | Parameter estimate | 95% CI |
|---|---|---|
| **Halibut** | **0.16** | **(.06 - .25)** |
| **Sole** | **0.24** | **(.08 - .39)** |
| **Tuna steak** | **0.51** | **(.36 - .66)** |
| **Canned albacore** | **0.14** | **(.07 - .20)** |
| **Constant** | **0.23** | **(.20 - .27)** |

P <0.01 for all; Adj. r-square = 0.24

## Timing of Telephone and FFQ




## Laboratory Method for Hair Mercury Analysis

- The method based on EPA 1631E
- Mercury determination by cold vapor atomic fluorescence spectrometry (CV-AFS) – SOP FGS-069
- Method detection limit: 0.075ng/g.

## BRFSS Fish Consumption Questions 2002

1. How often do you eat canned tuna?
2. When you eat canned tuna, about how much of a standard 6 oz. can do you usually eat per sitting?
3. Not including canned tuna and shellfish such as crab, clams, and shrimp; how often do you eat store bought fish either fresh or frozen including fish items such as fish sticks?

## BRFSS Fish Consumption Questions 2002

4. How often does child (in household under 5 years old) eat canned tuna?
5. When this child eats canned tuna, about how much of a standard 6 oz. can do they usually eat per sitting?
6. Not including canned tuna and shellfish such as crab, clams, and shrimp; how often does this child eat store-bought fish?
7. Have you read, seen or heard of any official advice about eating sport-caught or store-bought fish?

## BRFSS Fish Consumption Questions 2004

1. I'm going to read you a statement about eating fish and I would like you to tell me if you agree or disagree with the statement. Fish are healthy to eat. Do you agree or disagree?
2. In the past 12 months, have you eaten any sport-caught fish from the waters of Washington State?
3. In the past 30 days, how often did you eat sport-caught fish from Washington State waters?
4. Not including canned tuna or shellfish such as crab, clams, and shrimp; in the past 30 days, how often did you eat either fresh or frozen store bought fish, including fish items such as fish sticks?

## BRFSS Fish Consumption Questions 2004

5. In the past 30 days, how often did you eat canned tuna?
6. What kind of canned tuna do you usually eat? Is it..
   - **Albacore tuna, also called solid WHITE or chunk WHITE**
   - **LIGHT tuna, such as solid LIGHT or chunk LIGHT**
   - **No one particular kind**
   - **Don't know**
7. In the past 12 months, have you read, seen, or heard any health advice that recommends limiting the amount of fish you eat because of mercury contamination?
8. In the past 12 months, how much have you read or heard about limiting the amount of fish you eat because of mercury contamination? On a scale of 1 to 7, where 1 means "you've heard nothing at all" and 7 means "you've heard a lot", how much would you say you've heard or read about fish contaminated with mercury?
9. And, where did you learn about this advice?

## BRFSS Fish Consumption Questions 2005

1. Next, I have some questions about eating fish that was purchased at a GROCERY STORE or FISH MARKET. Not counting shellfish, please tell me all the types of FRESH FISH you ate in the past 30 days.
2. In the past 30 days, how many times have you eaten FRESH FISH that was purchased at a GROCERY STORE or FISH MARKET? This includes frozen fish such as fish sticks or frozen fillets.

## BRFSS Results (2002) Awareness of fish advisories

| | % read, seen or heard of any official advice about eating fish. (95% CI) |
|---|---|
| All adults (N=4698) | 29.0% (27.5-30.5) |
| Men (N=1892) | 30.1% (27.7-32.4) |
| Women (N=2806) | 27.9% (26.0-29.8) |
| Women (18-44 years) (N=1251) | 24.8% (22.0-27.6) |
| Pregnant women (N=60) | 19.4% (9.3-29.5) |

## BRFSS Results (2004) Consumption of store-bought fish

| | % ate any store bought fish in past 30 days (95% CI) | Mean times ate store bought fish in past 30 days (95% CI) (consumers) |
|---|---|---|
| All adults (N = 6347) | 74.0% (72.6-75.3) | 4.56 (4.4-4.7) |
| Men (N =2540) | 75.7% (73.7-77.8) | 4.55 (4.4-4.8) |
| Women (N =3807) | 72.3% (70.5-74.0) | 4.56 (4.32-4.80) |
| Women (18-44 yrs) (N =1573) | 68.4% (65.7-71.2) | 4.33 (4.0-4.67) |
| Pregnant women (N =59 ) | 68.8% (55.2-82.4) | 2.94 (2.27-3.62) |

### BRFSS Results (2002)
### Consumption of canned tuna

| | % ate any canned tuna (95% CI) | Mean times per month (95% CI) (consumers) | Mean ounces per month (95% CI) (consumers) |
|---|---|---|---|
| All adults (N=4756) | 84.2% (82.9-85.5) | 3.15 (2.94-3.37) | 2.93 (2.87-2.99) |
| Men (N=1875) | 85.3% (83.4-87.1) | 3.48 (3.09-3.87) | 3.33 (3.22-3.42) |
| Women (N=2778) | 83.2% (81.5-84.9) | 2.84 (2.65-3.02) | 2.55 (2.49-2.61) |
| Women (18-44 years) (N=1245) | 80.0% (77.2-82.8) | 3.14 (2.81-3.47) | 2.63 (2.54-2.72) |
| Pregnant women (N= 60) | 75.8% (63.6-88.1) | 2.12 (1.37-2.87) | 2.65 (2.28-3.02) |
| Children (1-4 years) (N=633) | 49.9% (45.4-54.5) | 3.24 (2.71-3.78) | 1.53 (1.43-1.63) |

### BRFSS Results (2004)
### Consumption of canned tuna in past 30 days

| | % ate any canned tuna in past 30 days (95% CI) | Mean times ate canned tuna in past 30 days (95% CI) (consumers) |
|---|---|---|
| All adults (N = 6378) | 56.6% (55.0-58.0) | 3.27 (3.08 -3.45) |
| Men (N =2547) | 54.1% (51.8-56.5) | 3.22 (2.89-3.57) |
| Women (N =3831) | 58.8% (56.9-60.7) | 3.30 (3.11-3.72) |
| Women (18-44 years) (N =1578) | 55.1% (52.2-58.1) | 3.42 (3.11-3.72) |
| Pregnant women (N = 60) | 37.1% (23.6-50.6) | 2.55 (1.42-3.67) |

