

Perspective on potential benefits and harms of fish consumption

Emily Oken, MD, MPH

Weighing fish consumption

Alternatives

Other
toxicants

DHA



Hg

Other nutrients
(Vit D, Iodine)

Ecological
concerns

Toxicant exposure - complexities

- Multiple contaminants may co-occur, with different or interactive health effects
 - PCBs and other persistent organic compounds, heavy metals, “contaminants of emerging concern” such as pharmaceuticals, personal care products, and perfluorinated organic compounds
- Most studies (and advisories) focus on single contaminants

Toxicant exposure - complexities

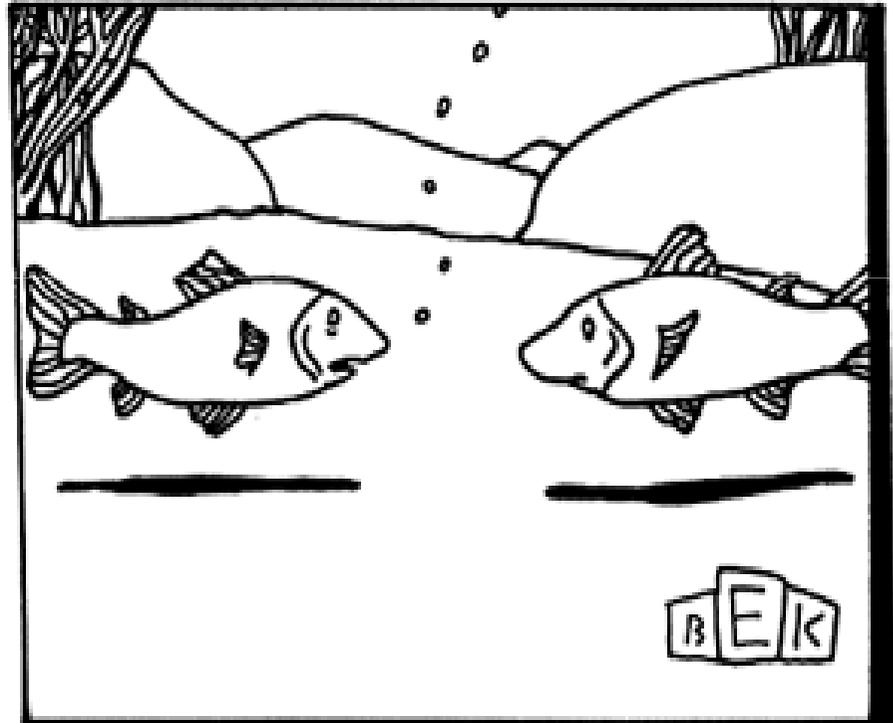
- Toxicant levels vary!
 - Within fish species – FDA threshold
 - Swordfish (“do not eat”) – mean 1 ppm mercury, but some fish 0 ppm
 - Halibut (fine) – mean 0.24 ppm, but up to 1.5 ppm
 - By source
 - Tilefish (“do not eat”) – high mercury if from Gulf of Mexico, low mercury if from Atlantic

Toxicant exposure - complexities

- Variable susceptibility to toxicities
 - Variation among individuals, also by stage of lifecycle
 - Fetus especially susceptible
 - US EPA/FDA advice specific to pregnancy, no advice for non-pregnant adults
 - Very limited information about effects on children
- Confounding by nutritional benefits

Fish is the primary dietary source of omega-3 long-chain polyunsaturated fatty acids

- Omega-3 LCPUFA:
 - Essential nutrients – we can't synthesize them, have to eat them
 - Necessary for fetal optimal fetal brain, eye development (DHA)
 - Most women eat too little: recommended 1400 mg DHA/week, US mean ~500 mg/wk



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



Maternal mercury and child cognition with low exposure

Child test score	Age and sex	MV
<hr/>		
Peabody Picture Vocabulary Test		
Hair Hg >1ppm	-5.3 (-10.1, -0.5)	-4.0 (-8.0, 0.0)
Hg < 90 th %ile	Referent	Referent
Wide Range Assessment of Visual Motor Abilities		
Hair Hg >1ppm	-3.4 (-7.0, 0.2)	-3.5 (-7.2, 0.2)
Hg < 90 th %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.



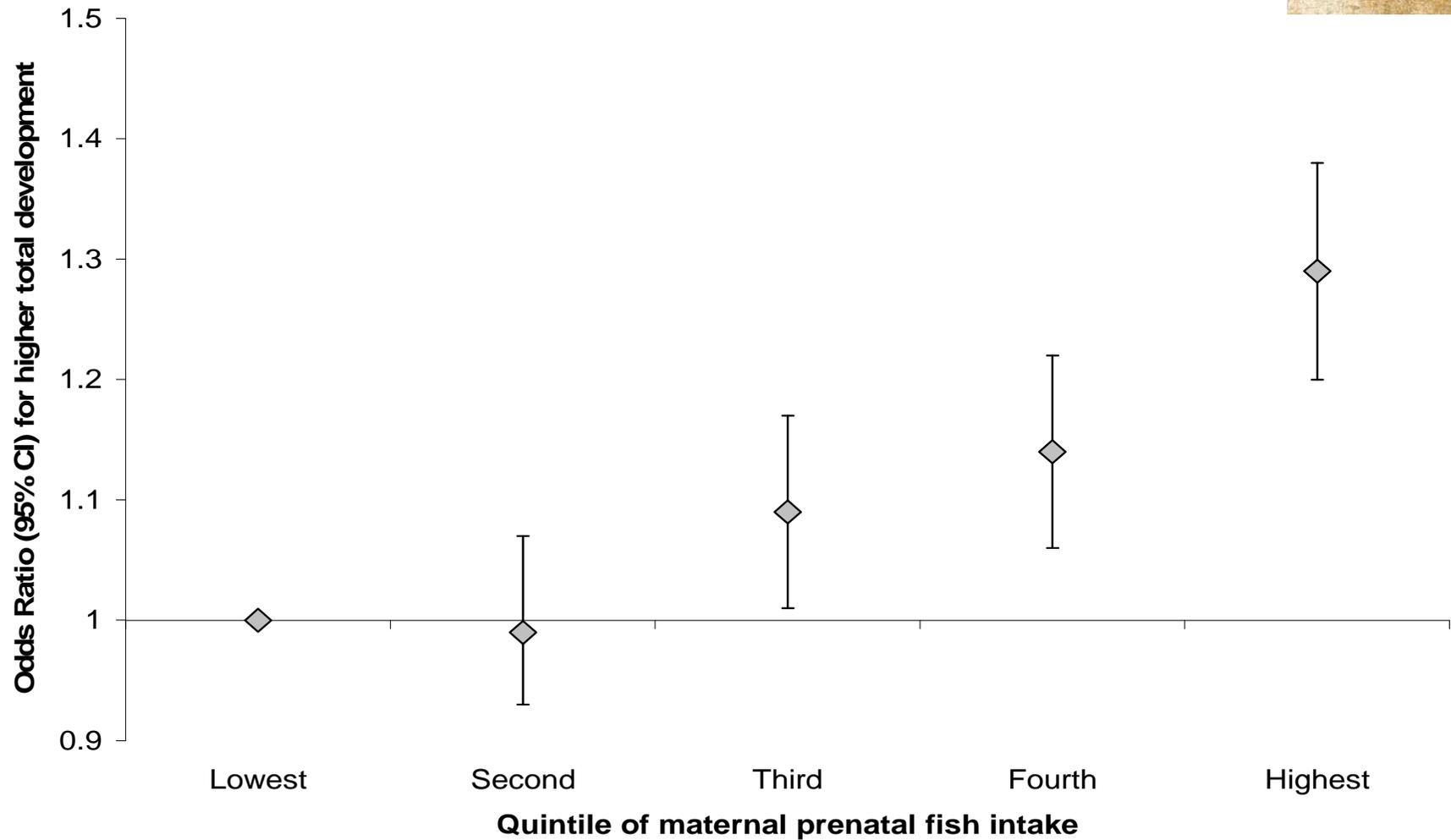
Maternal fish intake and child cognition – Project Viva

Child	Age and sex	MV
Test Score		
Peabody Picture Vocabulary Test		
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
Wide Range Assessment of Visual Motor Abilities		
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.

