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-F
Risks and Benefits

Moderator:

Rita Schoeny, U.S. EPA

Introduction – Risks and Benefits of Fish Consumption

Rita Schoeny

Risk Benefit Evaluations of Fish Consumption

Joanna Burger and Michael Gochfeld, Environmental and Occupational Health Sciences Institute, Rutgers University

Maternal Seafood Consumption in Pregnancy and Neurodevelopmental Outcomes in Childhood (ALSPAC Study)

Jean Golding, Joe Hibbein, and Colin Steer, University of Bristol

Project Viva: Maternal Prenatal Fish Intake, Blood Mercury and Child Cognition at Age 3 Years

Emily Oken, Harvard Medical School

Summary on the Institute of Medicine's (IOM's) Report, Seafood Choices: Balancing Benefits and Risks

Malden Nesheim, Cornell University

Moving Beyond the Reference Dose to Compare Risks and Benefits of Fish Consumption

Joshua Cohen, Tufts-New England Medical Center

Synthesis for Fish Consumption Advisory Impacts

Gary Ginsberg, Connecticut Department of Health

Panel Discussion on Risks and Benefits

Emily Oken, Joshua Cohen, Joanna Burger, Malden Nesheim, Jean Golding, Gary Ginsberg, and Dariush Mozaffarian

[This page intentionally left blank.]

Introduction – Risks and Benefits of Fish Consumption

Rita Schoeny, U.S. EPA

Biosketch

Dr. Rita Schoeny (Ph.D.) is Senior Science Advisor for EPA's Office of Water. She received her B.S. degree in Biology at the University of Dayton and a Ph.D. in Microbiology from the School of Medicine at the University of Cincinnati. After completing a postdoctoral fellowship at the Kettering Laboratory, Department of Environmental Health, she was appointed Assistant Professor in that department of the University of Cincinnati Medical School. Dr. Schoeny has held several adjunct appointments, and she regularly lectures at colleges and universities on risk assessment.

Dr. Schoeny joined EPA in 1986. Previously, she served as Associate Director of the Health and Ecological Criteria Division of the Office of Science and Technology, Office of Water. In that position, she was responsible for major assessments and programs in support of the Safe Drinking Water Act, including scientific support for rules on disinfectant by-products, arsenic, microbial contaminants and the first set of regulatory determinations from the Contaminant Candidate List. She has held various positions in the Office of Research and Development, including Chief of the Methods Evaluation and Development Staff, Environmental Criteria and Assessment Office, Cincinnati; Associate Director of the Cincinnati office of the National Center for Environmental Assessment; and Chair of the Agency-wide workgroup to review cancer risk assessments.

Dr. Schoeny has published in the areas of metabolism and mutagenicity of PCBs and polycyclic aromatic hydrocarbons, assessment of complex environmental mixtures, health and ecological effects of mercury, drinking water contaminants, and principles and practice of human health risk assessment. She served as lead author and co-author of the Mercury Study Report to Congress and served as Principal Scientist and Manager for Ambient Water Quality Criterion for Methylmercury. Recently, she has served as Chair of an EPA working group on the use of genetic toxicity data in determining mode of action for carcinogens. She participates in many EPA scientific councils, as well as national and international scientific advisory and review groups.

Dr. Schoeny has received many awards, including several EPA Gold, Silver, and Bronze Medals; EPA's Science Achievement Award for Health Sciences; the Greater Cincinnati Area Federal Employee of the Year Award; the University of Cincinnati Distinguished Alumnae Award; Staff Choice Award for Management Excellence; and the FDA Teamwork Award for the publication of national advice on mercury-contaminated fish.

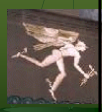
Risks and Benefits of Fish Consumption

2007 National Forum on Contaminants in Fish

July 24, 2007

To Eat or Not to Eat . . .

- Balancing risks and benefits?
- Making informed choices?
  - Eat fish. Choose wisely.
- What is the role of fish advisory programs?



Our Speakers

- Joanna Burger, Rutgers University
- Jean Golding, University of Bristol
- Emily Oken, Harvard Medical School
- Malden Nesheim, Cornell University
- Joshua Cohen, Tufts NE Medical Center
- Gary Ginsberg, Connecticut Dep. Health
- Dariush Mozaffarian, Harvard Public Health

. . . And you

Ground Rules

- Please limit questions after presentations to information and clarification.
- Please ask open ended questions during the panel discussion (4:10 pm).
- Please engage in lively, constructive debate during the panel discussion.

Risk Benefit Evaluations of Fish Consumption

Joanna Burger and Michael Gochfeld, Environmental and Occupational Health Sciences Institute, Rutgers University

Biosketch

Dr. Joanna Burger (Ph.D.) is Distinguished Professor Biology at Rutgers University. She obtained a Ph.D. in Behavioral Ecology from the University of Minnesota. Her interests are in the intersection of toxicology and human health, fish consumption and risk from chemicals, the effects of heavy metals on neurobehavioral development, human health risk assessment, and bioindicators of human health and well being. She has published numerous articles on fishing, fish consumption, risk from consuming contaminated fish, fish availability, human health risk assessments with fish and game consumption, risk perception, and risk communication. She has served as the Principal Investigator on many studies that have spanned the pure laboratory aspects to human health risk assessments and risk communication. She has been involved with several State and Federal governmental agencies in collecting fish, analyzing mercury and other heavy metals, assessing fish consumption rates and cooking methods, and combining the laboratory results with consumption patterns to examine human health risks from consuming fish. Her laboratory studies have focused on using avian models to examine the effect of heavy metals (lead, chromium, manganese, mercury) on behavioral development and developing bioindicators for environmental conditions and human health. Her interest in understanding food chain effects of contaminants has resulted in studying fish, fishing behavior, consumption patterns, and the contaminants in fish. This research involves risk assessment, risk management, and risk communication. She has advised several companies, State and Federal government agencies, and the National Research Council (NRC). She has served on several NRC committees and panels, as well as international panels on environmental health issues, including endocrine disruptors and heavy metals.

Abstract

Fishing is a popular pastime in many parts of the world and has the advantage of providing both recreation and food. Because fish are a healthy source of protein, omega-3 fatty acids, and other nutrients, there is considerable concern about the potential risk from contaminants that bioaccumulate in fish. Understanding the risks and benefits of fish consumption has become a concern of both State and Federal agencies, as well as many other health organizations.

Fishing is fun and provides many benefits, including being outdoors, communing with nature, getting away from life's demands, being with friends or family, or obtaining fish to eat, to sell or give away, or for fish fries. However, contaminants in fish (particularly methylmercury and polychlorinated biphenyls [PCBs]) can cause neurodevelopmental damage to fetuses and young children (and even to adults at high levels). The beneficial effects of fish consumption include a direct effect of n-3 fatty acids on nervous system development and on higher birth weight.

Balancing the risks and benefits of fish consumption is complex because it involves choices of what foods to eat, what quantities, and at what time in people's lives. The choices range from whether to eat and how much fish to eat, to what kinds and sizes of fish to eat, to what parts of fish to eat, and when to eat or avoid some species or sizes of fish. The risks and benefits of fish consumption need to be examined with respect to other food choices, which also includes price, availability, and personal tastes. If fish are not being eaten, then other sources of protein, such as beef, pork, or chicken, are being consumed. Risk analysis of fish consumption is a complex task that involves who is at risk (and when), consumption patterns (meals per week, meal size, cooking methods, fish species eaten), and contaminant loads. Fish are not created equal with respect to either the benefits or the risks. Individuals can make informed choices if presented with appropriate information.

RISKS AND BENEFITS OF FISH CONSUMPTION


Joanna Burger & Michael Gochfeld
CRESP, Rutgers University & UMDNJ-RWJ Medical School

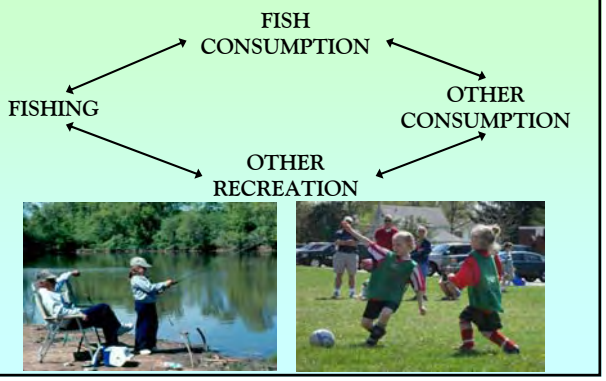
FISHING IS FUN


FISH IS A HEALTHY FOOD

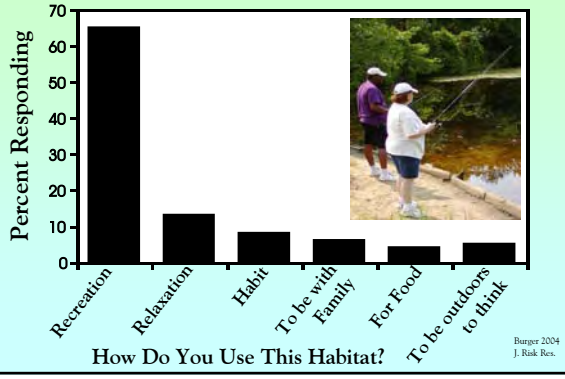
VS

FISH CAN HAVE CONTAMINANTS

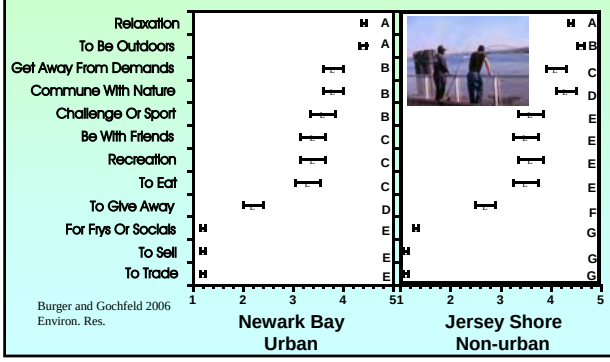
BALANCING RISKS AND BENEFITS



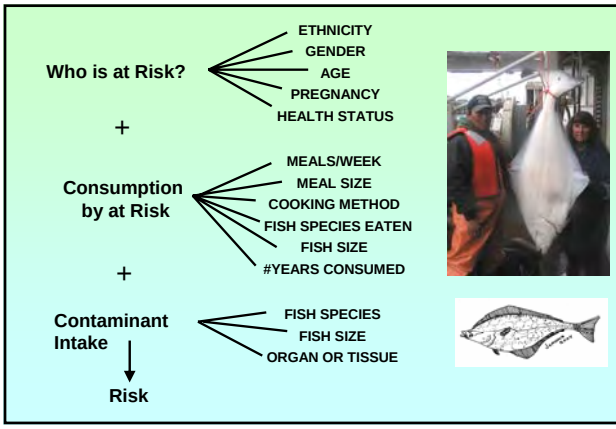
WHY PEOPLE FISH—NJ Coast Survey

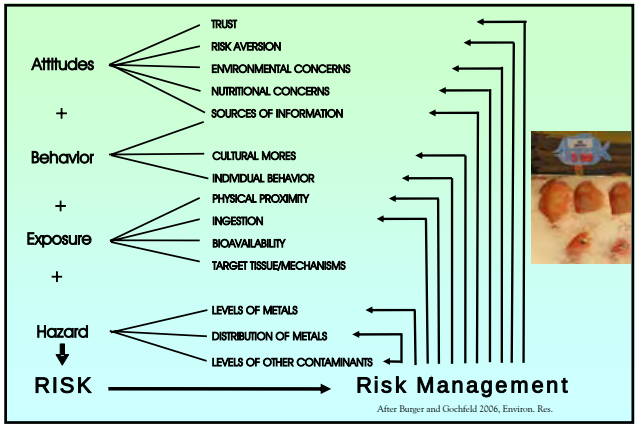


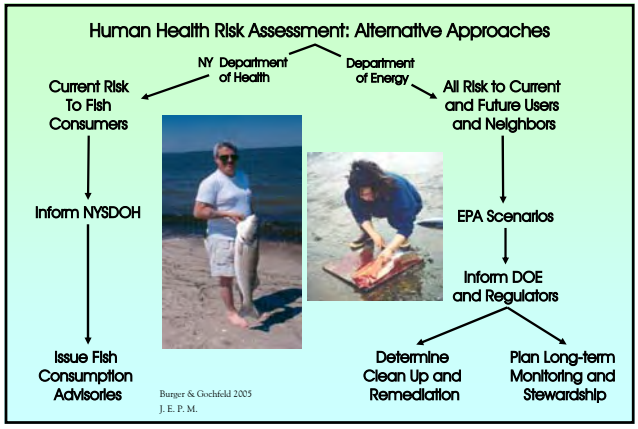
WHY PEOPLE FISH

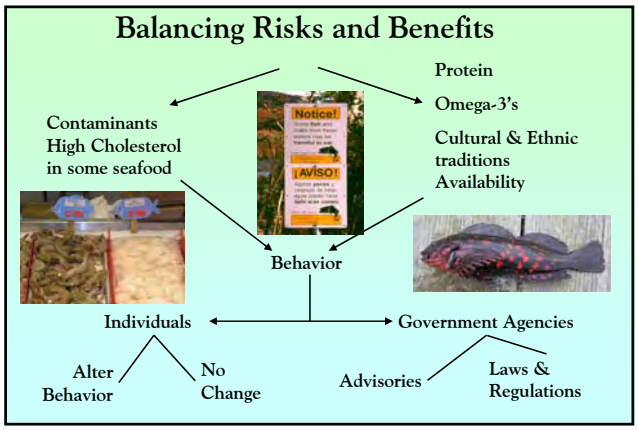


Burger and Gochfeld 2006 Environ. Res.