### BRFSS Results (2002)
### Consumption of store-bought fish

| | % ate any store-bought fish in past month (95% CI) | Mean times per month (95% CI) (consumers) |
|---|---|---|
| All adults (N=4647 ) | 78.2% (76.8-79.7) | 3.34 (3.18-3.51) |
| Men (N=1875) | 79.5% (77.2-81.7) | 3.26 (3.05-3.47) |
| Women (N=2772 ) | 77.0% (75.1-79.0) | 3.43 (3.17-3.69) |
| Women (18-44 years) (N=1246) | 72.6% (69.6-75.7) | 3.11 (2.70-3.53) |
| Pregnant women (N= 59) | 67.5% (54.4-80.6) | 6.73 (-0.48-13.95) |
| Children (1-4 years) (N=632) | 62.1% (57.6-66.6) | 3.71 (2.94-4.48) |

### BRFSS Results (2004 and 2005)
### Consumption of store-bought fish

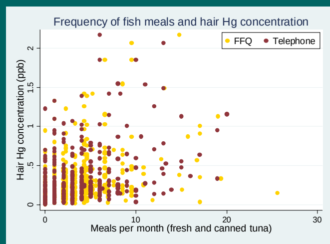
| | 2004 (N=6347) | | 2005 (N=4471) | |
|---|---|---|---|---|
| | % ate any store bought fish in past 30 days (95% CI) | Mean times ate store bought fish in past 30 days (95% CI) (consumers) | % ate any store bought fish in past 30 days (95% CI) | Mean times ate store bought fish in past 30 days (95% CI) (consumers) |
| All adults | 74.0% (72.6-75.3) | 4.56 (4.4-4.7) | 84.9% (83.6-86.2) | 3.85 (3.72-3.97) |
| Men | 75.7% (73.7-77.8) | 4.55 (4.4-4.8) | 83.6% (81.4-85.7) | 3.72 (3.54-3.91) |
| Women | 72.3% (70.5-74.0) | 4.56 (4.32-4.80) | 86.3% (84.7-87.8) | 3.96 (3.79-4.14) |
| Women (18-44) | 68.4% (65.7-71.2) | 4.33 (4.0-4.67) | 87.9% (85.3-90.4) | 3.39 (3.13-3.64) |
| Pregnant women | 68.8% (55.2-82.4) | 2.94 (2.27-3.62) | 87.1% (72.8-100) | 3.58 (2.62-4.54) |

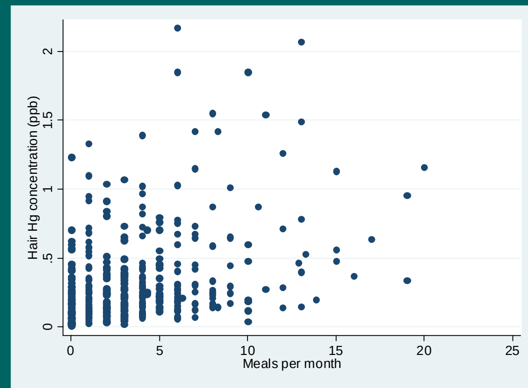
### BRFSS Results (2005)
### Types of store-bought fresh fish eaten in past 30 days

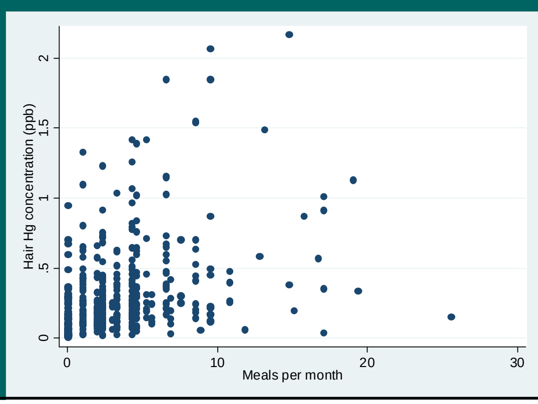
| % identifying type of fish (95% CI) | All adults | Men | Women | Women (18-44 yrs) |
|---|---|---|---|---|
| Salmon | | | | |
| Halibut | | | | |
| Rockfish | | | | |
| Sole | | | | |
| Trout | | | | |
| Cod | | | | |
| Snapper | | | | |
| Ball | | | | |
| Whitefish | | | | |
| Mahi Mahi | | | | |
| Tilapia | | | | |

### Percent reporting sources of fish advice (2004)

| Source of advice | All adults | Men | Women | Women (18-44) |
|---|---|---|---|---|
| Newspaper | 43.6% (41.8-45.3) | 46.5% (43.7-49.3) | 40.9% (38.7-43.1) | 30.8% (27.5-34.0) |
| TV | 50.6% (48.8-52.3) | 47.3% (44.6-50.1) | 53.5% (51.3-55.7) | 48.0% (44.3-51.6) |
| Radio | 13.0% (11.8-14.2) | 15.1% (13.1-17.2) | 11.1% (9.7-12.5) | 10.1% (8.1-12.2) |
| Magazines | 17.7% (16.3-19.0) | 13.7% (11.8-15.6) | 21.3% (19.5-23.1) | 22.0% (19.1-25.0) |
| Friend/family | 9.2% (8.2-10.3) | 8.1% (6.5-9.7) | 10.3% (8.9-11.7) | 14.1% (11.6-16.5) |
| Internet | 7.2% (6.3-8.1) | 8.5% (7.0-10.1) | 6.0% (5.0-7.1) | 8.3% (6.5-10.2) |
| Brochures or flyers | 2.4% (1.8-3.0) | 2.3% (1.4-3.1) | 2.5% (1.6-3.3) | 3.1% (1.5-4.8) |
| Health care provider | 2.0% (1.6-2.6) | 0.7% (0.2-1.3) | 3.3% (2.5-4.1) | 6.5% (4.8-8.3) |
| Other | 3.2% (2.6-4.0) | 2.5% (1.6-3.4) | 3.9% (2.9-5.0) | 6.6% (4.5-8.6) |
| Fish licenses | <1% | 1.2% | <1% | <1% |




## BRFSS Results (2004)
## Types of canned tuna usually eaten

| | % eating different kinds (95% CI) | | | |
|---|---|---|---|---|
| | Albacore | Light | No particular kind | Don't know |
| All adults (N = 3674) | 48.0% (46.0-50.0) | 22.4% (20.7-24.1) | 25.9% (24.1-27.6) | 3.7% (2.9-4.4) |
| Men (N =1392) | 42.1% (38.9-45.2) | 23.1% (20.3-26.0) | 30.2% (27.2-33.2) | 4.5% (3.2-5.8) |
| Women (N =2282) | 53.3% (50.9-55.8) | 21.7% (19.7-23.6) | 22.0% (20.0-24.0) | 2.9% (2.1-3.7) |
| Women (18-44 yrs) (N =878) | 45.4% (41.5-49.3) | 25.1% (21.8-28.4) | 26.6% (23.2-30.0) | 2.7% (1.5-3.8) |
| Pregnant women (N =25) | 40.2% (18.9-61.6) | 24.9% (5.0-44.7) | 31.4% (12.2-50.7) | 3.4% (-3.3-10.1) |