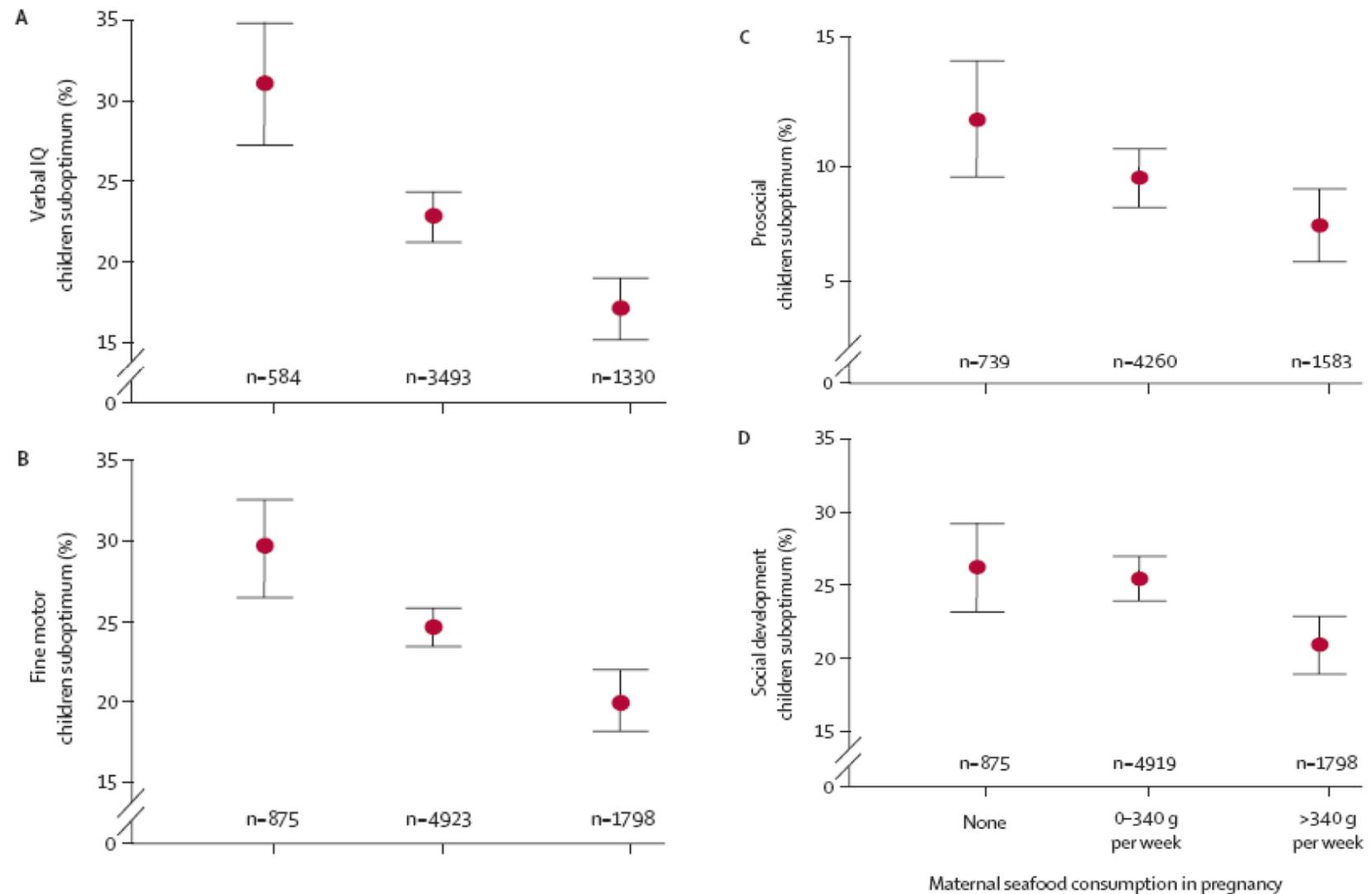


Danish National Birth Cohort



Oken, et al. Am J Clin Nutr 2009

Maternal seafood consumption in pregnancy and neurodevelopmental outcomes in childhood (ALSPAC study): an observational cohort study



Hibbeln JR, et al. Lancet 2007;369:578-85.

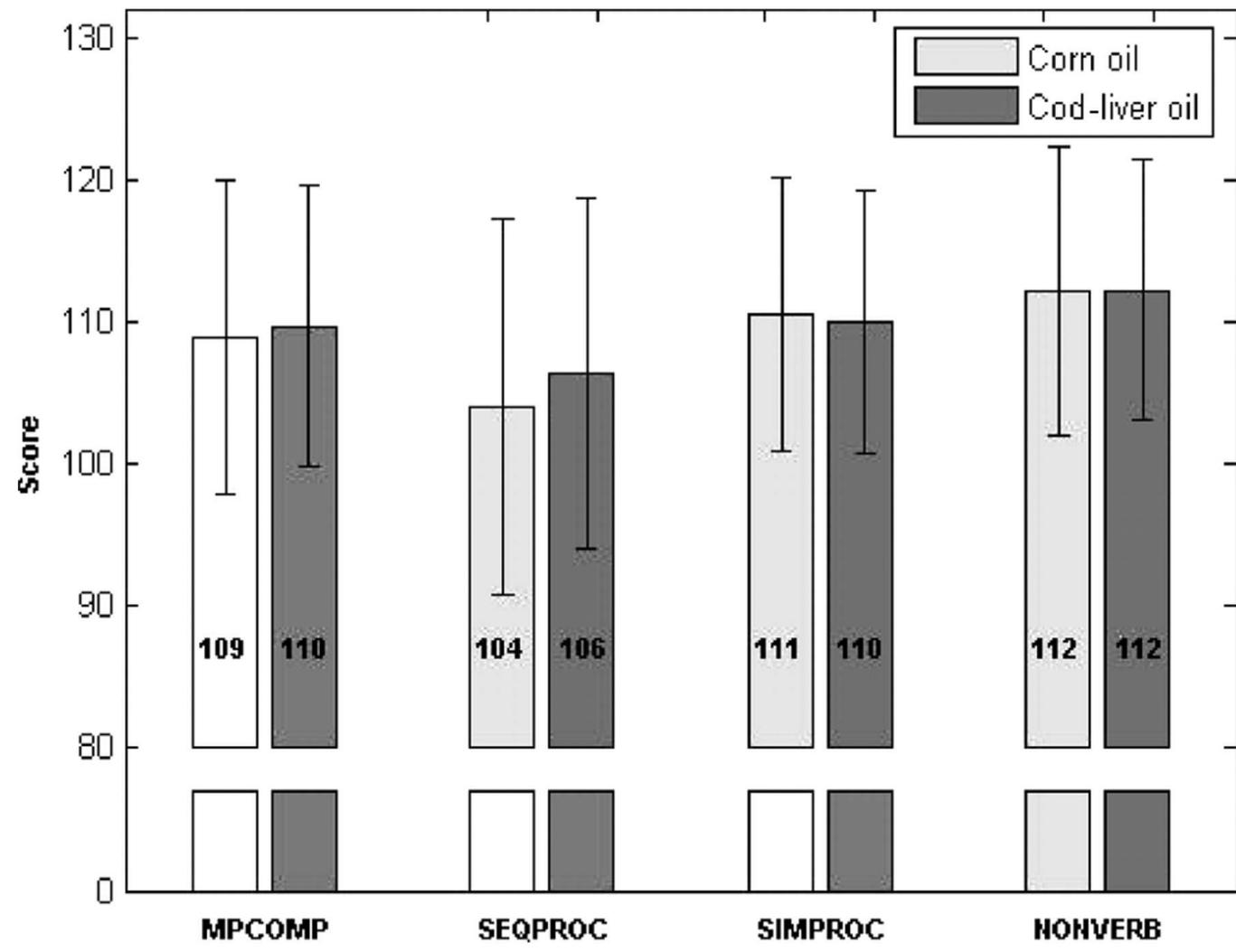
DHA Supplementation in Pregnancy, Birth Outcomes & Bayley Scores

(Makrides et al, JAMA 2011)

<u>Birth outcomes</u>	<u>RR (95% CI)</u>
Birth <34wks	0.5 (0.3, 0.94)
Birth wt <2500 g	0.7 (0.4, 0.96)
NICU admission	0.6 (0.3, 0.97)

<u>Cognition at 18 months</u>	<u>Beta (95% CI)</u>
Cognition	0.01 (-1.4, 1.4)
Language	-1.4 (-3.1, 0.2)
Motor	0.08 (-1.2, 1.3)
Adaptive behavior	-1.5 (-3.2, 0.1)

Scores on the K-ABC at 7 years of age for children whose mothers had taken cod liver oil (n = 82) or corn oil (n = 61) during pregnancy and lactation.



Helland et al, Pediatrics 2008.

Nutrient benefits - complexities

- Multiple co-occurring nutrients: protein, iodine, vitamin D, selenium, etc.
 - Some studies suggest lean fish in pregnancy at least as beneficial for birth outcomes
- Nutrient levels vary across species.
 - What does a 6 ounce meal give you?
 - Shrimp: ~250 mg DHA
 - Pollock: ~700 mg DHA
 - Salmon: ~2500 mg DHA
- Confounding by contaminant risk

Considering both mercury and fish

Visual recognition memory results in 6 month old infants

	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, n=135

Adjustment for nutrients and contaminants

	Maternal 2 nd 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)

Results in 6 month old infants (n=135).