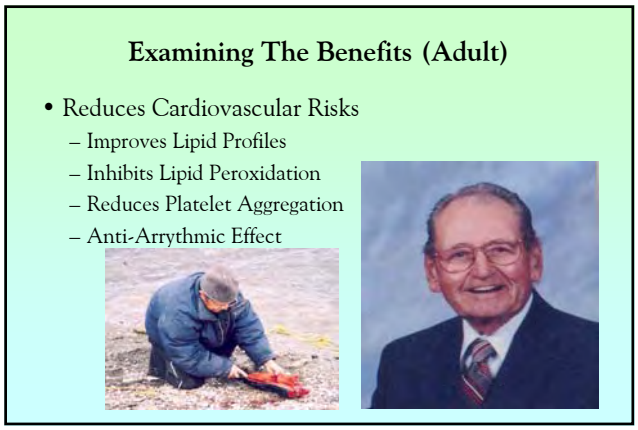



Attitudes
+
Behavior
+
Exposure
+
Hazard
RISK
TRUST
RISK AVERSION
ENVIRONMENTAL CONCERNS
NUTRITIONAL CONCERNS
SOURCES OF INFORMATION
CULTURAL MORES
INDIVIDUAL BEHAVIOR
PHYSICAL PROXIMITY
INGESTION
BIOAVAILABILITY
TARGET TISSUE/MECHANISMS
LEVELS OF METALS
DISTRIBUTION OF METALS
LEVELS OF OTHER CONTAMINANTS
Risk Management
After Burger and Gochfeld 2006, Environ. Res.


Human Health Risk Assessment: Alternative Approaches
NY Department of Health
Department of Energy
Current Risk To Fish Consumers
All Risk to Current and Future Users and Neighbors
Inform NYSDOH
EPA Scenarios
Inform DOE and Regulators
Issue Fish Consumption Advisories
Determine Clean Up and Remediation
Plan Long-term Monitoring and Stewardship
Burger & Gochfeld 2005
J. E. P. M.


Balancing Risks and Benefits
Protein
Omega-3's
Cultural & Ethnic traditions
Availability
Contaminants
High Cholesterol
in some seafood
Notice!
AVISO!
Behavior
Individuals
Government Agencies
Alter Behavior
No Change
Advisories
Laws & Regulations

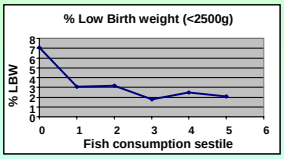

Examining The Benefits (Baby)
• Enhances Fetal Growth & Development
• Reduces Pre-Term Delivering
• Essential for CNS Development
FRESH LARGE KING SALMON

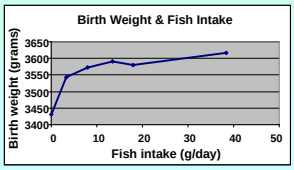

Examining The Benefits (Adult)
• Reduces Cardiovascular Risks
– Improves Lipid Profiles
– Inhibits Lipid Peroxidation
– Reduces Platelet Aggregation
– Anti-Arrythmic Effect

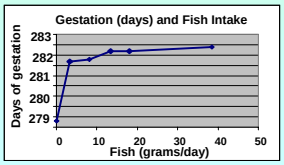

Why Are Fish Beneficial for Developing Nervous System?
•Direct effects of n-3 fatty acids on nervous system development.
•Protein quality.
•Unknown nutrients?
•Indirect effects through avoidance of harmful diets.
•Surrogate effects: people who eat fish also follow healthy lifestyles and have good prenatal care.

PREGNANCY BENEFIT CURVES

Olsen & Secher (2002) show main benefit in birth weight and gestation comes in switching from 0 group to 13.4 +g/day.

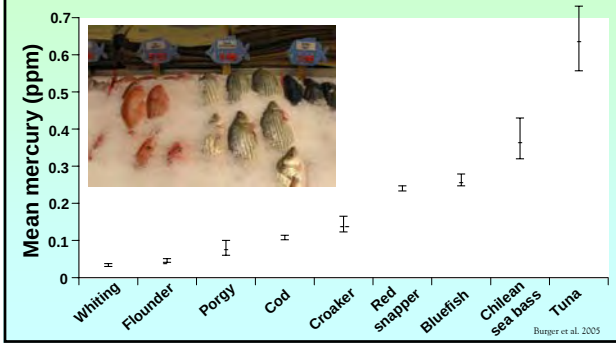






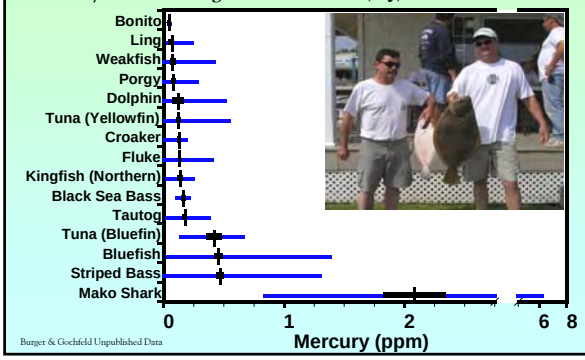
EXAMINING THE CONCENTRATIONS

Mercury In Commercial Fish (NJ):



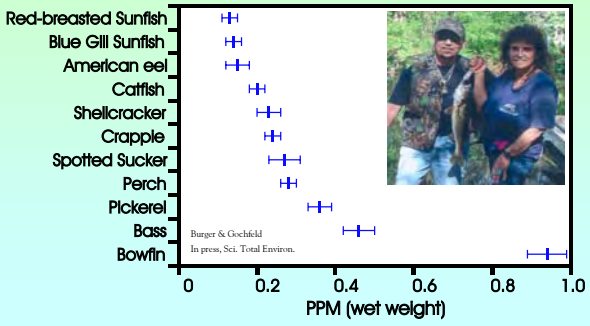
MERCURY CONCENTRATIONS

Mercury In Self-Caught Marine Fish (NJ):



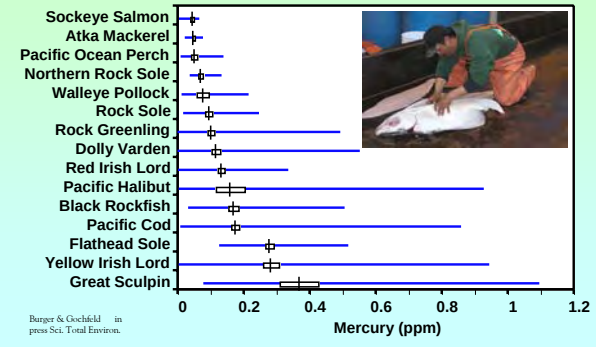
MERCURY CONCENTRATIONS

Mercury In Self-Caught Freshwater Fish (Savannah River):



MERCURY CONCENTRATIONS

Mercury In Self-Caught Fish (Aleutians):



VARIATION WITHIN A TYPE OF FISH

Mercury In Tuna	Mean Mercury (ppm)
Canned Tuna (Light)	0.10
Canned Tuna (White)	0.41
Tuna Steak (commercial)	0.61
Tuna Self-Caught (Bluefin, NJ)	0.43
Tuna Self-Caught (small Yellowfin, NJ)	0.13

Burger & Gochfeld 2004, 2005 A

Variation in PCBs within Fish

(ng/g wet weight)

	Washington DC	Maryland 1	Maryland 2 (month later)
Wild Alaska King Salmon	5.8	5.4	
Wild Coho Salmon		0.35	2.9
Wild Sockeye Salmon		2.2	5.0
Farmed Atlantic Salmon	1.8	12	7.4
Bluefish	140	110	280
Rockfish	20	35	39

From: Hayward D, Wong J, Krynitsky AJ. 2007. Polybrominated diphenyl ethers and polychlorinated biphenyls in commercially wild caught and farm-raised fish fillets in the united states. Environ Res 103(1):46-54.

MULTIPLE CONTAMINANTS---THE ALEUTIANS

Species	^{137}Cesium (Bq kg^{-1}, ww) and (% of samples above the MDA)	Mercury levels (ppm, wet weight) (ug/g)	Total PCBs (ppt, wet weight) (pg/g)
Atka Mackerel	0.1 (33%)	0.05 ± 0.01	
Pacific Ocean Perch	0.12 (33%)	0.06± 0.01	
Northern Rock Sole	0.1 (0%)	0.07 ± 0.01	
Walleye Pollock	0.31 (50%)	0.03 ± 0.01	
Rock Sole		0.07 ± 0.02	
Rock Greenling	< MDA of 0.29 (0%)	0.11 ± 0.01	749 ± 163
Dolly Varden	0.74 (100%)	0.16 ± 0.02	
Red Irish Lord		0.12 ± 0.01	
Pacific Halibut	0.24 (75%)	0.32 ± 0.10	2340 ± 1500
Black Rockfish	0.14 (100%)	0.17 ± 0.02	502 ± 74
Pacific Cod	0.29 (57%)	0.20 ± 0.02	1400 ± 119
Yellow Irish Lord	0.1 (33%)	0.24 ± 0.03	
Great Sculpin		0.45 ± 0.16	

Risk Versus Benefit

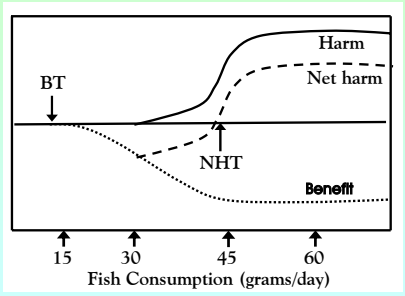
COMPOSITE BENEFIT-RISK BY DOSE CURVE

We proposed combining the dose response curves for harm and benefit

Hopefully maximum benefit can be realized before significant harm

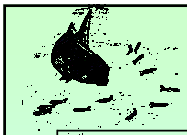
BT=Benefit Threshold

NHT=Net Harm Threshold



Gochfeld & Burger (2005) Neurotoxicology 26:511

Risks And Benefits

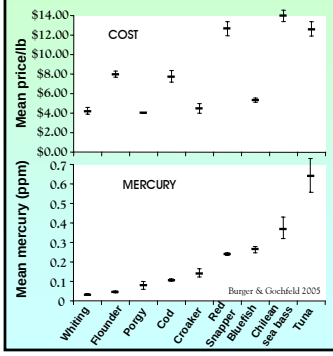


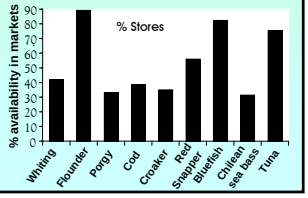
	PUFA's (mg/100g)	Mercury (ppm)	PCB's (ppb)
Catfish (Farmed)	177	<0.05	<50
Cod (Atlantic)	158	0.10	
Frozen Fish Sticks	214	<0.05	
Halibut	465	0.25	
Salmon (Farmed)	2648	<0.05	15-51
Salmon (Wild)	1043	<0.05	0.5-5
Shark	689	0.99	
Tuna (Light)	270	0.12	45
Tuna (White)	862	0.35	100

After Mozaffarim & Rimm 2007

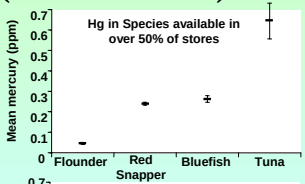
Availability, Cost and Mercury

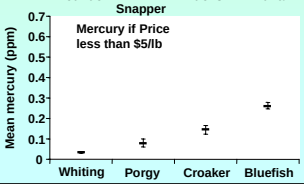
NJ Commercial fish





Optimizing Availability, Cost, and Mercury (Commercial Fish)





Fish Are Not Created Equal

- Variable Levels of Contaminants
- Variable Levels of Omega-3's
- Variable Levels of Disease
- Variable Desirability (taste, sport)
- Variables a Result of:
  - Species
  - Habitat
    - General
    - Specific
  - Size
  - Age
  - Growth Rate

Optimizing For Self-Caught Fish Extending The Model

- Availability:
  - » Length of Season
  - » Abundance
  - » Catchability
- Cost:
  - » Equipment (poles, boats)
  - » Time to Catch
- Contaminant Loads:
  - » PCB & Hg (high in some fish)
- Pleasure Factor:
  - » Nature
  - » Family Fun
  - » Tournament
  - » Fish Fry's
  - » Peace and Quiet

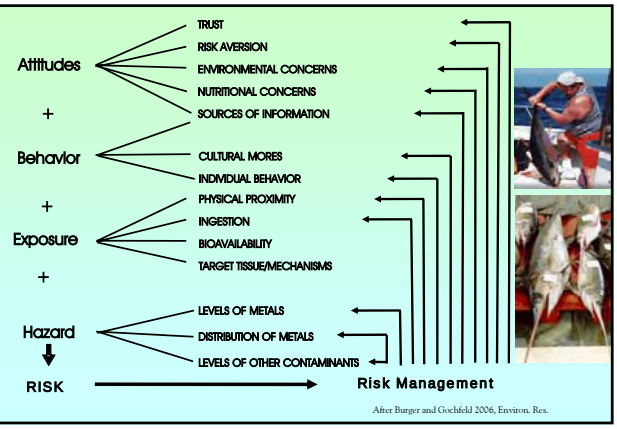
Optimizing

- Reduce Risks:
  - Fish species low in contaminants
  - Small-sized fish within species
  - Fish from low contaminated lakes or salt water estuaries/bays
  - Diversify fish species
  - Watch for condition
  - Seek out available information
  - Remove fat, skin, broil or bake
- Increase Benefits:
  - Fish high in Omega-3
  - More fish than red meat
  - Social aspect
  - Seek out available information

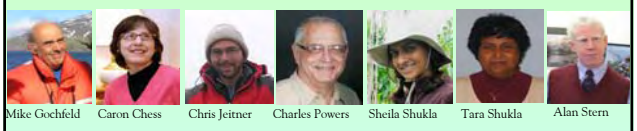
Decision Is Not Whether To Eat Fish…

But Rather-

- What species?
- When (or when not to)?
- Of what size?
- And cooked how?