## BRFSS Results (2004)
## Consumption of sport fish

| | % ate any sport fish in past 12 months (95% CI) | % ate any sport fish in past 30 days (95% CI) | Mean times ate sport fish in past 30 days (95% CI) (consumers) |
|---|---|---|---|
| All adults (N = 6409) | 34.9% (33.5-36.3) | 16.5% (15.4-17.6) | 2.88 (2.5-3.3) |
| Men (N = 2561) | 38.6% (36.3-40.9) | 19.2% (17.4-21.0) | 3.32 (2.65-4.0) |
| Women (N = 3848) | 31.3% (29.6-33.0) | 13.8% (12.5-15.1) | 2.28 (2.1-2.51) |
| Women (18-44 years) (N = 1584) | 29.7% (27.1-32.3) | 12.4% (10.5-14.3) | 2.16 (1.76-2.56) |
| Pregnant women (N = 60) | 21.2% (10.3-32.1) | 10.8% (2.2-19.5) | NA |

## Questions and Answers

*Q. Data suggest that fish consumption has decreased 50% since the last survey. Are you concerned? (Ralston)*

A. The questions in the 2002 and 2004 surveys were slightly different, so the survey data may not be directly comparable across survey years.

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# Increased Levels of Mercury Associated with High Fish Intake among Children of Different Ethnic Groups from Vancouver

*Sheila Innis, University of British Columbia*

## Biosketch

Dr. Sheila Innis is a Professor in the Department of Pediatrics and Director of the Nutrition and Metabolism Research Program at the Child and Family Research Institute, Oak Street campus, University of British Columbia. The nutrition and metabolism research program is one of the major research programs at the Child and Family Research Institute and was established in 2003 with the award of $5.5 million in funding from the Canadian Foundation for Innovation and from Provincial funding to establish a program of research, training, and education addressing the biological basis for how dietary components promote health during early development. Dr. Innis has been a faculty member at the University of British Columbia since 1983. Her research program spans basic research and preclinical and clinical studies, as well as community-based studies in infants, children, and pregnant women, and it ranges from physiological measures to studies on the effects of dietary components on measures of growth and development, as well as gene expression, proteins targets and metabolite profiles, and later consequences through epigenetic mechanisms.

Dr. Innis is currently involved in clinical studies focusing on omega-3 and omega-6 fatty acids and methyl donors, and she has considerable experience in preclinical and clinical trials, as well as community studies.

Dr. Innis has attracted more than $25 million in research funding over 20 years of scholarly activities, has given more than 300 invited presentations world wide at major national and international functions on numerous topics related to children's diet and health, and has organized and chaired many such events. Her record of peer-reviewed original communications exceeds 180. She is also recognized for her participation in expert panels establishing dietary recommendations, in national and provincial task forces addressing diet and health, and in working with regulatory authorities in Canada and the United States.

## Abstract

Fish and other seafoods are important dietary sources of omega-3 fatty acids, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), but they may be contaminated with mercury (Hg). Information is limited on Hg exposure among children in population subgroups whose traditional dietary practices include fish. In a population-based study in 2003–2004, we determined blood Hg and red blood cell phosphatidylethanolamine (RBC PE) omega-3 eicosapentaenoic acid (EPA) as a marker of fish intake and assessed indices of childhood behavior in preschool children 1.5–5 years of age (n=228) living in an ethnically diverse neighborhood in the inner city of Vancouver, British Columbia, Canada. The median blood Hg was 4.6 ηmol/L, range 0–67.9 ηmol/L. Twelve, or 6%, Chinese children had a blood Hg>28.9 ηmol/L. Blood Hg, total fish intake, and eicosapentaenoic acid were higher among Chinese than Caucasian children; however, higher fish intake did not predict blood Hg, showing that fish can be safely consumed without increasing risk of Hg exposure. Blood Hg was inversely associated with attentional focusing in children older than 3 years after adjusting for some confounding family variables, iron deficiency anemia and zinc deficiency. Major sources of fish among Chinese children were imported white fish, not local fish, which have very low levels of Hg. Cases of Hg toxicity are incidentally identified at our institution during routine blood work for children referred for developmental delays. In most cases, the children were of Asian background, with a high dietary intake of imported white fish. New guidelines are being developed provincially to more useful directives to maintain or improve the intake of omega-3 fatty acids while reducing risk of Hg exposure.

## Increased levels of mercury associated with high fish intakes among children of different ethnic groups in Vancouver, Canada

**Sheila M. Innis**

*Department of Pediatrics, Faculty of Medicine*

*Nutrition Research Program, Child & Family Research Institute*

*University of British Columbia*

Vancouver, Canada

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- a primer on British Columbia
- mercury levels in preschool children
- pregnant women & cord blood
- clinical experience with high mercury at B.C. Children's Hospital

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*Coastal community, population 2.1 million, B.C. population 4.1 million*


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*Vancouver .. Multi ethnic, City of Vancouver*

*Greater Vancouver*

City of Vancouver:
China Town

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***Greater Vancouver: multiple ethnic neighborhoods***


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| | B.C. | | Canada | |
|---|---|---|---|---|
| Year | Population | % growth | Population | % growth |
| 2006 | 4,113,487 | 5.3 | 31,612,897 | 5.4 |
| 2001 | 3,907,738 | 4.9 | 30,007,094 | 4.0 |
| 1996 | 3,724,500 | 13.5 | 28,846,761 | 5.7 |
| 1991 | 3,282,061 | 13.8 | 27,296,859 | 7.9 |
| 1986 | 2,883,367 | 5.1 | 25,309,331 | 4.0 |
| 1981 | 2,744,467 | 11.3 | 24,343,181 | 5.9 |
| 1976 | 2,466,608 | 12.9 | 22,992,604 | 6.6 |
| 1971 | 2,184,621 | 16.6 | 21,568,311 | 7.8 |
| 1966 | 1,873,674 | 15.0 | 20,014,880 | 9.7 |
| 1961 | 1,629,082 | 16.5 | 18,238,247 | 13.4 |
| 1956 | 1,398,464 | 20.0 | 16,080,791 | 14.8 |
| 1951 | 1,165,210 | 42.5 | 14,009,429 | 21.8 |
| 1941 | 817,861 | 17.8 | 11,506,655 | 10.9 |
| 1931 | 694,263 | 32.3 | 10,376,786 | 18.1 |
| 1921 | 524,582 | 33.7 | 8,787,949 | 21.9 |
| 1911 | 392,480 | 119.7 | 7,206,643 | 34.2 |
| 1901 | 178,657 | 82.0 | 5,371,315 | 11.1 |
| 1891 | 98,173 | 98.5 | 4,833,239 | 11.8 |
| 1881 | 49,459 | 36.4 | 4,324,810 | 17.2 |
| 1871 | 36,247 | | 3,689,257 | |