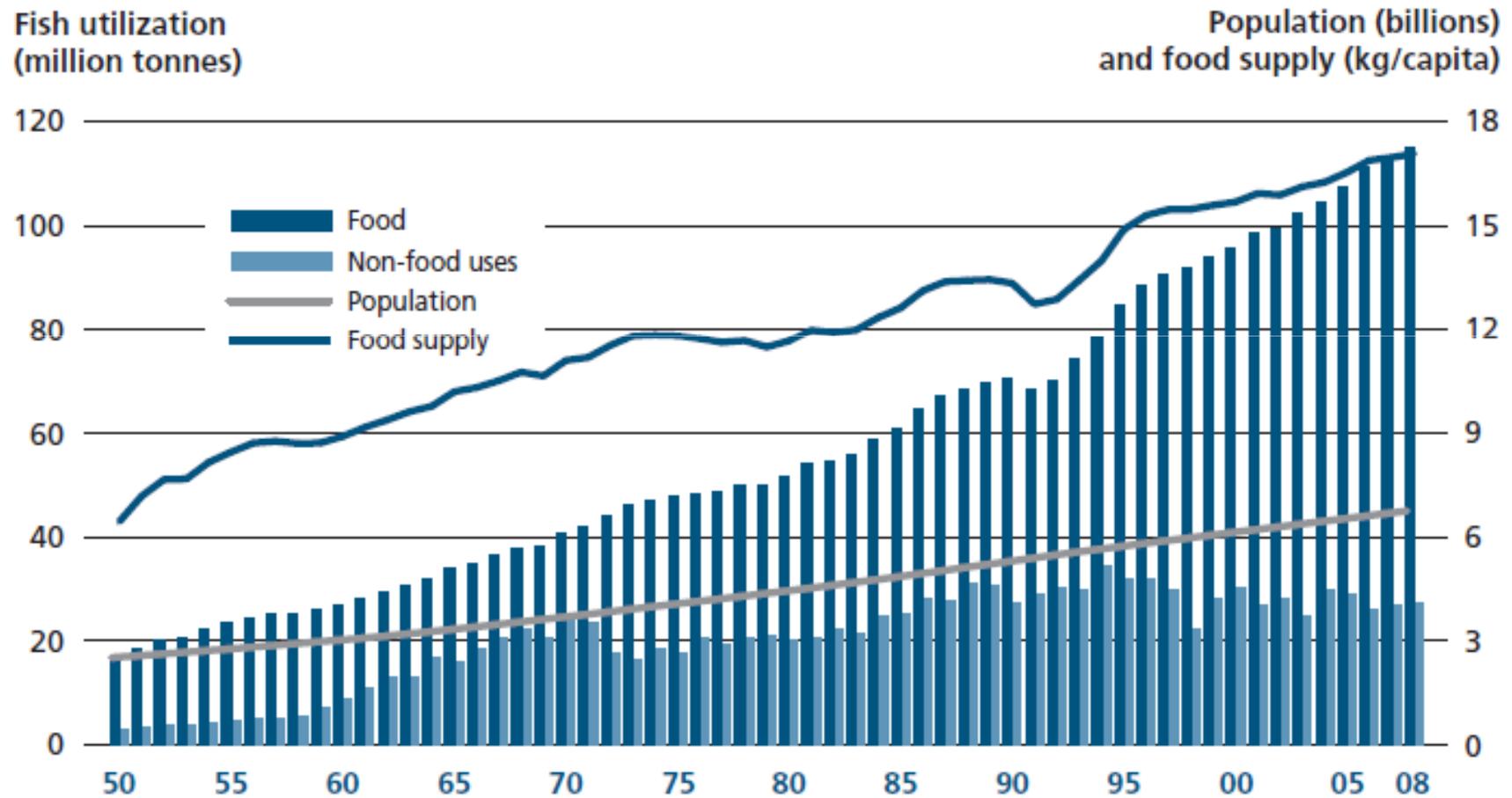
Adjusted for maternal age, race/ethnicity, education, marital status;
infant sex, gestational age, fetal growth, breastfeeding, age at testing

Perspectives:

Competing Interests

- Toxicant exposure & harms
- Nutritional health benefits
- Ecosystem concerns
- Economic influences

World fish utilization and supply

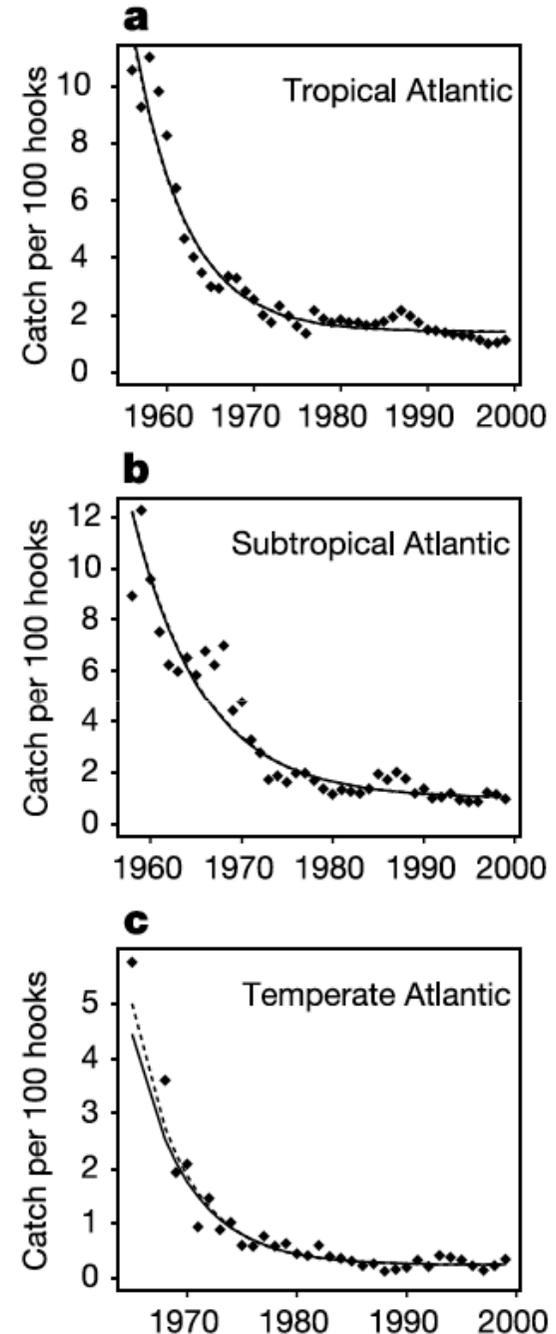


FAO "World review of Fisheries and Aquaculture" 2010

Humans and fish health

- Dramatic decline in fish populations, especially large pelagic (non-bottom dwelling) migratory fish such as tuna, swordfish
- Estimated biomass just 10% of pre-industrial levels
- Demand for protein expected to grow another 50% by 2050

Source: Myers and Worm, 2005



Aquaculture

May provide a solution to dwindling wild fish stocks:

- Fastest growing food production industry
- In 2008, 46% of fish food supply from aquaculture (vs. <10% in 1980)

BUT, important ecological risks:

- Up to 1/3 wild catch for feed
- Alteration of usual trophic levels
- Increase infection, spread to wild populations
- Use of hormones, antibiotics, pesticides
- Concentrated animal waste
- Escaped fish, impact wild populations
- Loss of wetlands for farm development

Ecologic guidance

Monterey Bay Aquarium Seafood Watch

The Monterey Bay Aquarium Seafood Watch program can help consumers and businesses make ocean-friendly choices. We'll provide you with a guide with you and share it with others to help spread the word.

BEST CHOICES

Arctic Char (farmed)
Barramundi (US farmed)
Catfish (US farmed)
Clams (farmed)
Cobia (US farmed)
Cod: Pacific (US bottom longline)
Crab: Dungeness, Stone
Halibut: Pacific (US)
Lobster: Spiny (US)
Mussels (farmed)
Oysters (farmed)
Sablefish/Black Cod (Alaska and BC)
Salmon (Alaska wild)
Sardines (US Pacific)
Scallops (farmed off bottom)
Shrimp: Pink (OR)
Striped Bass (farmed and wild*)
Tilapia (US farmed)
Trout: Rainbow (US farmed)
Tuna: Albacore, Skipjack, Yellowfin (US troll/pole)

GOOD ALTERNATIVES

Basa/Pangasius/Swai (farmed)
Caviar, Sturgeon (US farmed)
Clams (wild)
Cod: Atlantic (imported)
Cod: Pacific (US trawled)
Crab: Blue*, King (US), Snow
Flounders, Soles (Pacific)
Flounder: Summer (US Atlantic)*
Grouper: Black, Red (US Gulf of Mexico)*
Herring: Atlantic
Lobster: American/Maine
Mahi Mahi (US)
Oysters (wild)
Pollock: Alaska
Sablefish/Black Cod (CA, OR, WA)
Scallops: Sea
Shrimp (US, Canada)
Squid
Swordfish (US)*
Tilapia (Central & South America farmed)
Tuna: Bigeye, Tongol, Yellowfin (troll/pole)

AVOID

Caviar, Sturgeon* (imported wild)
Chilean Seabass/Toothfish*
Cobia (imported farmed)
Cod: Atlantic (trawled, Canada and US)
Crab: King (imported)
Flounders, Halibut, Soles (US Atlantic, except Summer Flounder)
Groupers (Hawaii, US Atlantic*)
Lobster: Spiny (Brazil)
Mahi Mahi (imported longline)
Marlin: Blue, Striped (Pacific)*
Monkfish
Orange Roughy*
Salmon (farmed, including Atlantic)*
Sharks* and Skates
Shrimp (imported)
Snapper: Red
Swordfish (imported)*
Tilapia (Asia farmed)
Tuna: Albacore*, Bigeye*, Skipjack, Tongol, Yellowfin* (except troll/pole)
Tuna: Bluefin*
Tuna: Canned (except troll/pole)

What is Optimal Fish Consumption Advice?