Acknowledgments



Mike Gochfeld Caron Chess Chris Jeitner Charles Powers Sheila Shukla Tara Shukla Alan Stern

Also: Tom Fote, Sean Burke, Dan Volz, Mark Donio, Tim Stamm, Ron Sniggaroff, David Kosson, Dan Sniggaroff, Sam Roe

Funding: EPA, NJ Angler's Association, Wildlife Trust, DOE (CRESP, DE-FC01-86EW07053), NJDEP, NIEHS (P30ES005022)

Questions and Answers

Comment: The health benefits of fish consumption exceed the health benefits of almost any other food. (Mozafarrian)

Maternal Seafood Consumption in Pregnancy and Neurodevelopmental Outcomes in Childhood (ALSPAC Study)

Jean Golding, Joe Hibbein, and Colin Steer, University of Bristol

Biosketch

Ms. Jean Golding is an Emeritus Professor of Paediatric and Perinatal Epidemiology within the University of Bristol. Initially trained as a mathematician, she spent 3 years as a Research Fellow in the Department of Human Genetics and Biometry at the University College London (UCL) where she conducted epidemiological research into the aetiology of birth defects. Throughout her career, she has been involved with large datasets, including the 1958 and 1970 national birth cohorts and the Oxford Record Linkage Study. Her analyses of these datasets revealed the difficulties in interpreting findings without finer detail about the processes involved. A chance meeting with Marcus Pembrey while planning a new survey resulted in the design of the Avon Longitudinal Study of Parents and Children (ALSPAC) with genetic, phenotype, and environmental measures. She served as Scientific and Executive Director of the study from its inception until December 31, 2005, and she has recently been elected a Fellow of the Academy of Medical Sciences.

Abstract

This study assesses the consequences of consuming <340 g of seafood per week by the mother in pregnancy as recommended to the U.S. population. The data are from the Avon Longitudinal Survey of Parents and Children (ALSPAC) study, which enrolled pregnant women in the county of Avon in the United Kingdom during 1990 through 1992. Women completed detailed dietary assessments using food frequency questionnaires that were designed especially to identify the different types of fat and fatty acids that the woman consumed. The frequency with which the woman consumed oily fish, white fish, and shellfish were enquired separately.

We followed up on the children at various time periods. In this paper, the results related to child development, behaviour, and IQ up to age 8 are presented, comparing the children of those women who consumed no seafood, 1–340 g, or more than 340 g of seafood during pregnancy. Statistical analyses took into account 28 possible confounders, including other dietary components, social conditions, educational attainment of the parents and birth weight, gestation, and gender of the child.

Of the 23 different tests assessed, there were nine that showed a statistically significant trend with fish intake, whereas only one would have been expected by chance. The significant outcomes were fine motor skills at ages 18 and 42 months, social development at 30 and 42 months, communication at 6 and 18 months, pro-social behaviour at 7 years, and full-scale and verbal IQ at age 8. All of these outcomes showed the trend that the more fish the mother consumed, the better the outcome. There was no indication that the child of the woman who consumed in excess of 340 g per week suffered any adverse effects of cognitive development or behaviour.

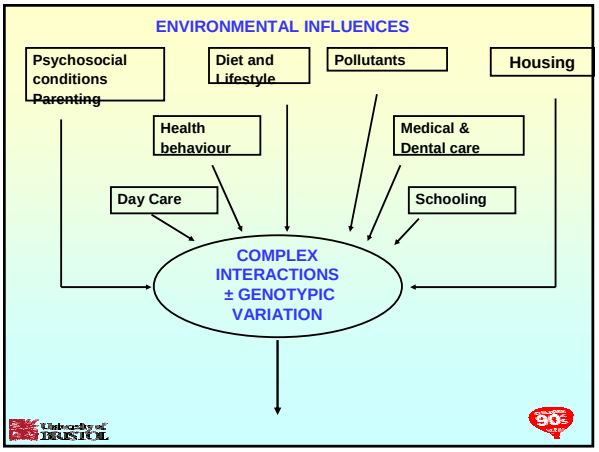
Maternal seafood consumption in pregnancy and neurodevelopmental outcomes in childhood.

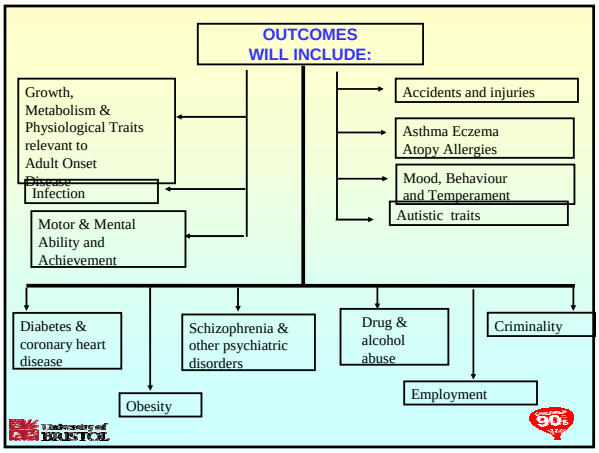
Jean Golding, Joe Hibbeln, Colin Steer

Avon
Longitudinal
Study of
Parents
And
Children

OVERALL OBJECTIVE

To understand the ways in which the physical and social environment interact, over time, with genetic inheritance to affect health, behaviour and development in children and then into adulthood.





ALSPAC

Inclusion criteria	**EDD 1.4.91-31.12.92** **Mother resident in Avon**
Enrolled pregnancies **(740 miscarriages/deaths)**	**14,541** **(~85% of total eligible)**
Being followed	**13,801 mothers** **13,971 children**

ALSPAC DATA

- Self completion questionnaires
- Health records
- Biological samples
- Environmental monitoring
- Education records
- Hands on assessments

ALSPAC DATA

- Self completion questionnaires
- Health records
- Biological samples
- Environmental monitoring
- Education records
- Hands on assessments

Questions on seafood intake asked of the mother at 32 weeks gestation

How many times nowadays do you eat:

(a) White fish (cod, haddock, plaice, fish fingers etc.)

(b) Dark or oily fish (tuna, sardines, pilchards, mackerel etc.)

(c) Shellfish (prawns, crabs, cockles, mussels etc.)

Response rate:

14510 mothers reaching 32 weeks gestation

88% responded (n = 12441)

Calculation of seafood intake

- portion size based on typical eating pattern in the UK
- frequency of consumption

Maternal seafood intake

- none 12%
- <3 portions/wk 65%
- 3+ portions/wk 23%

Outcome measures (1)

Early child development 6, 18, 30, 42m

- gross motor
- fine motor
- social skills
- communication skills

using maternal self-completion scales

Outcome measures (2)

Child behaviour at 7 years

- prosocial
- peer problems
- hyperactivity
- emotional problems
- conduct problems
- total behavioural

using maternal self-completion scales

Outcome measures (3)

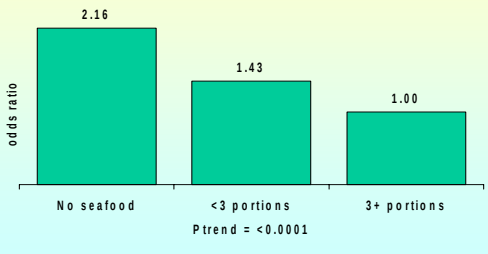
Cognition at 8 years

- verbal IQ
- performance IQ
- total IQ

Statistically significant associations with 19 of 23 outcomes

All 19 showed poorest outcome when mother ate no seafood in pregnancy, and best outcome when she ate 3 or more portions

Verbal IQ



Factors associated with seafood consumption

- maternal education
- housing tenure
- crowding
- stressful life events
- presence of a partner
- maternal age
- maternal smoking
- maternal alcohol
- parity
- breast feeding
- ethnic background

Other factors taken into account

- family adversity index
- parenting index
- low birthweight
- preterm delivery
- child's gender
- and 12 measures of diet known to be socially patterned

Early child development

No statistically significant associations after adjustment with:

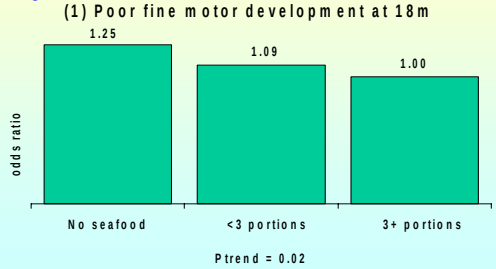
gross motor skills at 6, 18, 30, 42m

fine motor skills at 6, 30m

social development at 6, 18m

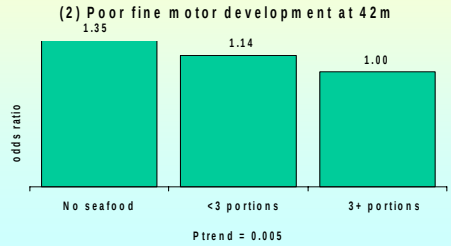
Early child development

Statistically significant associations after adjustment



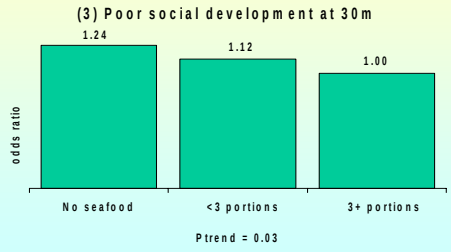
Early child development

Statistically significant associations after adjustment



Early child development

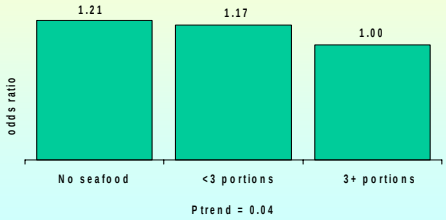
Statistically significant associations after adjustment



Early child development

Statistically significant associations after adjustment

(4) Poor social development at 42m

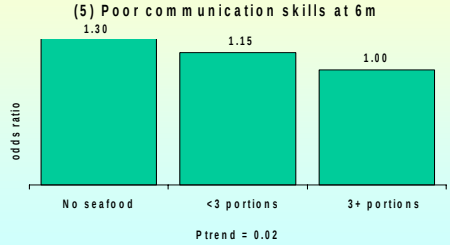


Ptrend = 0.04

Early child development

Statistically significant associations after adjustment

(5) Poor communication skills at 6m



Ptrend = 0.02

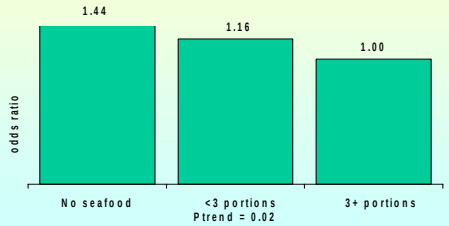
Child behaviour at 7yr

No significant association after adjustment with:

- **hyperactivity**
- **emotional problems**
- **conduct problems**
- **peer problems**
- **total difficult behaviour**

Behaviour at 7yr

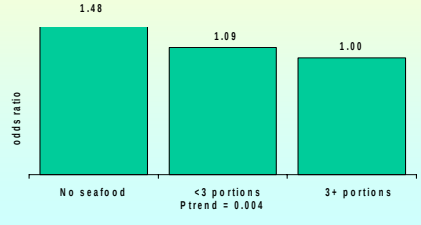
(6) Significant association after adjustment with poor prosocial behaviour



Ptrend = 0.02

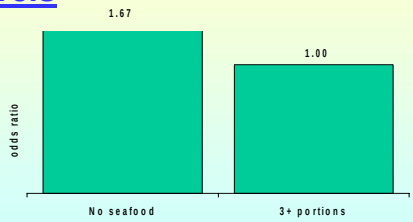
Verbal IQ at 8yr

(7) Significant association after adjustment

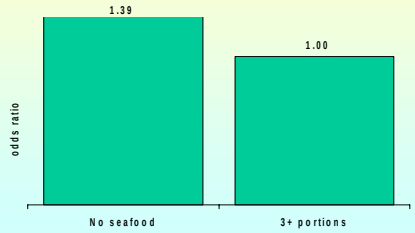


Ptrend = 0.004

Verbal IQ after additional adjustment for 14 nutrient levels



Verbal IQ after additional adjustment for paternal fish intake



Conclusions (1)

We tested maternal seafood intake against 23 cognitive and behaviour outcomes.

After adjustment for up to 28 factors, 7 remained significantly related.

(1 would have been expected by chance)

Conclusions (2)

- There was no suggestion that mothers eating 3 or more portions of seafood were harming their children's cognitive or behavioural development

Conclusions (3)

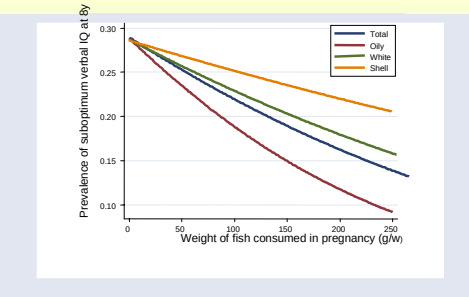
- Children of mothers who ate no seafood in pregnancy were at increased risk of poor outcome

Conclusions (4)

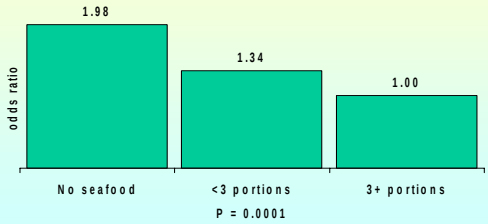
- The relationships between low maternal seafood intake and poor outcome were stronger with older age of the child.

