Balancing the Risks and Benefits of Seafood Consumption: A Tribute to the Career of the Late Kathryn R. Mahaffey

Elsie M. Sunderland
Harvard University
School of Engineering & Applied Sciences
and School of Public Health, Cambridge MA
(ems@seas.harvard.edu)

Harvard School of Engineering and Applied Sciences

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Kathryn R. Mahaffey (1943-2009)

Nutrition Reviews: Balancing benefits of n-3 polyunsaturated fatty acids and the risk of methylmercury exposure from fish consumption.

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Spectrum of Health Effects & Credibility

EPA RfD (2000) fetal neurodevelopmental effects
= 0.1 ug/kg body weight per day = 5.8 ug/L blood

Children IQ Deficits

Adult Cardiovascular Effects

From fetal exposures above MeHg RfD	From any fetal MeHg exposures	Male consumers of non-fatty freshwater fish with high MeHg	Male fish consumers	All fish consumers

Decreasing Credibility

Source: Rice and Hammitt, 2005

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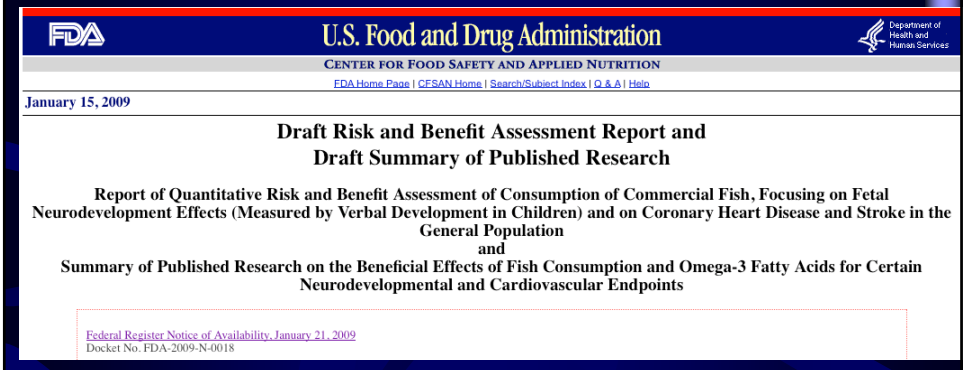
Revised FDA Guidelines?



FDA U.S. Food and Drug Administration Department of Health and Human Services

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January 15, 2009

Draft Risk and Benefit Assessment Report and Draft Summary of Published Research

Report of Quantitative Risk and Benefit Assessment of Consumption of Commercial Fish, Focusing on Fetal Neurodevelopment Effects (Measured by Verbal Development in Children) and on Coronary Heart Disease and Stroke in the General Population
and
Summary of Published Research on the Beneficial Effects of Fish Consumption and Omega-3 Fatty Acids for Certain Neurodevelopmental and Cardiovascular Endpoints

Federal Register Notice of Availability, January 21, 2009
Docket No. FDA-2009-N-0018

Docket was open for public comments last spring.

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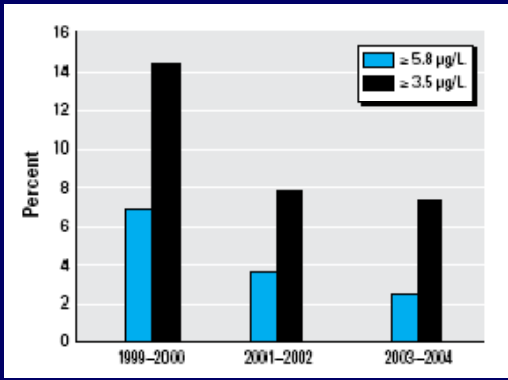
Temporal Trends in Blood Hg 1999-2004 from NHANES survey

Women Ages 16-49

~6% > EPA's RfD (1999-2002) => 316,588 - 637,233 children



Source: Mahaffey et al., 2009, Environmental Heath Perspectives

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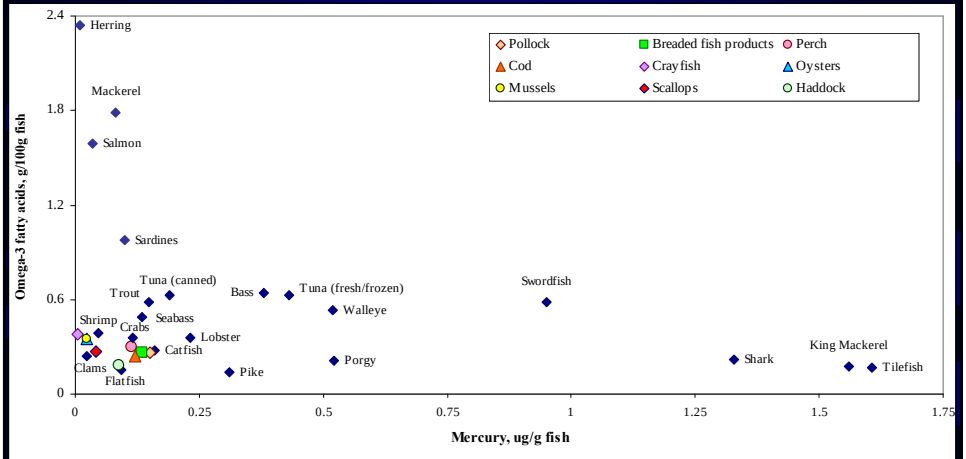
Good Fish? Bad Fish?