- Communicate harms only – assume switch to lower Hg fish to achieve benefit

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- Communicate harms & benefits



U.S. Department of Health and Human Services
and
U.S. Environmental Protection Agency



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March 2004

EPA-823-R-04-005

What You Need to Know About Mercury in Fish and Shellfish

“Eat up to 12 ounces (2 average meals) a week of a variety of fish and shellfish that are lower in mercury.”

Young Children

|October 4, 2007

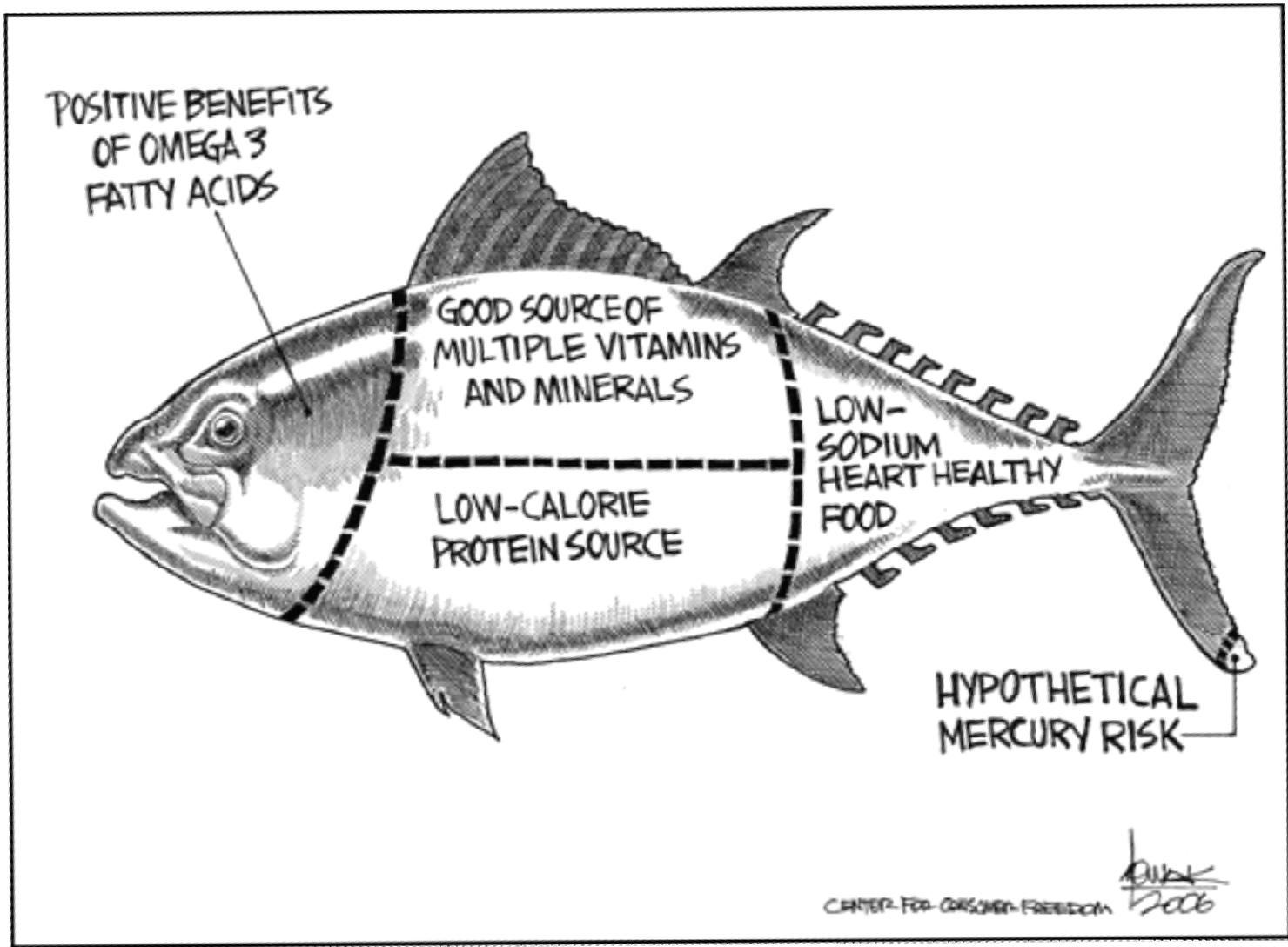
Maternal Nutrition Group Recommendations for Fish Consumption During Pregnancy

Recommendations for Pregnant Women Regarding Fish Consumption

I. Pregnant, breastfeeding and postpartum women are recommended to consume a

“Consume a minimum of 12 ounces of seafood per week.”

albacore tuna



POSITIVE BENEFITS
OF OMEGA 3
FATTY ACIDS

GOOD SOURCE OF
MULTIPLE VITAMINS
AND MINERALS

LOW-CALORIE
PROTEIN SOURCE

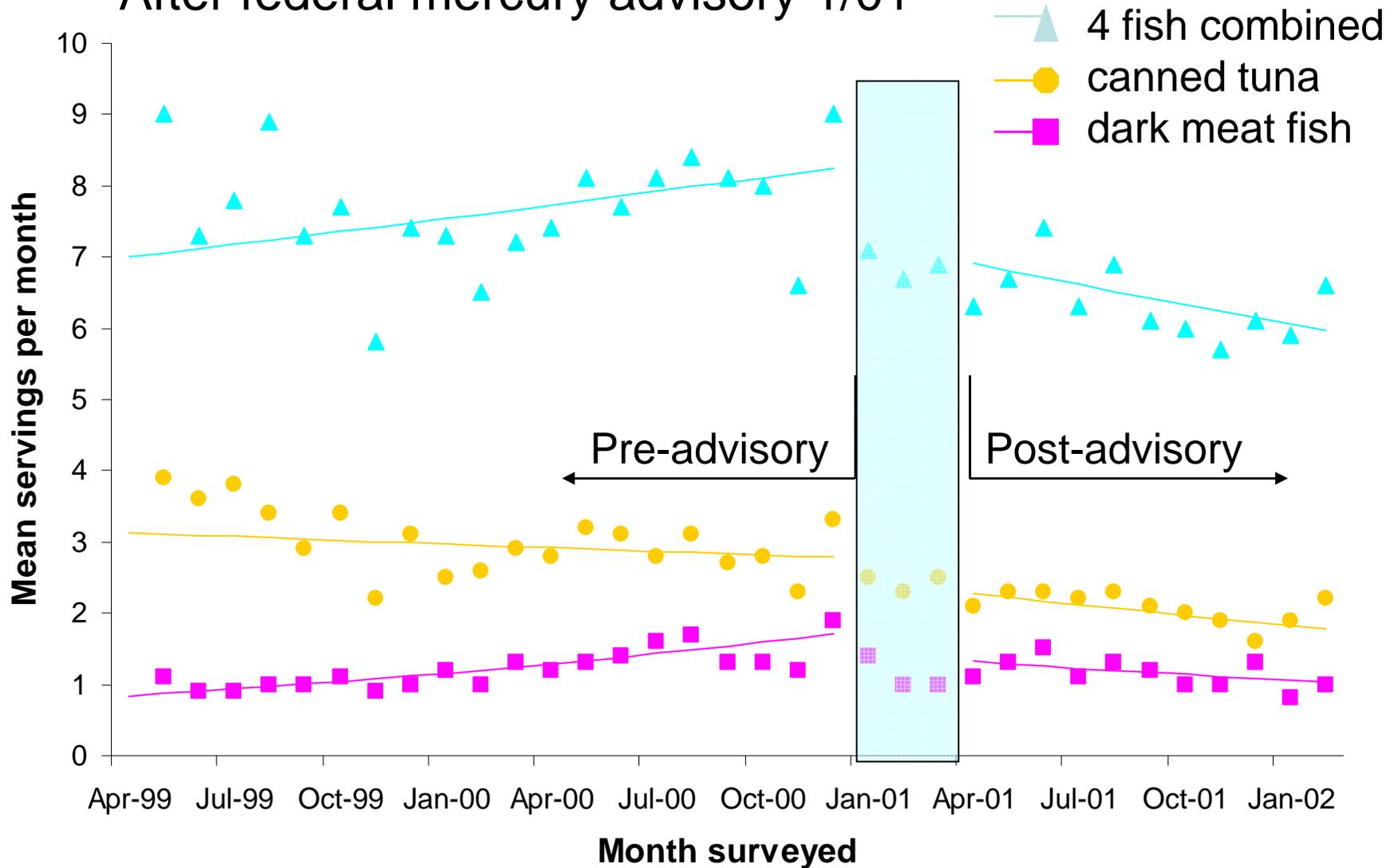
LOW-
SODIUM
HEART HEALTHY
FOOD

HYPOTHETICAL
MERCURY RISK

CENTER FOR CONSUMER FREEDOM
[Signature]
2006

Decline in fish consumption

After federal mercury advisory 1/01



Oken E, Kleinman K, Berland WE, Simon S, Rich-Edwards JW, Gillman MW.
Obstetrics and Gynecology 2003;102(2):346-351.