B.C. 1986–2006: 42% in 20 yr; Canada 1986–2006: 25% in 20 yr

Source: Statistics Canada

*B.C. represents 13% of Canadian population*

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B.C. Immigration by Area of Last Permanent Residence
January to December, 2006
Total Landings: 42,208 Persons

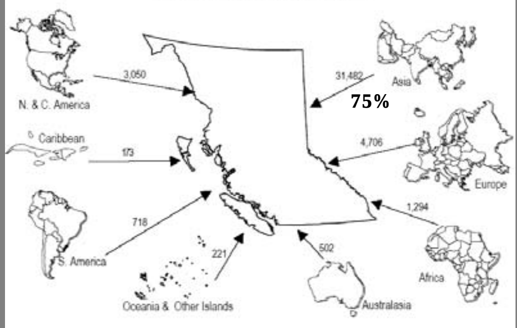


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Table 1: Immigrant Landings to B.C. and Canada - January to December, 2006

| SOURCE | Vancouver Area | Rest of B.C. * | Total B.C. | Canada | B.C. as a % of Canada |
|---|---|---|---|---|---|
| Europe | 3,500 | 1,206 | 4,706 | 37,244 | 12.6% |
| Africa | 952 | 342 | 1,294 | 26,642 | 4.9% |
| Asia | 28,561 | 2,921 | 31,482 | 149,407 | 21.1% |
| China-Mainland | 10,302 | 644 | 10,946 | 33,062 | 33.1% |
| India | 5,062 | 917 | 5,979 | 30,745 | 19.4% |
| Taiwan | 1,778 | 142 | 1,920 | 2,823 | 68.0% |
| Hong Kong | 540 | 55 | 595 | 1,488 | 40.0% |
| Australasia | 355 | 147 | 502 | 1,329 | 37.8% |
| N & C America | 2,116 | 934 | 3,050 | 15,071 | 20.2% |
| U.S.A. | 1,617 | 826 | 2,443 | 10,931 | 22.3% |
| Caribbean | 127 | 46 | 173 | 6,738 | 2.6% |
| South America | 578 | 140 | 718 | 13,424 | 5.3% |
| Oceania | 196 | 25 | 221 | 863 | 25.6% |
| Not Stated | 57 | 5 | 62 | 793 | 7.8% |
| **All Areas** | **36,442** | **5,766** | **42,208** | **251,511** | **16.8%** |

** "Rest of B.C." also includes immigrants with unknown destination. Many might have been destined for Vancouver Area.*

*Source: BC STATS, Date: June, 2007*

*Data Provided By: Citizenship and Immigration Canada*

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***ecologic study of blood mercury in children 1.5-5 years, n=201; 2003-2004***

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## *Health Canada Advisory & Guidelines 2001*

- Advise Canadians to limit consumption of shark, swordfish and fresh and frozen tuna to one meal per week. Pregnant women, women of child bearing age and young children should eat no more than one meal per month.

- Daily Hg Intake < 0.2 ug/kg body weight /day
  Commercial fish are required to have < 0.5 ppm Hg
  - Pregnant women may eat up to 4 times / week
  - Shark, swordfish, fresh tuna have > 0.5 ppm Hg, pregnant women should not eat > 1 / month

► ***Awareness, understanding, effectiveness and relevance of the advisory in the context of a multi-ethnic population***

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***ecologic study of blood mercury in children 1.5-5 years, n=201; 2003-2004***

- Preschool children, City of Vancouver (east Vancouver)
- Nutrition clinics held at Public Health Clinics & community centres in east Vancouver, 2003& 2004
  not the university, hospital or biomedical labs
- Anthropometrics
- Dietary intake by food frequency questionnaire
  - all forms translated & back translated, then completed with bilingual nutrition/dieticians assistants
- Free dental exams, $15.00 grocery vouchers

- Venous blood
  - whole blood mercury
  - red blood cell membrane n-3 fatty acids, eicosapentaenoic acid (EPA) as a marker of fish intake

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## Blood mercury levels in Vancouver preschool children 1.5-5 yrs

EPA reference 28.9 nmol/L

| | *n* | median | range | 5th | 95th |
|---|---|---|---|---|---|
| | | | nmol/L | | |
| All children | *201* | 4.6 | 0.0-67.9 | 0.0 | 36.0 |
| Caucasian | 54 | 0.8 | 0.0-18.1 | 0.0 | 10.5 |
| Chinese | 62 | 12.1 | 1.6-67.9 | 2.27 | 47.5 |
| Other[1] | 80 | 3.6 | 0-13.1 | 0.0 | 10.4 |
| Unknown | 5 | 4.1 | 0-19.0 | | |

Other incl: South East Asian n=17, First Nations n=17, African n=11, Middle eastern n=7

EVERY child with a blood mercury > 28.9 nmol/L was of Chinese background

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| | Blood Hg ≤ 28.9 ηmol/L | | Blood Hg >28.9 ηmol/L |
|---|---|---|---|
| | Caucasian & others n= 139 | Chinese n=50 | Chinese n=12 (20%) |
| **Family income** | | | |
| **<$20,000** | **64** | **18** | **7** |
| **20-50,000** | **39** | **26** | **5** |
| **>50,000** | **25** | **4** | **0** |
| **Unknown** | **11** | **2** | **0** |
| **Maternal education** | | | |
| **<high school** | **16** | **8** | **6** |
| **High school** | **27** | **12** | **2** |
| **College** | **38** | **8** | **0** |
| **University** | **54** | **22** | **4** |
| **Unknown** | **4** | **0** | **0** |

no apparent association with income or education, limited power

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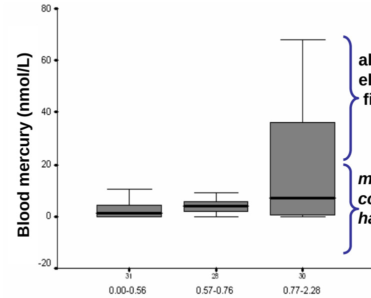
***Red blood cell membrane lipid EPA vs Hg***