Further research with this cohort will focus on cognitive, educational and behavioural outcomes in later childhood.

Multivariable analyses of three fish types



Verbal IQ – adjusted also for mercury



Mercury in umbilical cord after adjustment for all other factors

OR of low verbal IQ for each SD increase in mercury

1.14 [95% CI 1.02, 1.27]

P = 0.023

Publications

Lancet 2007; 369: 578-585

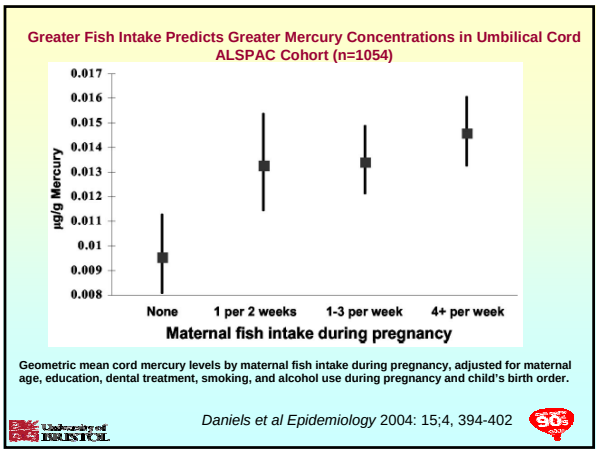
Lancet 2007; 370: 218

www.alspac.bris.ac.uk

Maternal seafood consumption at 32 wk gestation

How often nowadays do you eat?	White fish (cod, haddock, plaice, fish fingers, etc.)	Dark or Oily fish (tuna, sardines, pilchards, mackerel, herring, kippers, trout, salmon, etc.)	Shellfish (prawns, crabs, cockles, mussels ect.).
One portion **Composition based on typical consumption patterns of women in England**	**+50g of fried plaice in batter** **+30g of baked cod fillets** **+30g of fried haddock in crumbs** **+20g of grilled fish fingers**	**+60g of tuna canned in brine** **+12g of homemade salmon fish cakes** **+10g of canned pink salmon** **+8g of brown trout** **+5g of steamed salmon** **+5g of sardines canned in oil** **+5g of pilchards canned in tomato sauce** **+3g of sardines canned in tomato sauce**	**+43g of scampi, bread-crumbed and fried** **+21g of canned crab** **+10g of boiled mussels** **+15g of boiled prawns**
Omega-3	0.32 g	0.89 g	0.34 g

Never / rarely	once in 2 wk	1–3 times per wk	4–7 times per wk	more than once a day
0 portions/wk	**0.5 portions/wk**	**2 portions/wk**	**5.5 portions/wk**	**10 portions/wk**
0 gm/w	**86 g/wk**	**347 g/wk**	**951 g/wk**	**1730 gm/wk**


Greater Fish Intake Predicts Greater Mercury Concentrations in Umbilical Cord
ALSPAC Cohort (n=1054)
µg/g Mercury
0.017
0.016
0.015
0.014
0.013
0.012
0.011
0.01
0.009
0.008
None
1 per 2 weeks
1-3 per week
4+ per week
Maternal fish intake during pregnancy
Geometric mean cord mercury levels by maternal fish intake during pregnancy, adjusted for maternal age, education, dental treatment, smoking, and alcohol use during pregnancy and child's birth order.
Daniels et al Epidemiology 2004: 15;4, 394-402

Questions and Answers

Q. The exposure variables constructed are concerning since the exposure index and categorization works better for omega-3 fatty acids than mercury. (Mahaffey)

A. We can hypothesize that the outcomes are based around omega-3 fatty acids, but the study focuses on the outcomes of seafood consumption. Further research must be done to pinpoint the cause of the outcomes.

Q. The study uses blood samples, a short-term look at mercury which may not account for the entire pregnancy. When is the sample taken? (Frohmberg)

A. All samples were taken when the participants signed up.

Q. How different were the results from consumption of one to two meals per week versus the 3 or more meals per week? (Gochfeld)

A. After consumption of 250 grams of fish, no additional benefits appeared to occur.

Q. Did the study test for selenium? (Ralston)

A. We do have blood levels of selenium as a result of the study.

Q. It may be more significant to exclude those women who are allergic to fish or shellfish. (Anderson)

A. Very few subjects were allergic to fish or shellfish in the study.

Q. Are there any plans to take maternal IQs? It is the gold standard for analyzing neurodevelopmental outcomes. (Rice)

A. No funding is available for maternal IQ testing. We have the educational attainment, which is not the same, but is helpful.

Project Viva: Maternal Prenatal Fish Intake, Blood Mercury and Child Cognition at Age 3 Years

Emily Oken, Harvard Medical School

Biosketch

Dr. Emily Oken (M.D., MPH) is an Assistant Professor in the Department of Ambulatory Care and Prevention at Harvard Medical School and Harvard Pilgrim Health Care. Her research interests include the influence of nutrition during pregnancy and early childhood on maternal and child health. She has studied the balance of risk and benefit from maternal fish consumption during pregnancy on child development. She has also performed many studies on the influence of modifiable behaviors during pregnancy, such as smoking, physical activity, and diet on risk for obesity among both mothers and their children. In addition, Dr. Oken is a Primary Care Physician at the Fish Center for Women's Health at Brigham and Women's Hospital, and she has a clinical interest in medical care for women before, during, and after pregnancy. She is Board-Certified in both Internal Medicine and Pediatrics.

Abstract

The balance of contaminant risk and nutritional benefit from maternal fish consumption during pregnancy for child cognitive development remains uncertain. We studied the associations of maternal second trimester fish intake and erythrocyte total mercury (Hg) levels with child performance at age 3 years on the Peabody Picture Vocabulary Test (PPVT) and Wide-Range Assessment of Visual Motor Abilities (WRAVMA) among 341 mother–child pairs in Project Viva. The results showed that mean maternal total fish intake was 1.5 (SD 1.4) servings per month, and 40 (or 12%) of mothers consumed >2 weekly fish servings, whereas 47 (or 14%) never consumed fish. Mean (SD) maternal Hg was 3.8 (3.8) ng/g. After adjustment for parent and child characteristics using multivariable linear regression, maternal fish intake was directly associated with, and Hg levels indirectly associated with, child cognitive test performance. These associations strengthened with mutual adjustment: effect estimates (95% CI) for fish intake >2 servings per week versus never were 2.2 (-2.6, 7.0) for PPVT and 6.4 (2.0, 10.8) for WRAVMA; and for Hg in the top decile, -4.5 (-8.5, -0.4) for PPVT and -4.6 (-8.3, -0.9) for WRAVMA. Fish consumption ≤2 weekly servings was not associated with a benefit. In this U.S. population, maternal fish intake above 2 weekly servings was associated with somewhat improved child cognitive test scores despite an adverse effect of the concomitant higher Hg exposure. Dietary recommendations for pregnant women should incorporate the nutritional benefits, as well as the risks of fish intake.

Maternal prenatal fish intake, blood mercury and child cognition at age 3 years:

Data from a US cohort

Emily Oken MD, MPH
Fish Forum: July 24, 2007
Department of Ambulatory Care and Prevention
Harvard Medical School and Harvard Pilgrim Health Care

Objective

- Study associations of maternal prenatal fish intake and mercury levels with child cognition at age 3 years in a US cohort with moderate fish intake

PROJECT Viva

- Prospective longitudinal cohort
- Prenatal diet, maternal and offspring health
- Enrollment at initial obstetric visit (~10 weeks)
- 8 obstetric practices in eastern MA, US
- Recruitment 4/1999 - 7/2002
- Ongoing follow-up through age 7 years

Study population

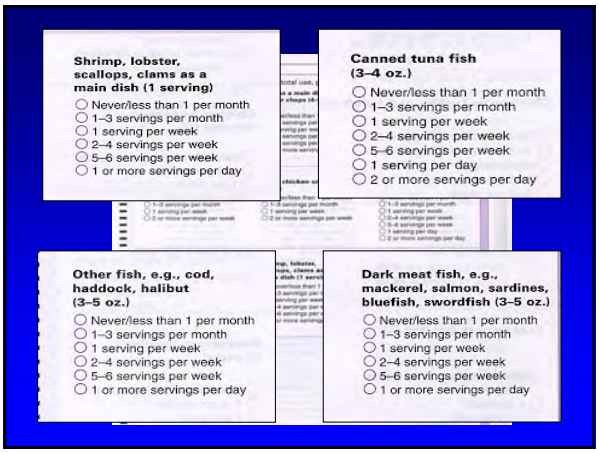
- 2128 births
- 1585 enrolled through age 3 years
- 896 with exposure & outcome data
- Funding for 341 mercury assays
  - Hair sample available (n=98)
  - Preterm or SGA (n=45)
  - Random sample (n=198)

Biosample collection and assay

- Maternal 2nd trimester blood (26-28 weeks)
  - Collected in tube with EDTA
  - Separated into plasma and RBC
  - Stored at -70 ºC
- Mercury assay of packed RBC
  - Sample in-homogeneity - cell lysis and centrifugation
  - Total mercury assayed using Direct Mercury Analyzer 80

Maternal diet

- Self-administered, optically-scanned semi-quantitative food frequency questionnaire (FFQ)
- 2nd trimester diet
  - Administered at 26-28 weeks gestation
  - Asked about diet "in the past 3 months"
- Harvard nutrient database used to estimate elongated n-3 fatty acid intake (DHA, EPA)
- Measured maternal blood DHA, EPA



Child age 3 year cognitive outcomes

- PPVT – language
  - Receptive vocabulary
  - Correlated with WISC-III verbal and full-scale IQ (r~0.90)
- WRAVMA – visual motor ability
  - Matching test (visual spatial)
  - Drawing test (visual motor)
  - Pegboard (fine motor)
  - Modestly correlated with IQ (r~0.60)
- Both standardized to have mean 100 and SD 15

Analysis

- Fish intake according to current guidelines
  - Never, <= 2, > 2 weekly servings
- Mercury dichotomized at top decile vs. below
  - Corresponds with 1.2 ppm (~RfD) of maternal hair in our population
- Outcomes continuous
- Multivariable linear regression
  - Adjusted for parent and child characteristics

Fish and elongated n-3 PUFA intake among Project Viva moms

Dietary Intake	Total fish (servings/mo)	DHA+EPA (g/day)
	Mean (range)	
Quartile 1 (lowest)	0	0.02 (0-0.05)
Quartile 2	3.1 (2-4)	0.09 (0.06-0.12)
Quartile 3	6.9 (6-8)	0.18 (0.12-0.24)
Quartile 4 (highest)	15.8 (10-96)	0.36 (0.24-2.53)

Oken et al.AJE 2004;160:774

Dietary Intake	Black	Non-Hispanic white	Asian	Hispanic
DHA+EPA				
Quartile 1	9%	77%	4%	6%
Quartile 2	11%	76%	4%	6%
Quartile 3	12%	71%	6%	7%
Quartile 4	17%	62%	9%	6%
p for trend	0.0004	<0.0001	0.0002	0.79
Fish				
No intake	9%	74%	4%	8%
Tertile 1	11%	75%	4%	5%
Tertile 2	13%	70%	5%	6%
Tertile 3	15%	66%	8%	8%
p for trend	0.02	0.003	0.04	0.68

N=~1800 pregnant women Oken et al.AJE 2004;160:774

Dietary Intake	College Grad	Parous	HH income <40K	HH income >70K
DHA+EPA				
Quartile 1	64%	65%	12%	56%
Quartile 2	66%	67%	9%	61%
Quartile 3	76%	70%	6%	61%
Quartile 4	75%	72%	8%	60%
p for trend	<0.0001	0.02	0.04	0.29
Fish				
No intake	60%	65%	10%	52%
Tertile 1	68%	66%	10%	60%
Tertile 2	72%	69%	7%	62%
Tertile 3	73%	73%	9.5%	60%
p for trend	0.0003	0.01	0.38	0.09

N=~1800 pregnant women Oken et al.AJE 2004;160:774

Higher Hg with higher fish intake

No difference in other characteristics

N=341	Fish intake		
	Never (14%)	<=2 svg/wk (74%)	>2 svg/wk (12%)
RBC mercury (ng/g)	1.9 (2.3)	3.9 (3.8)	5.6 (4.5)
RBC mercury top decile	2%	10%	23%
Hair mercury (ppm) (n=98)	0.28 (0.31)	0.56 (0.47)	0.80 (0.61)
DHA+EPA from fish (mg/d)	0 (0)	122 (97)	318 (160)
DHA+EPA total (mg/d)	22 (77)	148 (142)	301 (159)
Age (y)	31.7 (4.8)	32.8 (4.6)	32.3 (4.7)
White	85%	82%	85%
College graduate	82%	80%	83%
Breastfeeding (mos)	7.2 (4.4)	7.0 (4.5)	6.8 (4.7)

Maternal mercury and child cognition

Child test score	Age and sex	MV	MV + fish
PPVT			
Hg top decile	-5.3 (-10.1, -0.5)		
Hg < 90th %ile	Referent		
WRAVMA total			
Hg top decile	-3.4 (-7.0, 0.2)		
Hg < 90th %ile	Referent		

*MV adjustment = Child: fetal growth, gestation length, breastfeeding duration, birth order, language; Maternal: PPVT score, age, BMI, race/ethnicity, education, marital status, smoking; Paternal: education.