Decline in fish consumption after 2001 federal mercury advisory

Data from 15,000 US households:

- Targeted consumers decreased both Hg & omega-3
- Decrease across consumption distribution (including low consumers)
- No differential avoidance of high Hg fish
- No low Hg/high omega-3 substitution
- 50% decrease in >12 oz/wk consumption
- 60% increase in consumers with ~no fish intake

Source: Shimshack & Ward, J Health Economics 2010

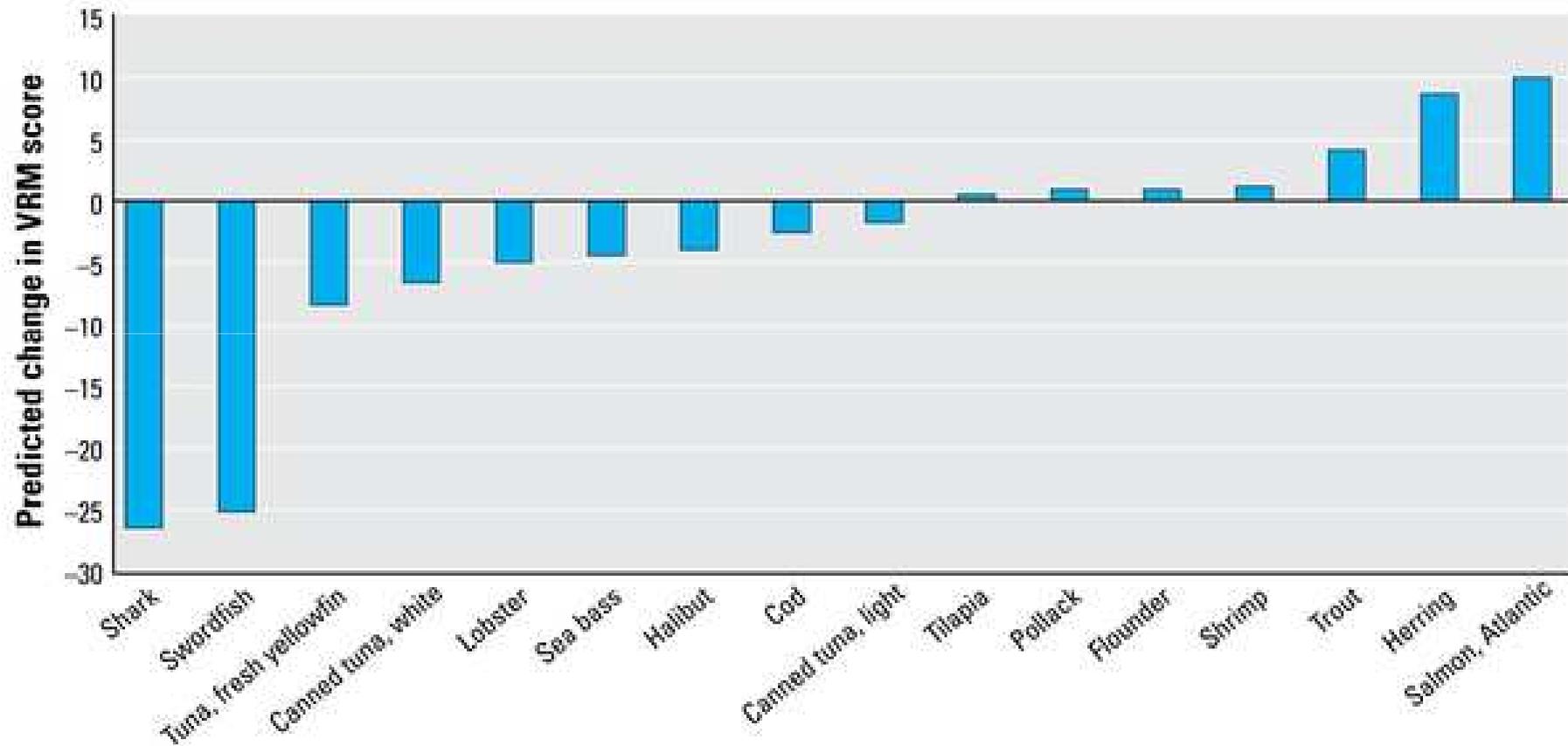
What is Optimal Fish Consumption Advice?

- Communicate harms only – assume switch to lower Hg fish to achieve benefit
- Communicate benefit only – assume benefit outweighs harms
- Communicate harms & benefits
- **Communicate risk trade offs
(contaminant vs. no fish)**

What is Optimal Fish Consumption Advice?

- Communicate harms only – assume switch to lower Hg fish to achieve benefit
- Communicate benefit only – assume benefit outweighs harms
- Communicate harms & benefits
- Communicate risk trade offs
(contaminant vs. no fish)
- **Species specific harm-benefit measures
(e.g., net effect)**