**all 20 children with elevated Hg consume fish**

***most children who consume fish do not have elevated Hg***

**tertile of red cell n-3 EPA**

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**Mercury levels in Vancouver children vs other cohorts**

| | *n* | median/geo mean ug/L | range |
|---|---|---|---|
| Vancouver, all children | *201* | 0.92 | 0 -13.1 |
| Chinese | *62* | 2.42 | 0.32-13.1 |
| Caucasian | 54 | 0.16 | 0 -3.62 |
| | | | *95th cent* 2.10 |
| NHANES, US, white 1-5y | 173 | 0.27 | *95th cent* 1.58 |
| Nunavik, cord blood, | *95* | 18.5 | 2.8-97.0 |
| maternal blood | *130* | 10.4 | 2.6-44.2 |
| Southern Quebec, cord blood | *1,108* | 1.0 | 0.9-1.0 |
| Greenland, Disko Bay, cord blood | *178* | 25.3 | 2.4-181 |
| maternal blood | *180* | 12.8 | 1.9-76 |
| Faroe Islands, cord blood 1st cohort | *894* | 22.9 | *nr* |
| 2nd cohort | *163* | 20.4 | 1.9-102 |

EPA reference 5.8 ug/L

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**High Mercury Exposure Through Excessive Seafood Consumption: A Concern for our Asian Community?**

**Clinical Experience at the B.C. Children's Hospital**

Andre Mattman, Ray Copes, Sheila Innis, Gillian Lockitch,

## Hg levels > 100 nmol/L in 2005

- Review of Clinical Requests for Whole Blood Heavy Metal Testing in adults for 2005
  - *n* = 850 Hg tests / year (plus Pb tests)
- Patients with a Hg level > 100 nmol/L, *n*=15

  Reference Dose = 29 nmol/L

  Level associated with adverse effect = 290 nmol/

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| | Age | Gender | Ethnicity | Mercury (nmol/L) | Source | Symptoms |
|---|---|---|---|---|---|---|
| 1a | 49 | M | Chinese | 261 | Seafood | *2 / 4 family* |
| 1b | 51 | F | Chinese | 199 | Seafood | *members on Neurontin* |
| 1c | 43 | M | Chinese | 121 | Seafood | *for sensory* |
| 1d | 56 | M | Chinese | 120 | Seafood | *paresthesia* |
| 5 | 55 | M | Chinese | 115 | | |
| 6 | 36 | F | Caucasian | 208 | Seafood | Malaise, fatigue |
| 7 | 53 | F | Chinese | 140 | Industrial | None |
| 8 | 71 | M | Caucasian | 108 | Industrial | Chelation Therapy |
| 9 | 34 | F | Caucasian | 204 | seafood | |
| 10 | 75 | F | Chinese | 319 | Seafood | Hypertension, leg paresthesia |
| 11 | 69 | M | Chinese | 154 | Seafood | None |
| 12 | 19 | F | Chinese | 129 | | |
| 13 | 59 | F | Caucasian | 105 | Unknown | Non-specific |
| 14 | 57 | F | Chinese | 101 | | |
| 15 | 21 | F | Caucasian | 100 | | |

10/15 Chinese, 8 could be linked to high seafood intakes

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Mercury levels in some fish found to be twice those allowed
The Vancouver Sun
June 1, 2007

Mercury levels in lake small-mouth bass and ocean rockfish caught on or around Vancouver Island are up to twice what Health Canada safety guidelines allow, says a senior research chair in aquatic ecology at the University of Victoria. Rockfish caught on the west coast of Vancouver Island were 40-per-cent higher than safety guidelines allow, Mazumder says, while fresh-water bass caught in lakes on Vancouver Island and Saltspring Island were as much as double the safety limit. In the rockfish samples Mazumder and his colleagues tested, .7 parts per million of mercury were present, while in the freshwater bass, it was as high as one part per million. Mazumder believes if mercury levels are this high in fresh-water bass and rockfish, the chances are good they are excessively high in other fish species as well.

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## *2005 cases*

- **Age:** Family of 4 Chinese adults
- **Diet:** regular intake of frozen black cod for > 3 years
- **Medical:** Paresthesias treated with neurontin in 2 / 4 family members
- **Mercury Testing:** Whole blood Hg ranged from 220 – 390 nmol/L (RfD < 29 nmol/L).
- **Additional:** Family read about newspaper reports of mercury toxicity from fish ingestion and asked to be tested.
- Mercury levels have returned to safe levels after cessation of black cod ingestion.

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## Pediatric Cases: #1

- **Age:** 3 year old Chinese male
- **Medical:** moderate developmental delay
- **Incidental Mercury Test** (Actually ordered a Pb level)
  - Whole Blood 400 nmol/L (RfD < 29 nmol/L)
  - Treated with Chelation therapy
- **Diet:** fish, eggs and tofu
  - fresh salmon, black cod and rock cod
  - Rock cod and black cod from the child's home were found to have high mercury levels of 0.5ppm and 1.0ppm, respectively.
- evidence seems to indicate that mercury levels are directly related to fish intake.

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## Case #2

- **Age:**2 year old Vietnamese male
- **Medical:** atypical febrile seizure age 18 months, developmental delay with respect to speech.
- **Incidental Mercury testing** (Actually ordered a Pb level)
  - Age 2 => whole blood 980 nmol/L (RfD < 29 nmol/L)
    - Started on Chelation Therapy
  - Mother => whole blood 11 nmol/L
  - Father => whole blood 39 nmol/L
- **Diet**: served fish 3 X / day since the age of 6 months.
  - The fish consisted of fresh halibut / Lingcod / Rock Cod / Sole
  - During the pregnancy, mother ate "as much fish as possible"
- **e**vidence seems to indicate that mercury levels are directly related to fish intake.

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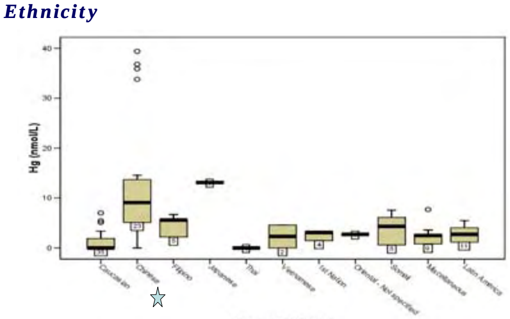
## *Whole Blood Hg in Pregnant Women by Maternal Ethnicity*




Mean Hg significantly higher than non-Chinese ethnicities (p<0.005). Lead, cadmium, copper, zinc, selenium were not different between Chinese and non-Chinese ethnicities.