Maternal mercury and child cognition

Child test score	Age and sex	MV	MV + fish
PPVT			
Hg top decile	-5.3 (-10.1, -0.5)	-4.0 (-8.0, 0.0)	
Hg < 90th %ile	Referent	Referent	
WRAVMA total			
Hg top decile	-3.4 (-7.0, 0.2)	-3.5 (-7.2, 0.2)	
Hg < 90th %ile	Referent	Referent	

*MV adjustment = Child: fetal growth, gestation length, breastfeeding duration, birth order, language; Maternal: PPVT score, age, BMI, race/ethnicity, education, marital status, smoking; Paternal: education.

Maternal mercury and child cognition

Child test score	Age and sex	MV	MV + fish
PPVT			
Hg top decile	-5.3 (-10.1, -0.5)	-4.0 (-8.0, 0.0)	-4.5 (-8.5, -0.4)
Hg < 90th %ile	Referent	Referent	Referent
WRAVMA total			
Hg top decile	-3.4 (-7.0, 0.2)	-3.5 (-7.2, 0.2)	-4.6 (-8.3, -0.9)
Hg < 90th %ile	Referent	Referent	Referent

*MV adjustment = Child: fetal growth, gestation length, breastfeeding duration, birth order, language; Maternal: PPVT score, age, BMI, race/ethnicity, education, marital status, smoking; Paternal: education.

Maternal fish intake and child cognition

Child Test Score	Age and sex	MV	MV + Hg
PPVT			
Fish > 2x/wk	-1.5 (-7.3, 4.4)		
Fish <= 2x/wk	-2.2 (-6.5, 2.2)		
Fish never	Referent		
WRAVMA total			
Fish > 2x/wk	3.7 (-0.7, 8.1)		
Fish <= 2x/wk	0.7 (-2.5, 4.0)		
Fish never	Referent		

*MV adjustment = Child: fetal growth, gestation length, breastfeeding duration, birth order, language; Maternal: PPVT score, age, BMI, race/ethnicity, education, marital status, smoking; Paternal: education.

Maternal fish intake and child cognition

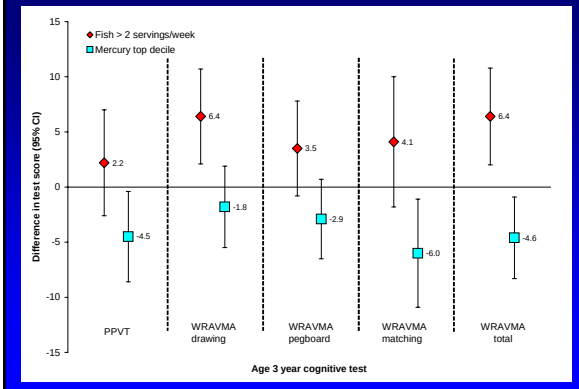
Child Test Score	Age and sex	MV	MV + Hg
PPVT			
Fish > 2x/wk	-1.5 (-7.3, 4.4)	1.2 (-3.5, 6.0)	
Fish <= 2x/wk	-2.2 (-6.5, 2.2)	-2.1 (-5.7, 1.4)	
Fish never	Referent	Referent	
WRAVMA total			
Fish > 2x/wk	3.7 (-0.7, 8.1)	5.3 (0.6, 9.6)	
Fish <= 2x/wk	0.7 (-2.5, 4.0)	1.1 (-2.2, 4.4)	
Fish never	Referent	Referent	

*MV adjustment = Child: fetal growth, gestation length, breastfeeding duration, birth order, language; Maternal: PPVT score, age, BMI, race/ethnicity, education, marital status, smoking; Paternal: education.

Maternal fish intake and child cognition

Child Test Score	Age and sex	MV	MV + Hg
PPVT			
Fish > 2x/wk	-1.5 (-7.3, 4.4)	1.2 (-3.5, 6.0)	2.2 (-2.6, 7.0)
Fish <= 2x/wk	-2.2 (-6.5, 2.2)	-2.1 (-5.7, 1.4)	-1.8 (-5.4, 1.8)
Fish never	Referent	Referent	Referent
WRAVMA total			
Fish > 2x/wk	3.7 (-0.7, 8.1)	5.3 (0.6, 9.6)	6.4 (2.0, 10.8)
Fish <= 2x/wk	0.7 (-2.5, 4.0)	1.1 (-2.2, 4.4)	1.5 (-1.8, 4.7)
Fish never	Referent	Referent	Referent

*MV adjustment = Child: fetal growth, gestation length, breastfeeding duration, birth order, language; Maternal: PPVT score, age, BMI, race/ethnicity, education, marital status, smoking; Paternal: education.



Continuous exposures

	PPVT	Total WRAVMA
Fish (weekly svg)*	0.6 (-0.3, 1.5)	1.2 (0.3, 2.0)
DHA+EPA fish (100mg/day)*	0.5 (-0.5, 1.5)	1.1 (0.1, 2.0)
DHA+EPA total (100 mg/day)*	-0.6 (-1.4, 0.3)	0.1 (-0.6, 0.9)
DHA+EPA in RBC (%)*	-0.1 (-0.8, 0.5)	-0.4 (-1.0, 0.3)
Blood Hg (ng/g)#	-0.4 (-0.8, -0.1)	-0.1 (-0.4, 0.2)
Log blood Hg#	-1.1 (-2.2, 0.04)	0.1 (-0.9, 1.2)
Hair Hg (ppm)# (n=98)	-2.0 (-6.7, 2.7)	-2.0 (-6.3, 2.4)

*adjusted for Hg; #adjusted for fish intake

Canned tuna fish

- 8% ate canned tuna at least 2x weekly, whereas 38% never ate canned tuna
- Higher scores for tuna > 2x weekly vs. never
  - PPVT: 3.7 (95% CI: -0.9, 8.3)
  - WRAVMA total: 5.6 (95% CI: 1.4, 9.8)

Limitations

- No measure of home stimulation
- Small sample
- May not be representative of larger US population
- Only a few outcomes
- Limited information about specific fish types
- No measure of PCB's/other toxicants

Conclusions

- Higher fish intake – higher mercury
- Higher mercury – lower age 3 scores
  - Stronger after adjustment for fish
- Higher fish intake – higher age 3 scores
  - Especially after adjustment for mercury
- Results generally consistent across all outcomes tested
- Extends our earlier findings

Mean 6 month VRM score by fish intake and Hg level

	Hair mercury <= 1.2 ppm	Hair mercury > 1.2 ppm
>2 weekly fish servings	72 (n=7)	55 (n=2)
<= 2 weekly fish servings	60 (n=114)	53 (n=12)

Unadjusted analysis

Oken E, et al. Env Health Perspect 2005;113:1376-80.

Similar findings with visual recognition memory testing at 6 months (n=135)

	Maternal 2nd tri fish intake (per svg/wk)	Maternal hair mercury at delivery (per ppm)
	Change in 6 month VRM score	
Fish	2.8 (0.2, 5.4)	---
Mercury	---	-4.0 (-10.0, 2.0)
Fish & mercury	4.0 (1.3, 6.7)	-7.5 (-13.7, -1.2)

Adjusted for maternal age, race/ethnicity, education, marital status; infant sex, gestational age, fetal growth, breastfeeding, age at testing

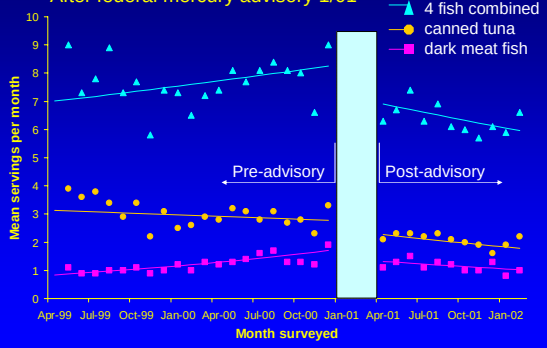
Oken E, et al. Env Health Perspect 2005;113:1376-80.

Conclusions (con't)

- Intake of n-3 fatty acids during pregnancy already poor; advisories may further worsen intake
- Decline in fish consumption after 2001 US federal mercury advisory

Decline in fish consumption

After federal mercury advisory 1/01



Oken E, et al. Ob Gyn 2003;102:346-51.

Conclusions (con't)

- Pregnant women should continue to eat low Hg fish
  - Though no overall harm from all fish types eaten by this population, including canned tuna
  - Greater benefit with lower Hg
- Future studies should include measures of both fish and Hg
- Recommendations for fish consumption during pregnancy should emphasize the nutritional benefits of fish as well as toxicant risks

Study team

- Chitra Amarasiriwardena
- David Bellinger
- Matthew Gillman
- Howard Hu
- Ken Kleinman
- Jenny Radesky
- Robert Wright
- Project Viva staff and participants

Questions and Answers

Comment: An additional analysis would be a multivariate analysis to examine the differences between participants who ate high amounts of fish with high mercury levels versus participants who ate high amounts of fish with low mercury levels, as well as a comparison to those participants who consumed no fish. (Mozaffarrian)

Q. *Do you have measures of the mother's diet during breastfeeding and/or children's diet? (Mozaffarrian)*

A. The survey did not address these questions.

Q. *Did you test the mercury levels in whole blood cells? (Sekerke)*

A. The tests were performed on packed red blood cells.

Q. *Did levels of DHA show differences in development at any other ages? (Sekerke)*

A. The tests were only performed at 3 years of age.

Q. *Were any analyses of total blood mercury performed? (Mahaffey)*

A. We did a rough calculation of total blood mercury; however, hair samples were more precise.

Q. *The results appear to show decline in fish consumption after the advisory. Did you see a decrease in DHA or mercury after the advisory as well? (Anderson)*

A. It is unclear whether we have enough mercury data to answer the question. The results of the DHA tests were only recently obtained.

Q. *Reference dose has an uncertainty factor of 10. Is this appropriate for use if we infer that the fish consumption advisory has decreased fish consumption? (Anderson)*

A. This question would be better for the open discussion.

[This page intentionally left blank.]

Summary on the Institute of Medicine's (IOM's) Report, Seafood Choices: Balancing Benefits and Risks

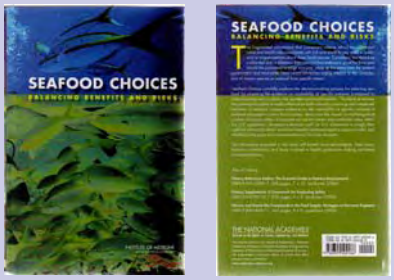
Malden Nesheim, Cornell University

Biosketch

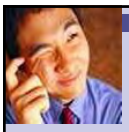
Dr. Malden C. Nesheim (Ph.D.) chaired the recent Institute of Medicine Committee on Risks and benefits of Seafood Consumption. He is Provost Emeritis and Professor of Nutrition, Director of the Division of Nutritional Sciences, and Vice President for Planning and Budgeting at Cornell University. He serves as the current Chair of the Board of Trustees of the Pan American Health and Education Foundation, and he has served as President of the American Institute of Nutrition, Chair of the NIH Nutrition Study Section, and Chair of the National Nutrition Consortium. He also chaired the 1990 USDA/Department of Health and Human Services Dietary Guidelines Advisory Committee. He is a Fellow of the American Academy of Arts and Sciences, the American Society of Nutrition, and the American Association for the Advancement of Science. His research interests include human nutrition, nutritional requirements, and nutrition policy.

Abstract

The Institute of Medicine of the National Academies released a report in October 2006 of a committee established to examine the nutrient relationships in seafood and to help consumers balance the risks and benefits. The study was conducted with funds provided by the Department of Commerce and the U.S. Food and Drug Administration. The report reviews the place of seafood in the American diet and the consumption trends over the past several years. The evidence of benefit from seafood consumption for pregnant women, children, and adults is summarized in the committee report. Similarly, evidence for risk from contaminants, including methylmercury, persistent organic pollutants, and microbial contamination, was also reviewed. Using the results of these reviews, the committee made recommendations on consumption of seafood by pregnant women, children, and adults that, in the judgment of the committee, would balance the benefits and risks. The committee also considered how consumers make decisions about what they eat and how to communicate issues of risk and benefit to consumers.



IOM Seafood Study 2007 National Academies Press
Food and Nutrition Board of the Institute of Medicine



Consumer Dilemma:

- Seafood is good for you

Consume regularly, but:

- Don't eat too much of wrong kinds from wrong places

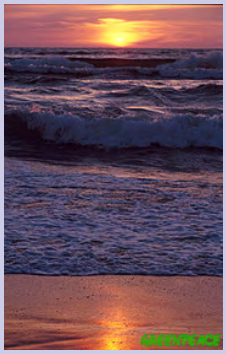
Consumer decisions re:

Farmed or wild
Endangered species
Where from?
Contaminants
Fatty acid content?

Long line caught
Trawl caught
Troll-pole caught
Hook and line caught

NOAA asked the Institute of Medicine to study benefits and risks associated with eating seafood

To help consumers make Informed choices.