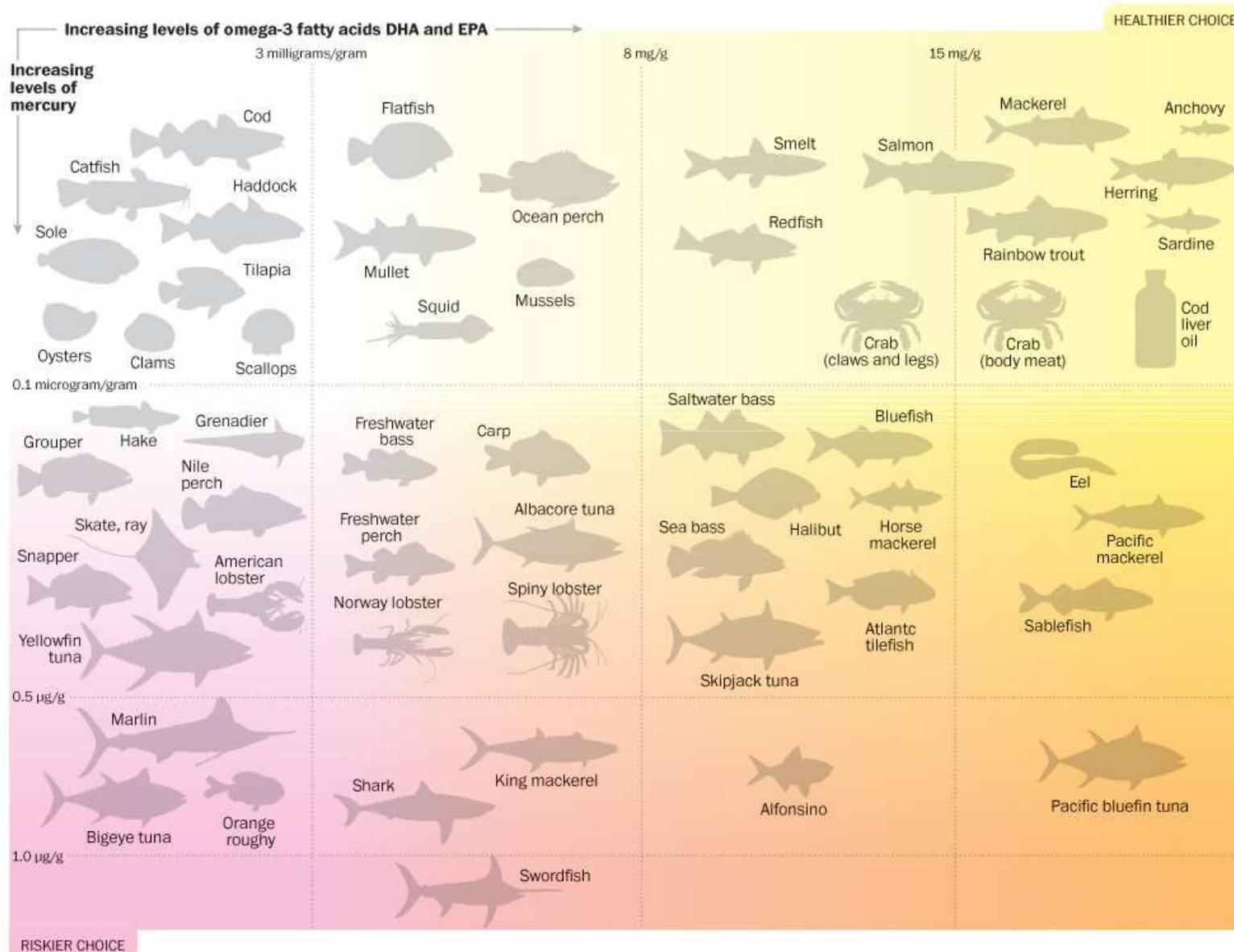
Balancing health harms and benefits



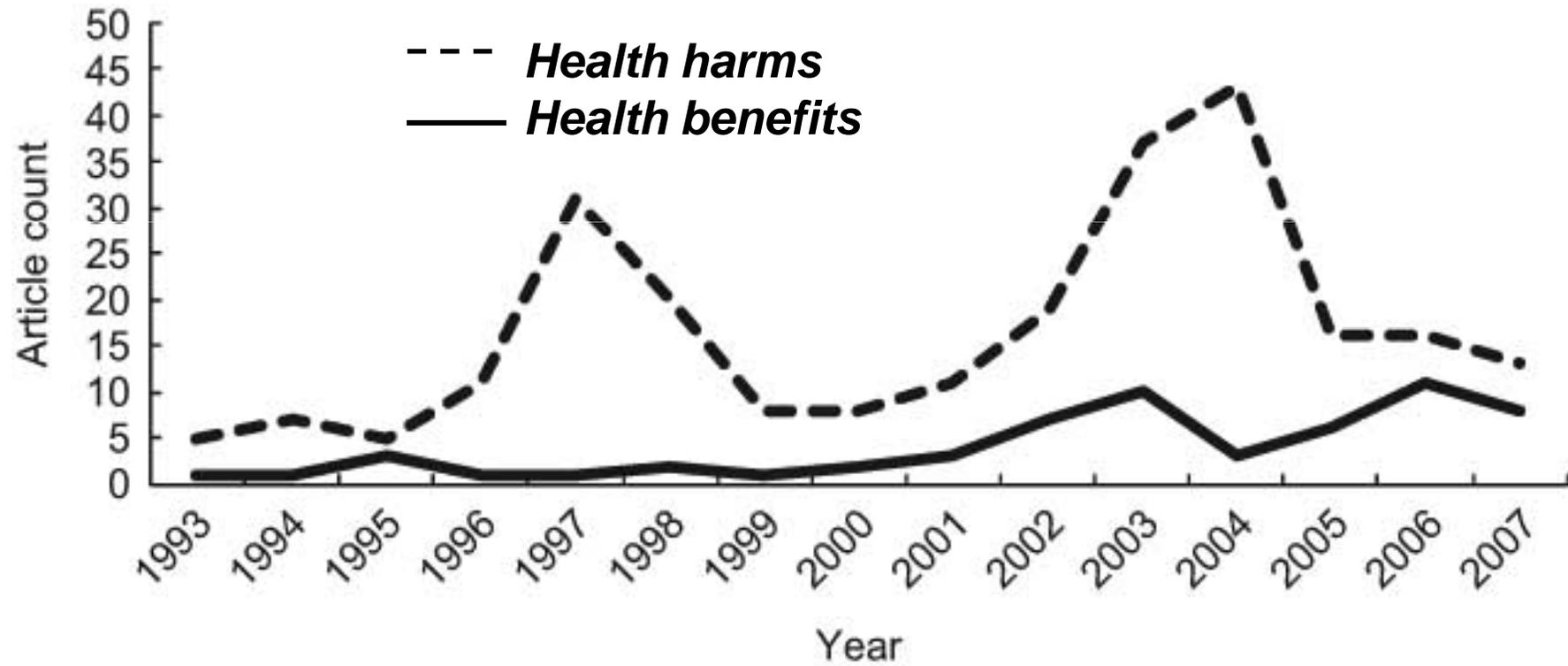
Source: Ginsberg & Toal, EHP, 2009

Seafood: The choice is yours

Seafood is an important source of energy, protein and other important nutrients, including omega-3 fatty acids, which tend to lower the risk of coronary heart disease. However, many types of seafood also can accumulate toxins, particularly the heavy metal mercury, which can pose a risk to neurological development in fetuses. [Read related story.](#)



The Press



The press

The New York Times January 23, 2008
High Mercury Levels Are Found in Tuna Sushi



The press

The New York Times January 23, 2008

High Mercury Levels Are Found in Tuna Sushi



Correction: January 26, 2008

A chart with the continuation of a front-page article on Wednesday about high mercury levels found in tuna sushi in New York stores and restaurants referred imprecisely to what the Environmental Protection Agency deems to be an acceptable level of mercury consumption over a period of several months by an adult of average weight. **(To find the acceptable weekly level of consumption over the long term, the reference dose is multiplied by seven.)**

No wonder women are confused

- “That’s the main thing I find confusing – so, like, salmon, that’s a pretty big fish, so maybe we shouldn’t eat it, but then maybe we should eat it because, like it’s higher in mercury but it’s also higher in good fat, so don’t eat it, but no, do eat it.”
- “You hear that fish is so good for you, yet on the other hand it’s filled with mercury and we need to look out for that...but yet we’re supposed to eat it at least twice a week.”

Bloomingdale A, Guthrie LB, Price S, Wright RO, Platek D, Haines J, **Oken E**.
A qualitative study of fish consumption during pregnancy.
American Journal of Clinical Nutrition 2010 Nov;92(5):1234-40.

Even MD's are confused

Dear Dr. Oken,

I am sorry to bother you, but my wife (a nephrologist) and I (a thoracic surgeon) read your chapter and thought you would be the best person to possibly answer our question.

My wife is breastfeeding our 2 month old and last night had grouper in a restaurant not realizing that this is a high mercury fish. **Is this worrisome and should she stop breastfeeding?**

Seafood Consumption Guides & Calculators

Source	Target population	Contaminant exposure	Fatty acid/ nutrient intake	Ecological impact	Economic influences
2004 FDA/EPA					
Monterey Bay					
EDF					
Dietary Guidelines					
Fish for your health					
Blue Ocean Institute					
Kidsafe					
Fishwise					
Washington State DOH					
Connecticut State DPH					
NRDC					
Turtle Island					
Food and Water Watch					
Mercury Policy Project					
National Geographic					
Star Chefs					
Greenpeace International					
NOAA					
Shedd Aquarium					

Oken E, Choi AL, Karagas MR, Mariën K, Rheinberger CM, Schoeny R, Sunderland E, Korrick S. Environ Health Perspect. 2012 Jun;120(6):790-8.

Lessons Learned

- Cannot be approached with reductionist messages. E.g., *not* like lowering cholesterol – ‘eat less red meat’

And

- With multiple competing risks, & consumer risk groups, a more comprehensive approach seems justified

But

- Experience suggests that more information is *not* necessarily health promoting. Complex information processing costs time & cognitive effort; consumers may avoid these ‘costs’

And

- Consumers have understandable limitations when making risk-risk trade-offs: (1) nuanced response is difficult, and (2) often respond more to negative information (avoid food risk is priority).

- Optimal approach may vary widely across consumers (need flexibility, multiple options, more comprehensive perspective)

(Taste, availability, & price are important determinants of seafood purchases)

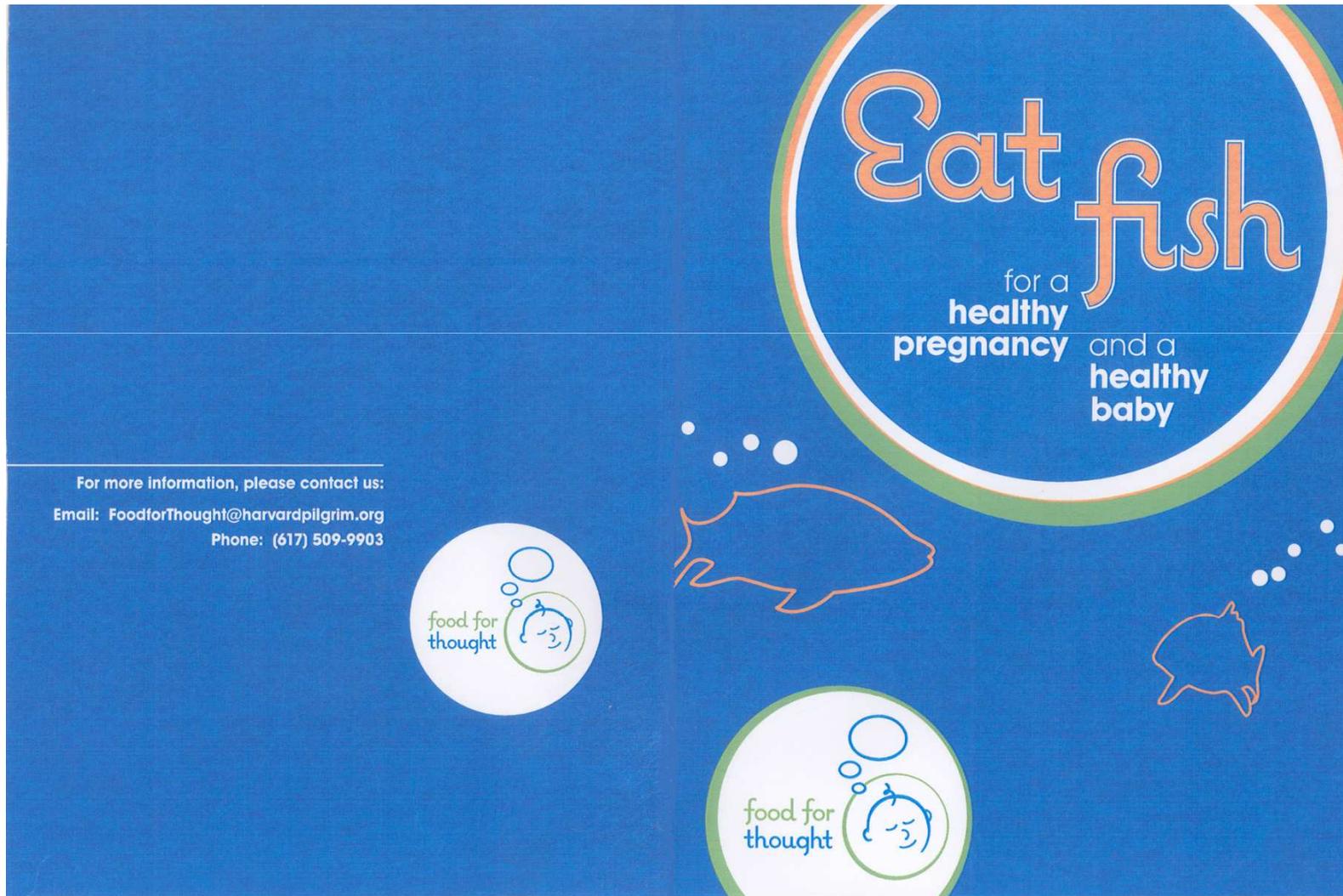
Can women act on a nuanced message?

food for
thought





Intervention Brochure





DHA helps babies be their best!