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## *Vancouver Pregnancy Hg Study*

- Subjects:
  - Convenience sample: 51 mother / neonate pairs from Vancouver
    - n=15 Asian, n=36 Caucasian
- Methods:
  - Maternal whole blood, maternal hair and cord blood sampled at delivery
    - Total Hg quantitated by ICP-MS

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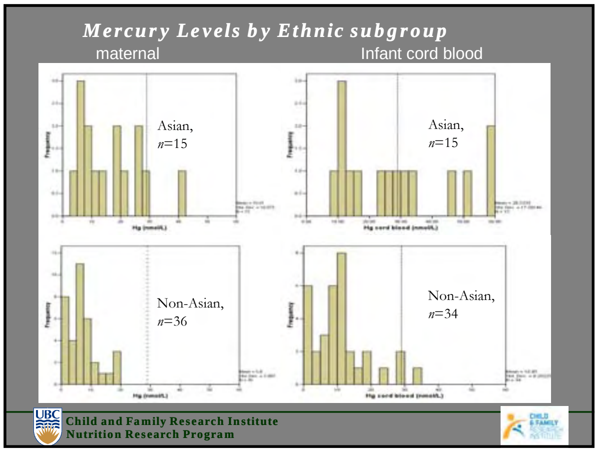
Mercury Levels by Ethnic subgroup
maternal
Infant cord blood
Asian,
n=15
Asian,
n=15
Non-Asian,
n=36
Non-Asian,
n=34
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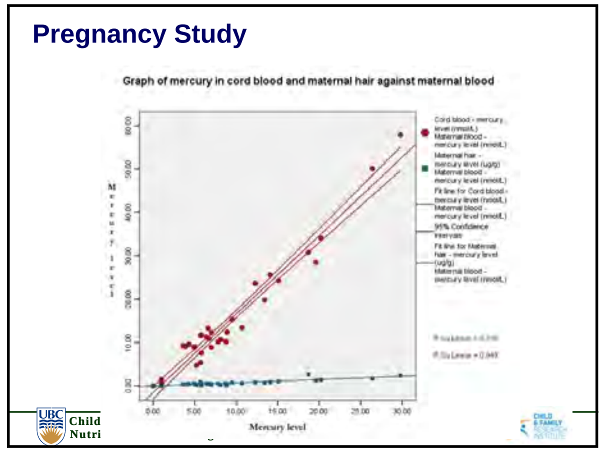
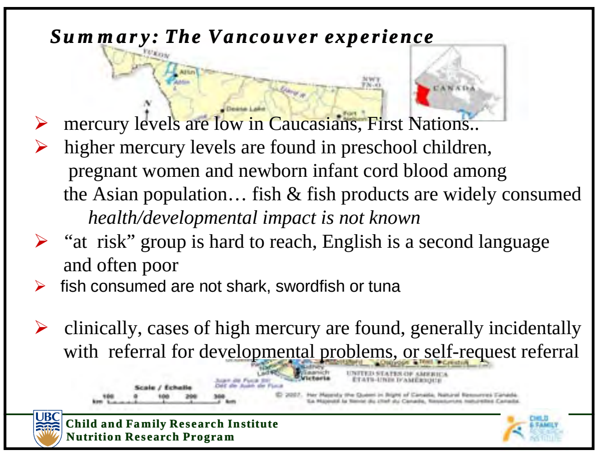

Pregnancy Study
Graph of mercury in cord blood and maternal hair against maternal blood
Mercury level
Child
Nutri


Summary: The Vancouver experience
mercury levels are low in Caucasians, First Nations..
higher mercury levels are found in preschool children, pregnant women and newborn infant cord blood among the Asian population… fish & fish products are widely consumed
health/developmental impact is not known
"at risk" group is hard to reach, English is a second language and often poor
fish consumed are not shark, swordfish or tuna
clinically, cases of high mercury are found, generally incidentally with referral for developmental problems, or self-request referral
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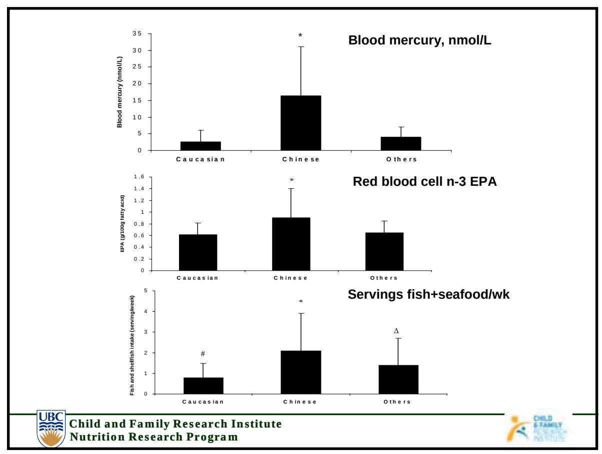
Blood mercury, nmol/L
Caucasian
Chinese
Others
Red blood cell n-3 EPA
Caucasian
Chinese
Others
Servings fish+seafood/wk
Caucasian
Chinese
Others
Child and Family Research Institute
Nutrition Research Program

# PBDE Biomonitoring of Great Lake Charter Captains

*Henry Anderson, Wisconsin Department of Health and Human Services*

## Biosketch

Dr. Henry Anderson received his M.D. degree from the University of Wisconsin Medical School in 1972. He is certified by the American Board of Preventive Medicine with a subspecialty in Occupational and Environmental Medicine and is a Fellow of the American College of Epidemiology. Dr. Anderson is Chief Medical Officer and State Environmental and Occupational Disease Epidemiologist with the Wisconsin Department of Health and Family Services. He has adjunct professor appointments in Population Health in the Wisconsin School of Medicine and Public Health and the Gaylord Nelson Institute for Environmental Studies. Over the past 25 years, he has conducted multiple research projects investigating human health hazards of consumption of Great Lakes and other sport fish and developed and evaluated the effectiveness of public health advisories.

## Abstract

Polybrominated diphenyl ethers (PBDEs) are chemicals that have been used as flame retardants in foams, fabrics, and plastics. They bioaccumulate in the environment and have been detected in Great Lakes fish in increasing concentrations. They have also been detected in a variety of foods, including commercial fish, meat, poultry, and dairy products; however, in contrast to polychlorinated biphenyls (PCBs) and dichlorodiphenyl dichloroethene (DDE), diet and specifically consumption of sport-caught fish from the Great Lakes does not appear to be the primary source of exposure in our study cohort. PBDEs are common contaminants of household dust and continue to be present in a wide variety of consumer products. Preliminary analyses of 478 participants show that lipid-adjusted serum PBDE levels are positively associated (high versus low PBDE groups and for PBDE as a continuous variable) with the following factors: age, obesity, income less than $45,000 USD/year, water bed use, hours spent outdoors, DDE and PCB levels, years of sportfish consumption, and shellfish meals per year.