Report concentrates on marine fish-
The primary ones available in the market

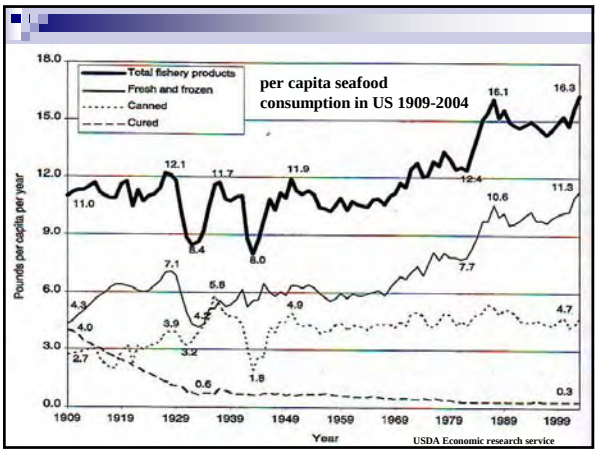
Committee on Nutrient Relationships in Seafood

- **Malden C. Nesheim, Ph.D. (chair)**
- **David Bellinger, Ph.D.**
- **Ann Bostrom, Ph.D.**
- **Susan Carlson, Ph.D.**
- **Julie Caswell, Ph.D.**
- **C. Earl Fox, M.D., M.P.H.**
- **Jennifer Hillard**
- **Susan Krebs-Smith, Ph.D.**
- **Stanely Omaye, Ph.D.**
- **Jose Ordovas, Ph.D.**
- **W. Steven Otwell, Ph.D.**
- **Madeleine Sigman-Grant, Ph.D.**
- **Nicholas Stettler, M.D., M.S.C.E.**

Report Outline

7 chapters - summary and appendices

- Introduction and Background
- Consumption patterns and composition
- Health benefits
- Health risks
- Balancing risks and benefits
- Understanding consumer decision making
- Supporting consumer seafood consumption Decisions



Sources of US Fish

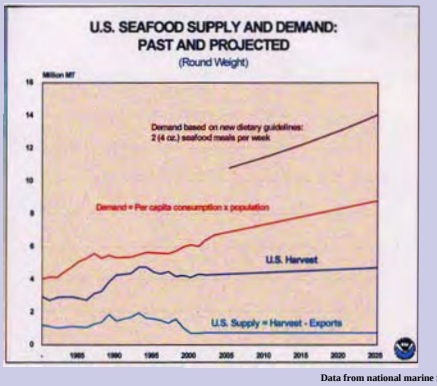
70% of US seafood is imported

40% of US seafood is from aquaculture
Shrimp, Atlantic salmon, catfish, trout, tilapia

USDA 2005 data

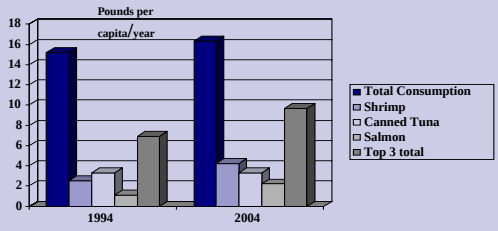
Seafood is the only major food source still supplied by capture of wild species

This creates issues not found with other foods



Data from national marine fisheries

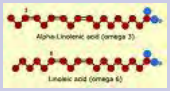
Seafood Consumption 1994-2004



Benefits of seafood

Healthful food- good source of good quality protein, low in saturated fat, a source of several vitamins and minerals

Seafood is richest source of the long chain unsaturated fatty acids, EPA, DHA

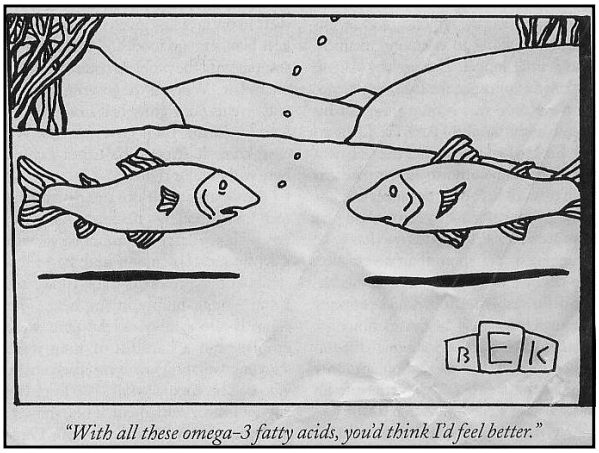


Findings - Women & Children

- **Duration of gestation increased**
- **Cognitive benefits in children**
- **Visual acuity in infants**
- **No convincing evidence about**
  - ADHD
  - Other behavioral issues
  - Asthma

Benefits:Findings with Adults

- **Seafood consumption**:
  - Decreased risk of cardiovascular deaths and Cardiovascular events in general population.
  - Mixed evidence for benefit of fish oil supplements for individuals with history of MI
  - Benefit inconclusive: blood pressure, stroke, cancer, asthma, type 2 diabetes, Alzheimer's



"With all these omega-3 fatty acids, you'd think I'd feel better."

Benefits and Risks Associated with Seafood Consumption

Benefits

- **Healthy food**
- **Development in infants**
- **Reduction of risk for cardiovascular disease**

Risks

- **Methyl mercury Especially pregnant Women**
- **POPs**
- **Microbiological Hazards**

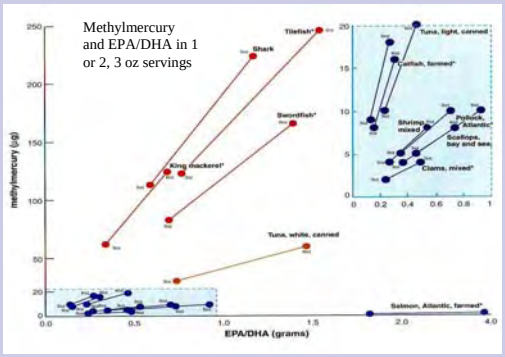
Risks to pregnant women and their child

Findings about risks

- **Methylmercury -most data available to consider risk**
- **POP exposures decreasing on population basis but vary greatly by geographic region**
- **Uncertainties for health risks of methylmercury and POPs in commercially obtained seafood.**
- **Seafood-borne illness not increasing but persistent and affected by consumer practices.**

Committee accepted FDA/EPA advisory on methylmercury

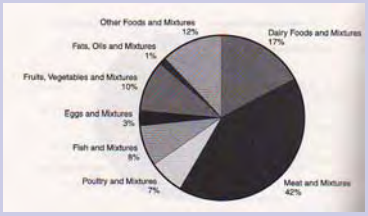
Methylmercury and EPA/DHA in 1 or 2, 3 oz servings



Effects of organic pollutants

- **Evidence for specific health effects inconsistent**
- **Inability to determine threshold level of adverse effect.**

Contribution of foods to DLC intake



The report spends considerable time discussing literature on how consumers make choices and the way consumer messages about benefit and risk could be devised.

Provided guidance to all segments of the population

Used expert committee approach on risks and benefits

Summary of advice

Females who are or may become pregnant or are breast feeding:

May benefit from consuming seafood, especially Those relatively higher in EPA and DHA

Reasonable intake: 2 3-ounce (cooked) servings a week, but can safely consume 12 ounces per week.

Pregnant Women

Can consume up to 6 ounces of albacore (white) tuna per week

Should avoid large predatory fish such as shark, swordfish, tilefish or king mackerel

Follow local advisories for locally caught fish

The committee provided the same advice to children up to 12 years of age except that serving size should be age appropriate

Adolescent males, adult males and females who will not become pregnant:

--May reduce their risk for cardiovascular disease by consuming seafood regularly e.g. 2 3-ounce servings a week

Those who consume more should consume a variety of seafood to reduce risk of contaminants from a single source

Adolescent males, adult males and females who will not become pregnant:

--May reduce their risk for cardiovascular disease by consuming seafood regularly e.g. 2 3-ounce servings a week

Those who consume more should consume a variety of seafood to reduce risk of contaminants from a single source

Adult males and females at risk of coronary Heart disease

Same advice as for other adults

Although supporting evidence is limited
There may be additional benefit for including
Seafood selections high in EPA/DHA

Recommendations

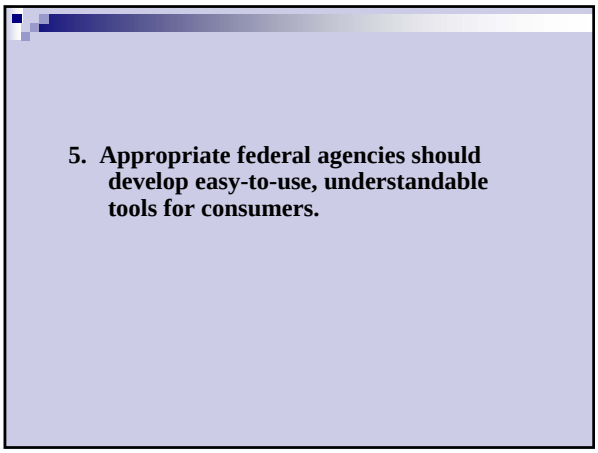
Federal agencies should:

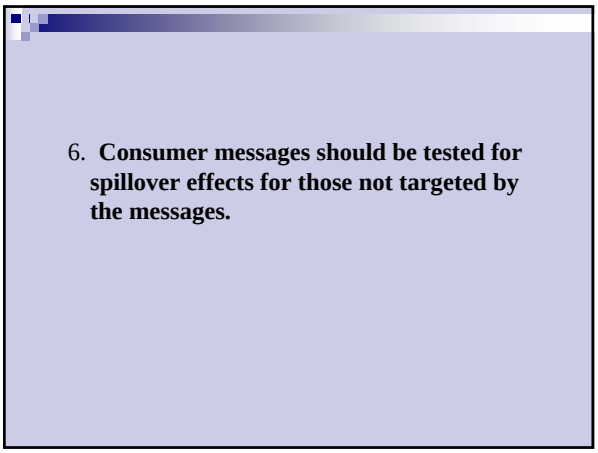
1. **Advise that seafood is part of a healthy diet .**
   Can substitute for other protein sources higher in saturated fat and improve the overall nutrient content of the diet

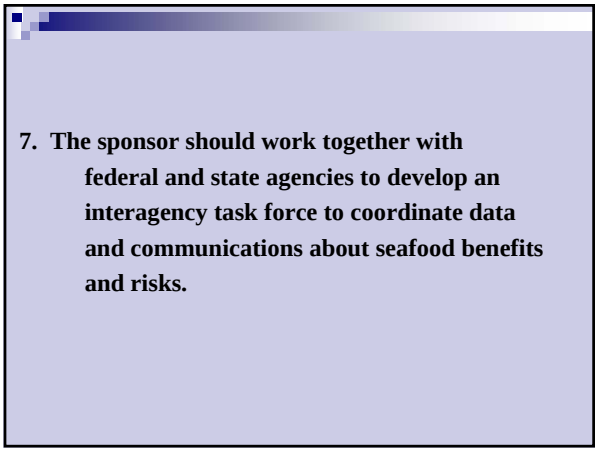
2. **Support inclusion of seafood in the diets of pregnant women. They should stay within federal and state advisories for certain types of fish.**

3. **Monitoring of methyl mercury and POPs should increase for seafood, and the results made available to the public**

4. **Sources and changes in types of seafood must be accounted for in the methodology used for sampling and analyzing for nutrients and contaminants.**


5. Appropriate federal agencies should develop easy-to-use, understandable tools for consumers.


6. Consumer messages should be tested for spillover effects for those not targeted by the messages.


7. The sponsor should work together with federal and state agencies to develop an interagency task force to coordinate data and communications about seafood benefits and risks.

Questions and Answers

Q. Could more be done to get the more contaminated fish out of the stores so that consumers could be more confident in their seafood choices? (Kyle)

A. It does not appear likely that these fish could be removed at this time.

Q. Can you comment on the use of pharmaceuticals in foreign fish? Guidelines should be all inclusive and not just pertain to certain contaminants.

A. It is important that guidelines provide advice on all contaminants. The IOM report does state that more monitoring and assessment is needed to provide better guidance.

Q. Was there a concrete portion size which was recommended or standardized in the IOM report? (Lee)

A. Portion size is an issue, but the IOM tried to follow the current portion size recommendations.

[This page intentionally left blank.]

Moving Beyond the Reference Dose to Compare Risks and Benefits of Fish Consumption

Joshua Cohen, Tufts-New England Medical Center

Biosketch

Dr. Joshua Cohen (Ph.D.) is a Research Associate Professor of Medicine at the Tufts-New England Medical Center Institute for Clinical Research and Health Policy Studies, in the Center for the Evaluation of Value and Risk. His research focuses on the application of decision analytic techniques to public health risk management problems with an emphasis on quantifying tradeoffs and on the proper characterization of uncertainty. Dr. Cohen is involved in a wide range of projects, including work on an online registry of cost-effectiveness analyses of medical interventions, a cost-effectiveness analysis of screening strategies for Alzheimer's disease, an analysis of the tradeoffs between the nutritional benefits of fish and resulting exposure to mercury, and an assessment of the risks associated with bovine spongiform encephalopathy in the United States. Dr. Cohen recently served on a National Academy of Sciences (NAS) committee charged with evaluating EPA's risk assessment of dioxin, and he currently serves on a NAS committee that is reviewing EPA's risk assessment practices in general. Dr. Cohen received his Ph.D. in Decision Sciences and his B.A. degree in Applied Mathematics from Harvard University.

Abstract

The U.S. Environmental Protection Agency's (EPA's) Integrated Risk Information System (IRIS) database characterizes the non-carcinogen risk associated with mercury (Hg) exposure in terms of the reference dose (RfD), which is designed to protect against the cognitive development effects of Hg due to *in utero* exposure. Although fish is an important source of Hg exposure, it is also rich in n-3 polyunsaturated fatty acids (PUFAs), which aid in cognitive development and also contribute to cardiovascular health in adult populations. As a result, changes in fish consumption patterns can result in a tradeoff between the benefits of reduced Hg exposure and the benefits of increased n-3 PUFAs. This discussion will explain why the RfD is an inadequate tool for the purpose of evaluating this tradeoff and describe an approach for evaluating the potential risks and benefits resulting from shifts in population fish consumption due to the EPA/U.S. Food and Drug Administration 2004 fish advisory. We find that the net benefits of such an advisory can be positive or negative, depending on the public's behavior. The results strongly depend on how the dose-response relationship data from the Faroe Islands studies are interpreted.