Your body needs omega-3 fatty acids, but it cannot make them. This means you have to eat them. **DHA** (docosahexaenoic acid) is one type of omega-3 fatty acid. It is a very important nutrient for you and your baby. Here's why:

- DHA is a building block of the brain and eyes.
- Kids need DHA early! 90% of the DHA in the brain is taken up during pregnancy and infancy.
- Before birth and while breastfeeding, your baby gets all of his or her DHA from you.

Most pregnant women in the U.S. do not eat enough DHA. **The average woman eats just 1/4 of the DHA she needs!** Moms who have lower levels of DHA may not pass enough of this nutrient to their babies.



remember
to eat a variety
of types
of fish

2

Fish is the best way to get DHA.

Fish is one of the only foods that is naturally high in DHA.

Pregnant moms who eat more fish have higher levels of DHA and other omega-3 fatty acids in their blood, their breast milk, and the baby's umbilical cord blood.

Eat about 1400 milligrams of DHA each week (an average of 200 milligrams each day). Pages 4 and 5 of this brochure explain how much fish you should eat to get enough DHA.

aim for
2 fish meals
each week

In research studies, moms who ate more fish during pregnancy had:

- a lower risk of premature birth
- fewer pregnancy complications like preeclampsia and depression
- children with a lower risk of asthma and allergies
- children with better development and higher IQ

DHA supplements are safe but have some drawbacks.

- Supplements can cost a lot.
- It can be hard to remember to take supplements.
- No supplement has the combination of DHA and other nutrients that nature puts in fish.
- A supplement is not a meal! Eating fish provides a satisfying meal for you and your baby. Fish is also low in bad fats and is a good source of the protein, iodine, and vitamin D you and your baby need.

Vegetable sources of omega-3s (like flax and walnuts, for example) have ALA, which is a related omega-3 fatty acid. But these sources don't have any DHA. Your body can turn ALA into DHA, but it can't make enough for your growing baby. This is where fish comes in!



3

these fish

all **have DHA**
and are **low in mercury**



ONE 6-ounce serving of these fish each week will give you the recommended weekly amount of DHA:

- salmon (farm raised)
- salmon (wild caught)
- salmon (canned)
- whitefish/walleye
- herring
- anchovies (canned)
- trout (farm raised)

TWO 6-ounce servings (12 ounces total) of these fish each week will give you the recommended weekly amount of DHA:

- atlantic mackerel
- sardines (canned)
- trout (wild caught)
- mussels
- pollock
- salt cod/bacalao

These fish have less DHA, but they are still a good source of protein and other nutrients:

- | | |
|----------|--------------------------------|
| whiting | tilapia |
| scallops | catfish |
| octopus | eel |
| haddock | crayfish |
| cod | crab (includes imitation crab) |
| clams | |
| shrimp | |

THREE 6-ounce servings (18 ounces total) of these fish each week will give you the recommended weekly amount of DHA:

- squid/calamari
- ocean perch
- flattish
- flounder
- sole

Source: USDA Nutrient Database release 27, September 2009. <http://www.nal.usda.gov/nrc/foodcomp/search/>

Fish may be contaminated with mercury; some types contain very little, others contain a lot.

Mercury is a pollutant in the air, water, and soil that is harmful for brain development. The amount of mercury in fish can vary quite a bit. Most kinds of popular fish and shellfish are low in mercury, including those on pages 4 and 5. Other types of fish have a lot more.



While you are pregnant and nursing, avoid eating these fish, because they have high levels of mercury and other contaminants:

- king mackerel
- swordfish
- shark
- tilefish (from the Gulf of Mexico)
- raw or uncooked fish
- raw or uncooked shellfish
- freshwater fish caught in streams, rivers, lakes, and ponds in Massachusetts
- tuna steak
- lobster caught in New Bedford Harbor
- bluefish caught off the Massachusetts coast
- lobsters, flounder, soft-shell clams, and bivalves from Boston Harbor

www.mass.gov/Eso0hms2/docs/dph/environmental/avoidance_fish_eating_guide.pdf

If you eat tuna, choose chunk light tuna.

Most tuna fish contains some mercury, some more than others.

- Larger tuna fish have more mercury. These fish are in tuna sushi, tuna steak, and albacore (white) canned tuna fish.
- Smaller tuna fish have less mercury. These fish are in light (chunk light) canned tuna.

One 6-ounce can of chunk light tuna gives you almost twice your daily DHA needs.

Vary chunk light tuna with other types of fish so you can get your DHA without getting too much mercury.

Don't give up on fish!

Studies show that pregnant women who do not eat fish are at higher risk for:

- premature delivery
- having children with poorer development

Eat a variety of fish throughout pregnancy. Just choose types lower in mercury.

Remember to take the wallet card we give you to the grocery store and to restaurants. It will remind you which types of fish to choose.

choose
different types
of fish
each week



Wallet card

Eat fish

for a healthy pregnancy and a healthy baby

food for thought

While you are pregnant and nursing, avoid eating these fish, because they have high levels of mercury and other contaminants:

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food for thought

For more information, please contact us:
 Email: FoodforThought@harvardpilgrim.org
 Phone: (617) 509-9903

these fish

all have **DHA** and are **low in mercury**

ONE 6-ounce serving of these fish each week will give you the recommended weekly amount of DHA:

- salmon (farm raised, wild caught, or canned)
- whitefish/walleye
- herring
- anchovies (canned)
- trout (farm raised)

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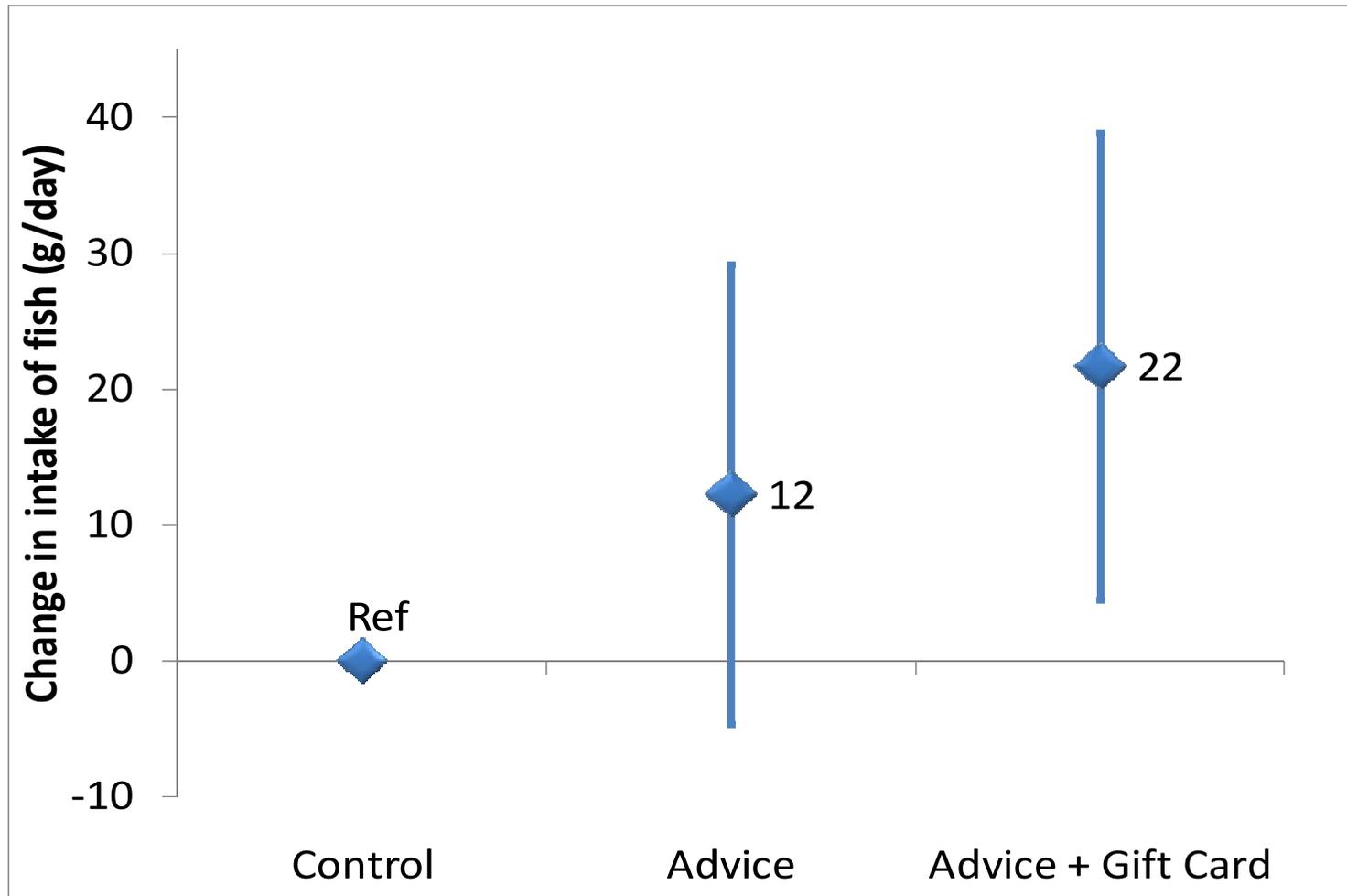
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- scallops
- octopus
- haddock
- cod
- clams
- shrimp
- tilapia
- catfish
- eel
- crayfish
- crab (includes imitation crab)