## PBDE Monitoring of Great Lakes Charter Captains

Findings from a US Cohort of Frequent and Infrequent Consumers of Sport-caught Fish

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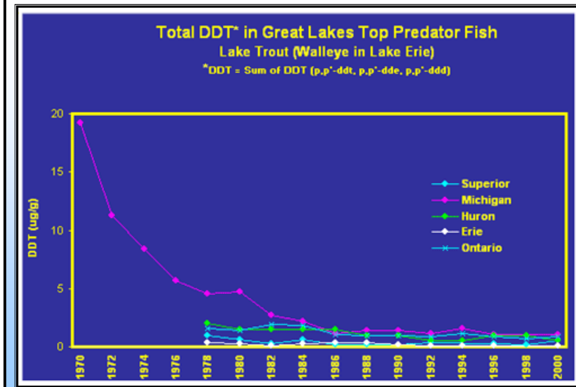
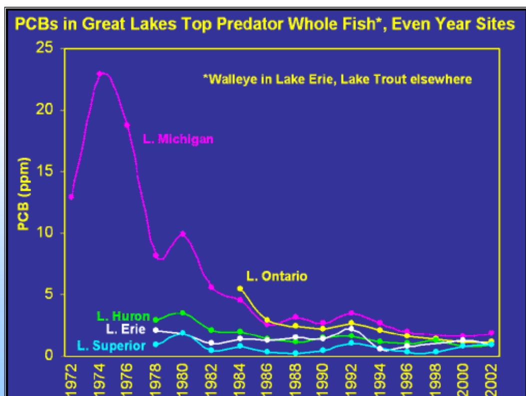
Madison, WI
John Mathew and Carol Buelow
Wisconsin State Laboratory of Hygiene, Madison, WI
Mary Turyk and Victoria Persky
University of Illinois at Chicago, IL
Robert Chatterton, Jr, Peter Koop and Yu-cai Lu
Northwestern University

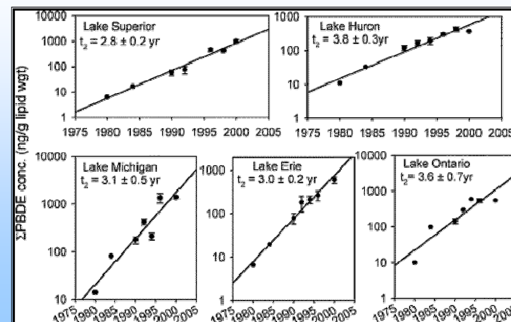



USEPA




USEPA

## PBDEs in Great Lakes Fish




Zhu LY, Hites RA., *Environ Sci Technol*, **38(10)**, 2779-2784 (2004)

GREAT LAKES FISH CONSUMPTION STUDY

## 1992 – Current

3,895 frequent and infrequent Great Lakes fish consumers

## Goals of the Study

Characterize fish consumption and endocrine system status using self-administered questionnaires.

Assess association between PCB, DDE and PBDE serum concentrations and endocrine health status by analysis of blood and urine specimens and survey responses to health status questions.

## Study Methods

**Volunteers were recruited from a cohort of 3,865 frequent and infrequent consumers of Great Lakes fish and 1,788 completed a survey on health conditions and fish consumption.**

**Blood and urine samples and surveys on fish consumption, diet and lifestyle were collected from 478 participants.**

**Serum was analyzed for 9 PBDE congeners, 30 PCB congeners, DDE, lipids, hormones, and hemoglobin A1c.**

**Urine analyzed for iodide and thyroid hormone metabolites.**

## Statistical Methods

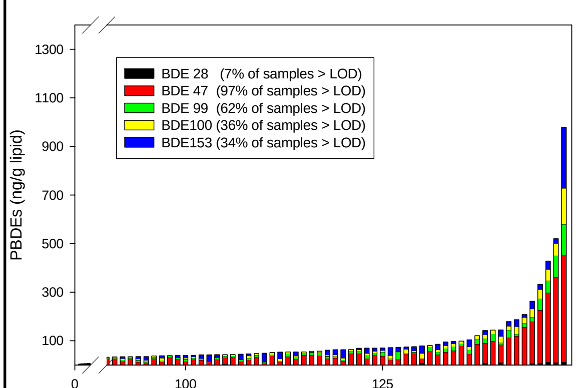
**Relationships of PBDEs with demographics and exposures were examined using nonparametric statistical methodology.**

**PBDE serum levels were expressed as an ordinal variable (individuals in the highest and lowest 10% of lipid-adjusted PBDE levels).**

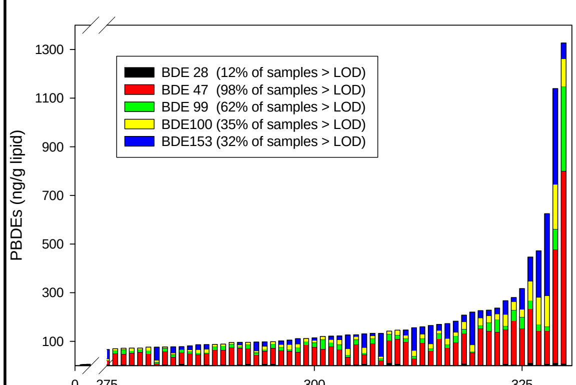
## PBDEs, PCBs and DDE Levels in 478 Participants in 2005

| | Geo Mean (ng/g lipid) | Minimum, Maximum (ng/g lipid) |
|---|---|---|
| Total PBDEs | | |
| Men | 27.1 | ND - 1,359 |
| Women | 25.3 | ND - 995 |
| NHANES 2003-4* | 32.1 | ND – 2,321 |
| Total PCBs | | |
| Men | 304.9 | ND - 4,309 |
| Women | 135.6 | ND - 1,422 |
| NHANES 2001-2* | 134 | ND – 3,569 |
| DDE | | |
| Men | 317.4 | ND - 3,964 |
| Women | 223.6 | 25 - 2,813 |
| NHANES 2001-2* | 287 | ND – 7,480 |