Source: Mahaffey et al., 2008, Environmental Research

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Why are the essential fatty acids important metabolically?

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

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Omega-3 Fatty Acids

- Fatty acids with a double bond between the carbon atoms (-C=C-) have to be supplied in the diet because humans cannot synthesize them.

Alpha-linolenic (18:3 omega 3)

CH_3-CH_2-CH=CH-CH_2CH=CH-CH_2-CH=CH-$(CH_2)_7$-COOH

Used to synthesize:

Eicosapentaenoic or EPA (20:5 omega 3),
Docospentaenoic (22:5 omega 3) or DPA and

Docosahexaenoic (22:6 omega 3) or DHA

CH_3-CH_2-CH=CH-CH_2-CH=CH-CH_2-CH=CH-CH_2-CH=CH-CH_2-CH=CH-CH_2-CH=CH-$(CH_2)_2$-COOH

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Omega-3 Fatty Acids

- α-linolenic acid comes from dietary oils – predominantly soybean oil and flax seed oil.

- EPA and DHA
  synthesized from the precursor α-linolenic acid *or*
  supplied preformed from the diet.

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Human Capacity to Synthesize EPA and DHA from ά Linolenic Acid

- If alpha linolenic is in the diet humans can make some EPA and DHA. Adult males seem to form less than 10% of the amount that is needed.
- Women, especially during pregnancy, are able to form EPA and DHA at a higher rate because of the effects of estrogens.
- Fetus depends on transfer of EPA and DHA from the mother - Both are important to optimal neurological status during development.

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Dietary Sources of Omega-3s

- Algae – basic source.
- Fish, shellfish, and marine mammals are the usual sources, but depend on algae for basic synthesis.
- Other animals (chickens, beef) can be a source of omega-3 fatty acids if these animals are grown “free range” or are able to graze in the open.
- Special diets fed to chickens can produce eggs containing more than 600 mg of omega-3 fatty acids per each 100 gram egg.
- Food supplements such as fish oil or supplements based on algae.
- Biotechnologically produced omega-3 fatty acids; e.g. microalgae.

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The Balance: Omega-3s and Methylmercury in Seafood

- Recommendations (US NAS/NRC) = average 1350 milligrams/day
- Reference dose for CH_3Hg based on fish consuming cohorts
- *Little association between* CH_3Hg *in fish and DHA in fish.*
- Can have nutritional benefit from fish and still have low CH_3Hg intake

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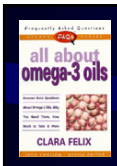

Nutritional Recommendations

- Nutritionists recommended a 4-fold increase in fish consumption in order to attain the proposed recommended combined EPA and DHA intake of 650 mg/day (Kris-Etherton et al., 2000).
- *If levels of 1600 for men and 1100 mg/day are used this would be approximately an 8-fold increase in fish intake.*
- This would result in an increase in exposure to methylmercury and other contaminants.

How much fish do you need?

- *Mackerel provides 1790 mg combined EPA and DHA/100 gram serving. Takes ~ 75 grams of mackerel to provide 1350 milligrams of combined EPA and DHA.*
- Cod contains 250 mg combined EPA and DHA/100 gm serving. Takes ~560 grams of cod to provide 1350 milligrams combined EPA and DHA.

Omega-3 Content of Fish & Shellfish Vary Widely - Virtually All Contain Methylmercury

Fish Species	EPA + DHA Mg/ 100 gms of Fish	Hg µg/g of Fish	Gms of Fish Containing 1350 mg EPA + DHA	Hg intake for 1350 mg EPA + DHA in this fish species.	µg Hg per kg bw for a 70 kg adult
Mackerel	1790	0.087	75	6.5	0.09*
Salmon	1590	0.035	85	3.0	0.04*
Swordfish	580	0.950	230	220	3.2
Cod	240	0.121	560	68	0.97