Moving Beyond the Reference Dose to Compare Risks and Benefits of Fish Consumption

Joshua T. Cohen, Ph.D.

Center for the Evaluation of Value and Risk
Institute for Clinical Research and Health Policy Studies
Tufts-New England Medical Center (NEMC)

July 2007

1

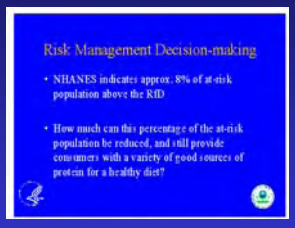
Questions Related to the 2004 Fish Advisory

1. What is the basis for the advisory – why those specific limits?
2. Does adherence to this recommendation improve child health?
   - What about the nutritional benefits of LC n-3 PUFAs?
   - What happens if compliance is imperfect?
3. How might other adults be affected by the advisory?

2

Part 1 - Basis for the 2004 Fish Advisory

FDA and EPA Development of a Joint Advisory for Methylmercury-containing Fish Consumption for Women of Childbearing Age and Children
July 2003



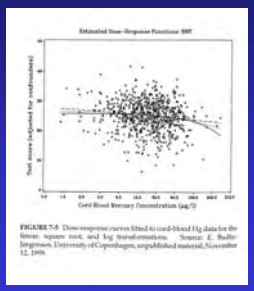
- Interpretation
  - Exposure > reference dose assumed unacceptable
  - Exposure < reference dose assumed "safe"

http://www.cfsan.fda.gov/~dms/mehg703b/sld034.htm

3

Reference Dose is an Artificial Line

- There is no evidence of an effect threshold
  - More Hg somewhat worse
  - Less Hg somewhat better



4

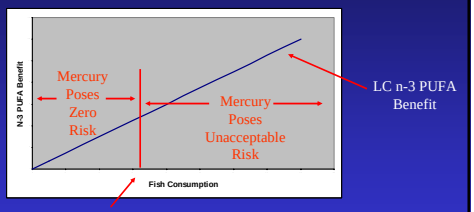
Preoccupation with Fish Consumption Resulting in Exposure > RfD

- National Research Council* estimated
  - "… that over 60,000 children are born each year at risk for adverse neurodevelopmental effects due to in utero exposure to MeHg" (p. 327).
  - Value corresponds to number of children above the reference dose
- Environmental Working Group**
  - "… an average woman following [FDA's] advice… would exceed a safe dose of mercury (the reference dose) by 30 percent…"

•National Research Council (2000). Toxicological Effects of Methylmercury. Washington, DC
•Environmental Working Group. 2003. Data Quality Act Challenge: Request for Correction of FDA's "Advice for Women Who Are Pregnant, or Who Might Become Pregnant, and Nursing Mothers, About Avoiding Harm to Your Baby or Young Child From Mercury in Fish and Shellfish

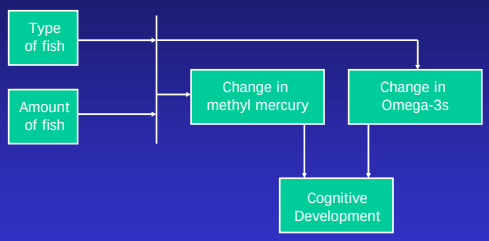
5

The Reference Dose Complicates Comparison of Risks and Benefits



6

Part 2 –Advisory's Implications for Child Health



7

Potential Scenarios Considered

- Challenge: We don't know advisory's actual impact on fish consumption
- Approach: Consider a range of plausible scenarios

	Scenario	
	Optimistic	Pessimistic
Women of childbearing age	Shift to low mercury fish but maintain same intake	Decrease total intake 17%*

* Estimate based on: Oken, E., et al. 2003. Obstet. Gynecol. "Decline in fish consumption among pregnant women after a national mercury advisory." 102:346-51.

8

Estimating MeHg – IQ Dose Response

- Weight standardized results from each test domain
- Weight corresponds to extent to which domain informs estimate of change in terms of IQ

Domain	Subjective Weight
Motor	0.2
Attention	0.3
Visuospatial/ Visuomotor	0.4
Language	0.6
Memory	0.6
Intelligence	1
Learning / Achievement	0.6

9

Within Each Test Domain

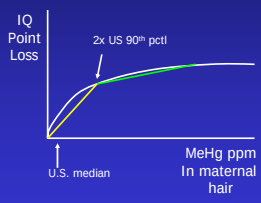
- Limit attention to 3 main longitudinal studies
- Weight by sample size
  - Proxy for precision

Population	Weight
Faroe Islands	734
Seychelles	643
New Zealand	115

Cohen JT et al. 2005. Am J. Prev Med "A quantitative analysis of prenatal methyl mercury exposure and cognitive development." 29(4):353-65 .

10

Linearization of Faroe Islands Results



Use FI slope over first quartile: 0.7 IQ points/ppm MeHg

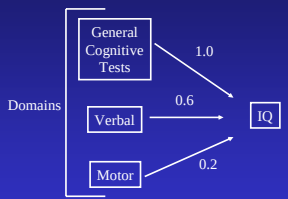
Use FI slope over 1st to 3rd quartile: 0.2 IQ points/ppm MeHg

Louise Ryan analysis with original data from FI study: 0.13 IQ points/ppm MeHg

We used the slope over the first quartile

11

Combining Results Across Studies Using Different Types of Tests



$$\text{Weighted influence} : \frac{\text{GenCog} + 0.6(\text{Verbal}) + 0.2(\text{Motor})}{1.8}$$

Cohen JT et al. 2005. Am J. Prev Med "A quantitative analysis of prenatal intake of n-3 polyunsaturated fatty acids and cognitive development." 29(4):366-74 .

12

Individual Risks and Benefits

	Scenario	
	Optimistic	Pessimistic
IQ gain per child	0.1 points	0.02 points

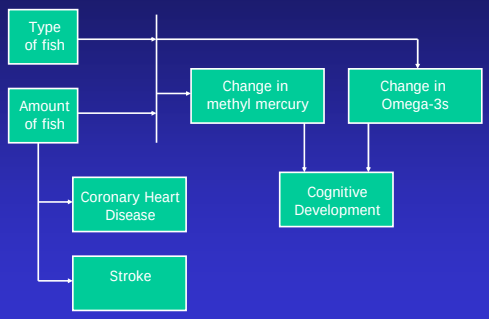
13

Aggregate U.S. Population Risks and Benefits

	Scenario	
	Optimistic	Pessimistic
IQ gain	410,000 points	92,000 points

14

Part 3 – Impact on Other Groups

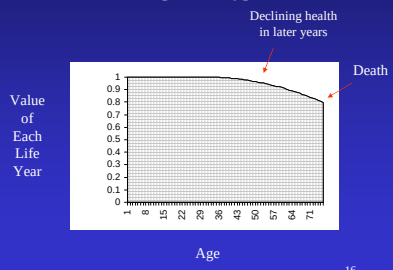


15

Health Effects Compared by Conversion to QALYs

- Value of year in perfect health = 1
- Value of death = 0
- Other health states between 0 and 1
- QALYs used extensively in the health economics literature

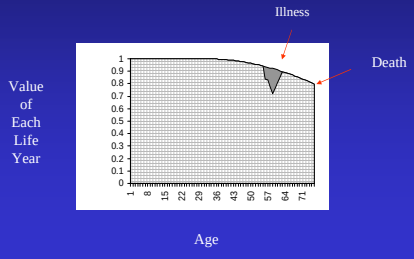
Example 1 – Typical Life



16

QALYs (continued)

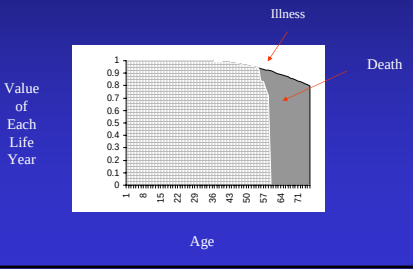
Example 2 – Illness followed by recovery



17

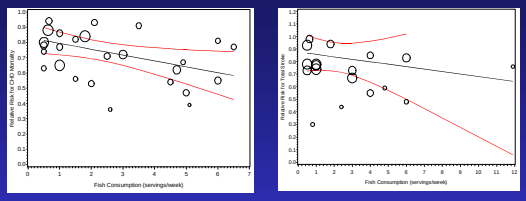
QALYs (continued)

Example 3 – Illness followed by death



18

Stroke and Coronary Heart Disease



CHD Mortality Stroke Incidence

Notes: Area of each circle is proportional to data point's weight. Red lines represent the 95% confidence interval for the best-fit dose-response.

Bouzan C et al. 2005. Am J. Prev Med "A quantitative analysis of fish consumption and stroke risk ." 29(4):347-52 .
Konig, A et al. 2005. Am J. Prev Med "A quantitative analysis of fish consumption and coronary heart disease mortality

19

Scenarios

	Scenario		
	Optimistic	Middle	Pessimistic
Women of childbearing age	Shift to low mercury fish but maintain same intake	Decrease total intake 17%	Decrease total intake 17%
Other adults	No change	No change	Decrease total intake 17%

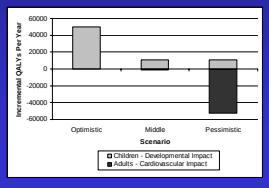
20

Results

Natural Units

	Scenario		
	Optimistic	Middle	Pessimistic
Cognitive – Net IQ points gained	410,000	92,000	92,000
CHD and stroke – annual fatalities	14	71	7,900
Non-fatal stroke – incidence	14	68	1,500

QALYs



21

Conclusions

- Advisory is beneficial to child health if women of childbearing age follow advice as intended
  - Maintain fish consumption
  - Shift to lower mercury fish
- Benefits remain positive if women reduce fish consumption instead of shift to low mercury fish
  - Net benefits substantially smaller

22

Conclusions (2)

- Small decreases in fish consumption among other adults (3% to 4%) can eliminate net benefits
- Assumed slope of MeHg-IQ dose response from Faroe Islands study is a key source of uncertainty

23

Questions and Answers

Q. I believe this study mischaracterizes the reference dose. Data from the Seychelles study are now showing effects of high mercury levels. Are you considering going back to look at the data given new results in the Seychelles study? (Mahaffey)

A. Further analyses cannot be completed without further funding. All of the methods used in this study are available for further analysis, but I believe the problem with the reference dose is that it does not give a probability of adverse effects at varying mercury levels.

Q. The mercury-selenium binding interaction may be able to help with the effects of high mercury levels. (Ralston)

A. There are internal and external generalizations that must be evaluated. The applicability of the Faroe and Seychelles data and conclusions must be evaluated.

Q. We use the Seychelles reference dose as an adverse effect of mercury, but it really represents the benefit of fish consumption minus risks of mercury consumption. Other studies look at supplements that display all of the benefits of fish consumption. Mercury studies show the effects of both omega-3 and mercury levels. (Anderson)

A. The mercury effects in the Seychelles study may be isolated more so than the benefits of omega-3's I believe it is extremely important to perform research and marketing analyses on the effect of fish consumption advisories to ensure that the public is not more alarmed by the risks of mercury than persuaded by the benefits of fish consumption.

Synthesis for Fish Consumption Advisory Impacts

Gary Ginsberg, Connecticut Department of 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

While some studies have focused on the adverse neurodevelopmental effects of mercury (Hg) from fish ingestion (Axelrad, et al., 2007; Budtz-Jorgenson, et al., 2000; Crump, et al., 1998; Davidson, et al., 1998), others have focused more on the benefits of fish consumption (Daniels, et al., 2004; Hibbeln, et al., 2007). Reviews have provided an important perspective, but not a quantitative analysis or framework that could be used in developing fish consumption advisories (e.g., Mozaffarian and Rimm, 2006). However, one particular study (Oken et al., 2005) provides data on the risks and benefits of fish consumption on neurodevelopment, putting these two counter-balancing effects on a common scale–visual recognition memory (VRM) at 6 months of age. Oken et al. found that VRM was negatively associated with maternal hair Hg, but it was positively associated with the number of fish meals and omega-3 fatty acid intake. After adjustment for confounding factors, the increase in VRM score per weekly fish meal (4 units per meal), per 100 g omega-3 fatty acids per day (2 units/100 g), and the decrease per ppm of maternal hair Hg (-7.5 units per ppm), could be used in a combined risk/benefit analysis. Using the one compartment fish biokinetic model, we estimated the increase in hair Hg concentration per fish meal for a range of species (e.g., swordfish, cod, tuna, salmon). We also estimated the omega-3 fatty acid intake per day from ingestion of these species. The expected VRM decrement due to Hg was subtracted from the benefit expected from the omega-3 fatty acid dose to yield a net effect on VRM score for each fish. A plot across all analyzed species shows the negative influence of swordfish and shark on one end, the positive influence of herring and salmon on the other, with a variety of species at intermediate levels of net risk or benefit. This exercise was conducted purely as a demonstration project, which is not ready for fish consumption advisory development because the source data are too limited in many respects; however, it points out the type of information needed to conduct a quantitative risk/benefit analysis for Hg and omega-3 fatty acids in fish.

Risk-Benefit Synthesis for Fish Consumption Advisories

Gary Ginsberg
Connecticut Dept of Public Health

National Forum on Fish Contaminants
Portland ME July, 2007

Introduction

- Review Risk Benefit Approaches for FCA
- Recent Qualitative Approaches
- Recent Quantitative Efforts
- Quantitative focus on Risk-Benefit of Individual Species
- Summary / Discussion Points

Possible Risk Benefit Approaches for FCA

- Retain current advisory but improve risk communication – only balance the msg?
- Redo current advisory in some way to better balance the advisory?
- Refocus advisory on individual fish?
- Separate risk-benefit assessment for diff endpoints and types of receptors?