*NHANES estimates for 820 non-hispanic white adult participants




**Female Participants**




**Male Participants**

## Highest and Lowest Exposure Groups

| Characteristic | PBDE (ng/g lipid) | | P-values |
|---|---|---|---|
| | <7.5 | >102 | High vs Low |
| Number | N = 49 | N = 48 | |
| Mean age in years | 54 | 61 | < 0.0001 |
| % Obese (BMI > 29.9) | 22% | 42% | 0.04 |
| Weight loss (% reported) | 35% | 10% | 0.004 |
| Household Income (<$45,000/yr) | 24% | 46% | 0.03 |
| Education (≤ 12 yrs) | 24% | 40% | 0.11 |
| Gender (% Male) | 55% | 73% | 0.07 |

## DDE, PCBs and Fish Consumption

| Characteristic | PBDE ng/g lipid | | P-values |
|---|---|---|---|
| | <7.5 | >102 | High vs low |
| DDE (geo. mean-lipid adj) | 171 | 388 | <0.0001 |
| PCB (geo. mean-lipid adj) | 148 | 273 | <0.0001 |
| Commercial fish meals/yr | 38 | 25 | <0.0001 |
| Shellfish meals/yr | 16 | 18 | <0.0001 |
| Sportfish meals/yr | 16 | 19 | <0.0001 |
| Yrs of sportfish consumption | 27.3 | 41.2 | <0.0001 |
| Recent fish oil use | 14% | 19% | 0.56 |

## Activities/Diet and PBDE Exposure

| Characteristic | PBDE (ng/g lipid) | | P-values |
|---|---|---|---|
| | <7.5 | >102 | High vs Low / Continuous* |
| **Waterbed use** | **0%** | **12%** | **0.009 / 0.21** |
| Current Tobacco use | 8% | 13% | 0.48 / 0.09 |
| New cars in last 10 years | 4.1 | 3.6 | 0.27 / 0.11 |
| **Outdoor hours/day** | **3.4** | **5.3** | **0.004 / 0.02** |
| Computer use hours/day | 2.0 | 1.8 | 0.74 / 0.21 |
| Meat servings/week | 10.5 | 10.2 | 0.61 / 0.74 |
| Dairy servings/week | 16.6 | 13.8 | 0.16 / 0.15 |

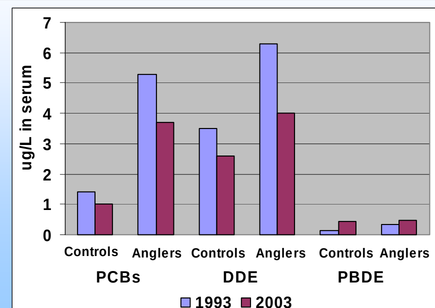
*n=478 total participants

## SUMMARY AND CONCLUSIONS

**Lipid-adjusted PBDE levels in serum were positively associated with:**

**Age**
**Obesity**
**Income of less than $45,000 USD/year**
**Water bed use**
**Hours spent outdoors**
**DDE and PCB levels**
**Years of sportfish consumption**
**Shellfish meals per year**
**Cat fish meals in last year**

## PCB, DDE and PBDE Levels 1993 vs 2005




## Endocrine Disruption

**Thyroid Function**

**Role of PCB, DDE and PBDE**

## Thyroid disruption by PCBs

- PCBs cause decreased thyroxine in animals.
  - Decreased binding to transport protein (TTR)
  - Increased conversion of T4 to T3
  - Increased metabolism
- In human studies results are mixed.
  - No effect found in some studies.
  - Positive association of PCBs with free T4 in Slovakia studies—very high exposures
  - Inverse associations of PCBs with thyroid hormones in studies with lower exposure levels
  - Relationships may be stronger in women than men
  - NHANES data suggests stronger effects
    - in older persons
    - in women
    - with dioxin-like exposures

## Results in GL Fish Consumers-1993

- 178 men and 51 women
- Thyroxine was negatively and significantly associated with PCBs and GL fish consumption
- Associations were stronger in women
- TSH not associated with PCBs or GL fish consumption
- In men, SHBG-bound testosterone was negatively associated with PCBs

## Thyroid disruption by PBDEs

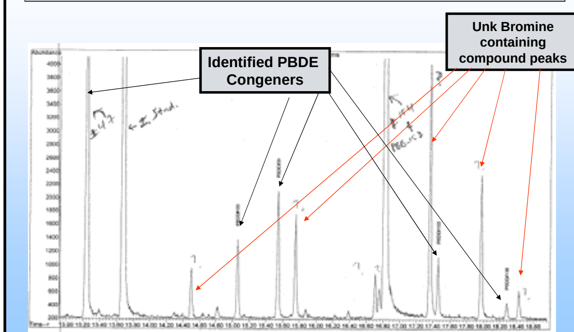
- PBDEs decrease thyroxine levels in animals.
  - Decreased binding to transport protein
  - Increased metabolism
- Little data in humans.
  - Inverse association between TSH and BDE 47 in male fisheaters

## Associations of Hormones and Exposures in 257 Men - Spearman Correlation Coefficients

| Hormone | BDE 47 | PBDEs | PCBs | Years SCF |
|---|---|---|---|---|
| **Total $T_3$** | -0.10 | **-0.12*** | **-0.12*** | -0.05 |
| **Total $T_4$** | 0.02 | 0.05 | -0.05 | **-0.14**** |
| **Free $T_4$** | 0.04 | 0.07 | -0.06 | -0.08 |
| **Urinary total $T_4$** | **0.19**** | **0.19**** | -0.06 | 0.10 |
| **TSH** | **-0.12*** | -0.09 | 0.10 | -0.01 |
| **TBG** | **-0.18**** | **-0.18**** | -0.10 | -0.08 |
| **$T_4$-bound TBG** | **-0.13**** | **-0.11*** | 0.04 | 0.03 |
| **$T_4$-bound albumin** | **0.12**** | **0.11*** | -0.05 | -0.01 |

*0.05<p<0.10 **p<0.05

## Chromatogram from a participant showing identified PBDE congeners and unknown peaks




## Questions and Answers

Q. *Can you speculate as to why animal data are much more consistent than human consumption data? (Mahaffey)*

A. Determining the effects of certain contaminants in a clinical setting is more difficult since humans are more likely to interfere with effects of the contaminant. For example, thyroid disease in humans is generally treated with medication, therefore we think the contaminant effects are suspect. Animals are not generally treated for thyroid conditions.

Q. *Bioaccumulation and the incidence of thyroid disease generally increase with age. Can you speculate if other factors may be involved?*

A. It is possible that the co-contaminant bioaccumulation is occurring as well.

Q. *Will you look at other congeners with respect to the thyroid data as well? Will you look at deca congeners as well? (Staskal)*

A. We plan to; however, any lab that gives you 209 is suspect.