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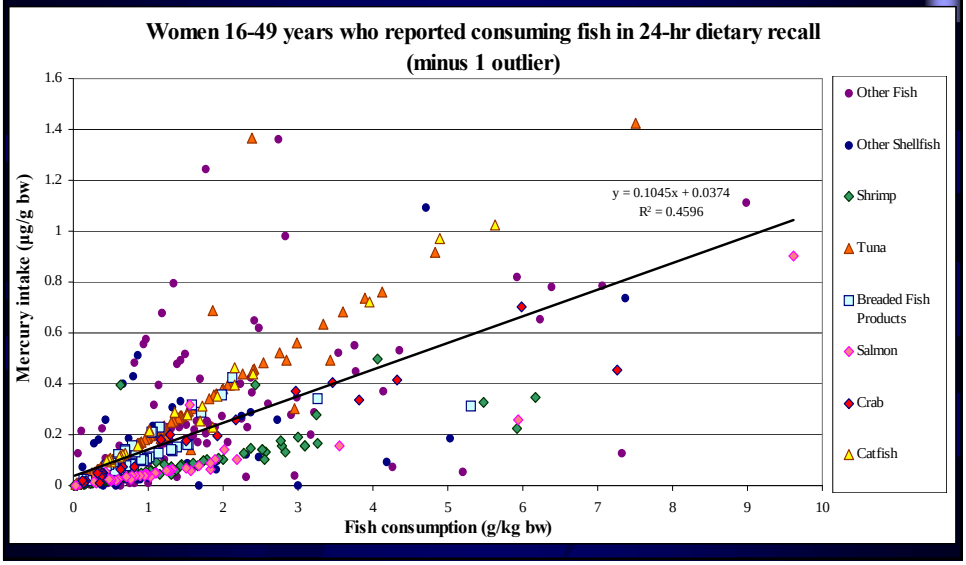
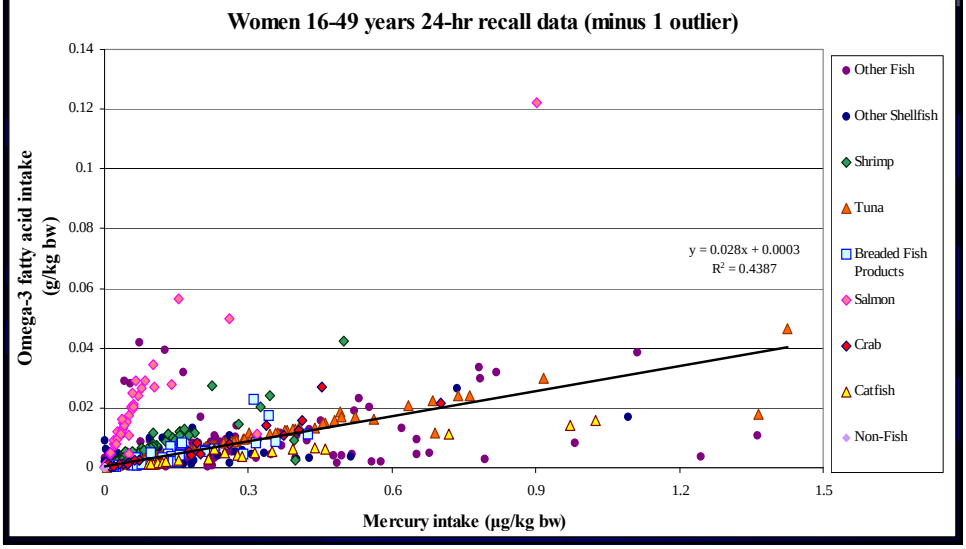
NHANES 1999-2002

Correlation between Total Fish Intake and Mercury Intake, both normed to body weight (Pearson Correlation R=0.68, p<0.001, n=509). *(Mahaffey et al., Env Res 2008)*



NHANES 1999-2002

Omega-3 Fatty Acid (EPA + DHA) and Mercury Intake from Fish
(Pearson Correlation R=0.66, p<0.001, n=3,614).
(Mahaffey et al., Env Res 2008)



If fish alone were relied upon to increase the intake of omega-3 fatty acids the following problems would occur:

- Potential for severe depletion of marine fish.
- *Need to rely more on other sources*
- If there were an 8-fold increase in fish intake, there would be increased exposure to contaminants. How severe the increase is depends on pollution and on the fish species.

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Reducing MeHg Exposures

- Pollution control – the most important solution. But may be a very long term solution.
- Use of algae.
- Use of biotechnology.
- Use of diet modification to increase the omega-3 fatty acids in other non-fish foods.
- Use of food enrichment with EPA and DHA. In US approximately 100 food products have DHA added to them.

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Important Data Needs

- More quantitative data on human ability to synthesize EPA and DHA from ά-linolenic acid.
- *More information on which species of fish are consumed in individual countries.*
- More data on the EPA and DHA concentrations of specific fish species.

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