Qualitative Assessment: IOM, 2006

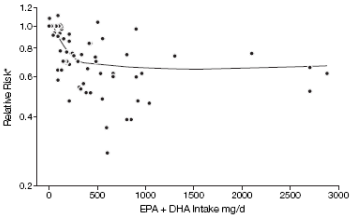
- Qualitative review of fish consumption patterns, benefits,risks, uncertainties
- Recommendations
  - Include seafood in diet
  - Keep consumption w/in federal advice for high risk group for mercury in seafood
  - Increase monitoring
  - Gen pop – eat 2 3oz meals/wk – CV benefit
    - If eat more, choose from a variety of species

Qualitative Evaluation: Mozaffarian and Rimm, 2006

- Reviewed D/R for CV benefits and Hg risks
- Table of nutrients & contams in fish species
- Reviewed costs, supplements, n6:n3 ratio
- Evidence synthesis
  - Benefits outweigh risks – but …..
  - Women of CBA/nursing moms - follow federal advice
  - All others, no limits; if > 5 mls/wk, no high Hg species
  - Don't worry about cancer risks from organoCl's

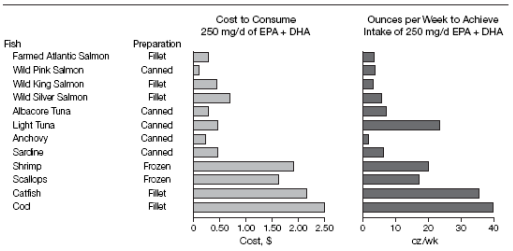
Mozaffarian and Rimm, 2006

Figure 2. Relationship Between Intake of Fish or Fish Oil and Relative Risks of CHD Death in Prospective Cohort Studies and Randomized Clinical Trials



Mozaffarian and Rimm, 2006

Figure 6. Estimated Costs of Consuming the equivalent of 250 mg/d EPA + DHA From Fish

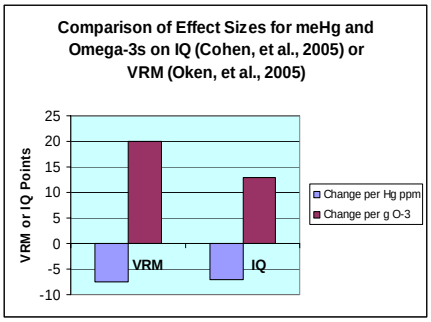


Quantitative Analyses

- Ponce, et al., 2000
  - MI prevention benefits of fish vs
  - meHg neurodevelopmental effects
    - delayed speech - Iraq - maternal hair
  - weighted by QALYs
  - evaluated net effect of fish consumption
    - Risk - benefit of MI vs CNS development
    - Across range of fish concs (0-2 ppm)
    - Endpoints differ, key receptors differ, not species specific

More Quantitative Analysis

- Cohen et al, 2005
  - Regression slopes for
    - meHg on IQ
    - DHA on IQ
    - fish consumption on stroke and CHD
  - Evaluated ↓ed consumption from advisories and over-reaction
  - Standardized fish consumption patterns and federal databases for meHg and omega-3
    - no individual fish analyzed
  - Converted health endpoints to QALYs



Conclusions – Cohen et al.

- Fish consumption advisories can yield developmental benefits if followed
- Can lead to increased risks if advisory → worry → fish avoidance

•Are fish advisories that focus on good species less likely to cause avoidance?

Risk-Benefit Analysis of Oken et al., 2005

Table 2. Associations of maternal second-trimester fish consumption and maternal hair mercury at delivery with infant cognition at 6 months (VRM score): results from six linear regression models among 135 mother–infant pairs in Project Viva.

Model	Change in VRM score [% novelty preference (95% CI)]	
	Effect per weekly fish serving	Effect per ppm maternal hair mercury
Fish only	2.5 (–0.01 to 5.0)	—
Fish and participant characteristics[a]	2.8 (0.2 to 5.4)	—
Mercury only	—	–4.6 (–10.3 to 1.1)
Mercury and participant characteristics[a]	—	–4.0 (–10.0 to 2.0)
Fish and mercury	3.9 (1.2 to 6.5)	–8.1 (–14.1 to –2.0)
Fish, mercury, and participant characteristics[a]	4.0 (1.3 to 6.7)	–7.5 (–13.7 to –1.2)

[a]Participant characteristics adjusted for include maternal age (continuous), race/ethnicity (white vs. nonwhite), education (college graduate vs. not), marital status (married or cohabiting vs. not), and infant sex, gestational age at birth (continuous), birth weight for gestational age (continuous), breast-feeding duration (continuous), and age at cognitive testing (continuous).

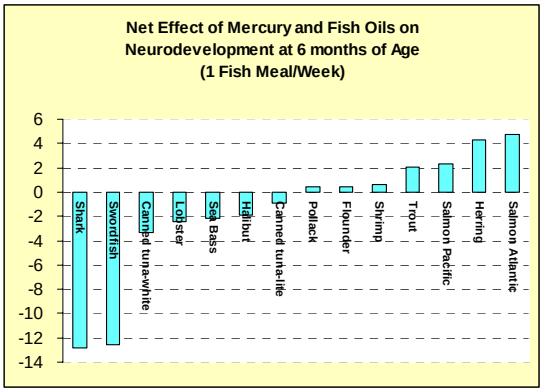
Analysis of Oken Data

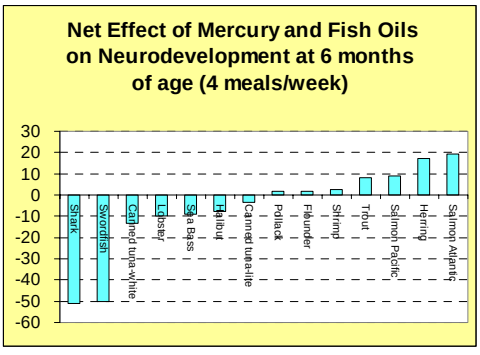
- Dose response relationships
  - change in VRM per ppm hair Hg = -7.5 pts
  - change in VRM per 100mg/d O-3 = 2.0 pts
    - (p=0.094)
- Fish Hg and O-3 data from FDA, USDA, 2005, American Heart Assoc, Mozaffarian & Rimm, Domingo, 2007, Burger, 2005
- One compartment PK model to convert fish meal (3oz) to hair Hg concentration

Net VRM Benefit or Loss =

((O-3 mg/meal) (#meals/wk)(1 wk/7d)*(2 VRMpts/100mg O-3)) –

((Hair Hg/fish meal/wk) (7.5 VRM pts/1 ppm Hair Hg))





Limitations in Current Data

- Common metric data for toxicant and fish nutrients not commonly available
  - Endpoints may differ - Toxicant may cause cancer, nutrient may help neurodevelopment
- Multiple contaminants and nutrients
  - Hg, PCBs, dioxin, pesticides, PBDEs
  - O-3s, iodine, selenium, iron, protein
- Thus far, limited datasets, weak stat power

Summary

- Burger: Cultural benefits
- Golding: ALSPAC - fish benefits on CNS
- Oken: Viva – fish benefit, Hg risk on CNS
- Nesheim: IOM – seafood impt, advice impt
- Cohen: QALYs risk-benefit analysis
- Ginsberg: Risk-benefit by fish species

Discussion Points

- Fish advisories – not a matter of what but how?
  - Is advice correct, but only need better communication?
    - Should there be more focus on good fish?
  - Are there adjustments needed – more than 2 meals per week for really healthy fish?
  - Do we need better analytical tools for risk-benefit equation?
    - QALYs vs other approaches
  - What data needs to inform better risk-benefit analysis?
    - Hg and nutrient fish data, refined epi studies, more endpoints

Questions and Answers

Q. Do you feel that omega-3 levels calculated from study surveys may be overestimated with respect to the mercury found in hair samples? (Mozaffarrian)

A. As a risk assessor, my highest priorities are to steer people toward the consumption of fish species with low contaminant levels, and to stress the importance of both quantity and quality of study results.

Panel Discussion on Risks and Benefits

Emily Oken, Joshua Cohen, Joanna Burger, Malden Nesheim, Jean Golding, Gary Ginsberg, and Dariush Mozaffarian

Q. *We have a measure for prenatal health, but we don't test for omega-3's and mercury during early pregnancy. Why aren't we testing for omega-3's in lipid profiles? It may be more effective to tailor specific advice to individuals than to provide a blanket fish consumption advisory. (Anderson)*

A. There are critical periods in neonatal development. More information needs to be known about the development than just omega-3 levels in the first trimester. (Burger)

A. Part of the purpose of the advisory is to prevent women entering into the first trimester with high mercury levels. (Ginsberg)

A. Additionally, more information is needed before we can say if individual advice is effective from a cost-benefit perspective. (Oken)

A. An omega-3 index has been suggested, but pertinent information may be able to be gained by asking fish consumption questions even without the tests. (Mozaffarian)

A. We cannot assume all mercury is obtained from fish consumption. (Golding)

A. Long-term effects need to be looked at quite carefully before the endpoints and effects of omega-3 and mercury levels can be determined with confidence. (Nesheim)

Q. *I am concerned that full-scale IQ is used as an endpoint, as IQ is a complex measure containing responses in language, auditory, etc. Reporting a full-scale IQ is ignoring the subtlety of IQ. That is, we need to know what portion of cognition is really being enhanced by omega-3's or what portion of decline is due to mercury effects. (Bradbard)*

A. IQ analysis is a complicated concept. The Faroes study has seven different tests to look for patterns and attempt to understand what is going on biologically. But we have to make decisions on the net benefits or risks at this point in time. The question needs to be addressed at different levels. (Cohen)

Q. *The children with the highest mercury concentrations correspond to the lowest ADD [Attention Deficit Disorder] test responses. IQ scores at young ages only marginally correspond to IQ levels at 7 years of age. Can you comment on this? (Bradbard)*

A. The quality and strength of the evidence needs to be parsed more strongly. In mercury studies, subtleties are not often adjusted for, although they need to be. There's a difference between understanding the science and making advice to be safe since we don't know the certainties. Given uncertainties, it is better to be the safe side. (Mozaffarrian)

Q. *What do you say to the women that have consumed more fish but do not intend to get pregnant? (Gochfeld)*

A. If the half-life of mercury was on the order of hours instead of months, I wouldn't mind relaxing the principles. Half of all pregnant women do not intend to get pregnant, however. (Ginsberg and Oken)

Q. *How satisfied were you with the press response to the IOM report? Where did the spin enter the press releases? (Frohmberg)*

A. You cannot control what comes out of a report as far as findings, but fish consumption advisories were advocated. I was pleased with the press reports stemming from Mozaffarrian's study and IOM.

Both said there were benefits and they did mention the cautions of the reports. Some groups try to be blind to the risks of fish. (Nesheim)

A. It is more important to gage the people's impression of the press. I feel that the bias is that fish is more harmful than beneficial. More people are more worried about the risks than knowledgeable about the benefits. (Mozaffarrian)

A. I believe more people know more about the benefits than risks of fish consumption. More information is needed overall. (Burger)

A. It would be beneficial for panel data to have been collected from supermarkets to assess how consumption changes over time. (Cohen)

A. The IOM headline tended to be confusing since the headlines said fish are beneficial but did not stress the advisory information. (Ginsberg)

Q. How do we tailor this advice to people consuming the fish with the highest mercury? (Kim)

A. It would be preferable to provide advice rather than commenting on their current diets. We want to present a model that works within cultural habits, etc. (Burger)

Q. How linear is the dose-response curve if you consume one meal per week? Are you getting enough of the benefits? Can you elaborate on EPA/DHA on infant development? What is the strength of the evidence since the testing has been performed using supplements? (Mahaffey)

A. So far, data have only shown that the people who eat fish seem to be doing better than people are not eating fish. More research is needed. Regarding infant development, there may be other benefits to fish, but we do know there are particular benefits to EPA/DHA. (Nesheim)

A. All prenatal fish consumption studies have shown a benefit, even though more studies have been performed using EPA/DHA supplements. (Oken)

A. The bulk of the benefits are correlated with EPA/DHA. There could be other components in fish that make a difference. (Mozaffarian)

Q. It appears that all commercial fish are providing the really high levels of mercury. Are these fish still considered beneficial? (Sekerke)

A. If there is a threshold to the benefits of EPA/DHA, people who consume high levels of commercial fish could be entering a range where risk outweighs the benefits. (Ginsberg)

Q. With regard to Sheila Innis' presentation, we need to be careful because we do not know the optimal level of EPA/DHA. Some of the effects may be due to nutritional deficiencies. Some recommendations were 300 mg to 400 mg of EPA/DHA during pregnancy. What do you think? (Sheeshka)

A. I think those recommendations may have been retracted as there are limited data on the level of blood EPA/DHA. Many studies extrapolate from post-natal, but this may not be accurate. (Oken)

A. People are very bright, able to make risk decisions, and are anxious for more information. (Burger)

A. Basic science about mercury from toxicologists makes it difficult to decide whether people have been more responsive to risk communication or benefit communication. (Oken)

A. This is a tradeoff problem in which we are always confronted with uncertainty. The question is, do we act now with what we think we know? (Cohen)

A. As a rule, fish is generally healthy. It may be appropriate to question why there are not as many forums on the consumption of other food types. (Mozaffarian)

A. Mercury stands out because it is not like other contaminants and because it primarily comes from fish. It is important to maximize the benefit. If something can come out of a species-by-species analysis of fish consumption risks, we might be able to maximize the benefits. (Ginsberg)