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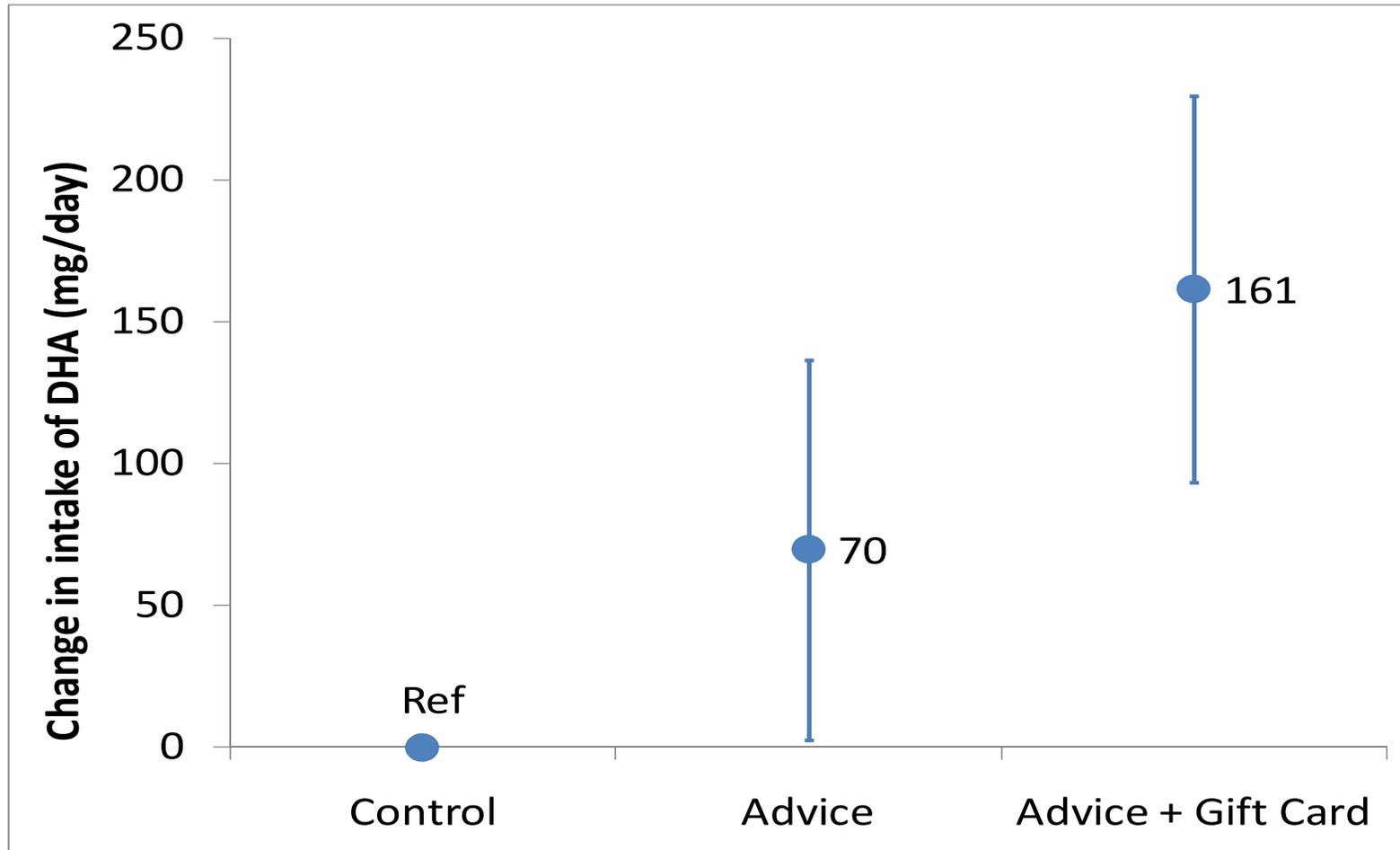
Fish Intake



Oken et al. Nutrition Journal 2013, 12:33



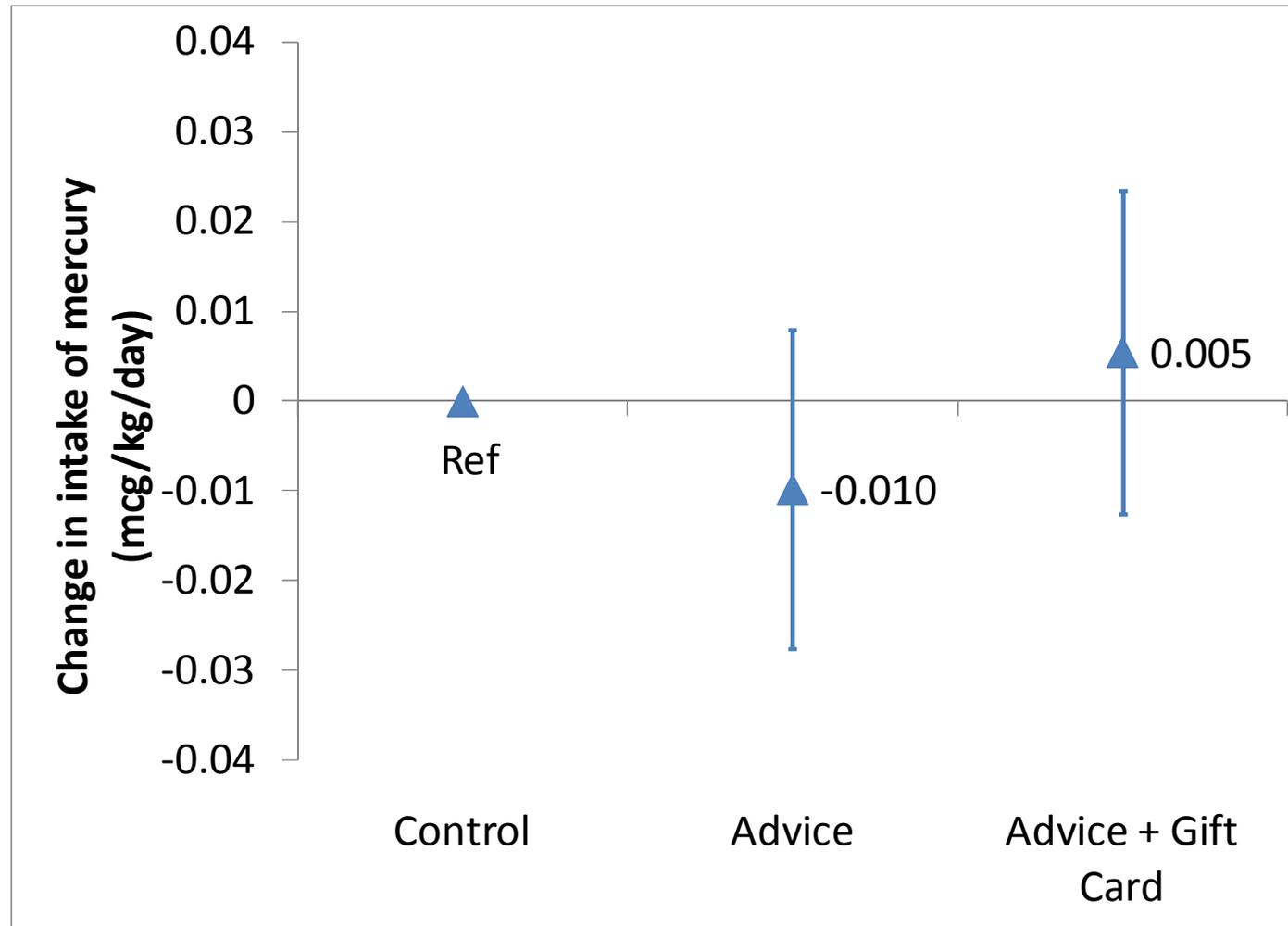
DHA Intake



Oken et al. Nutrition Journal 2013, 12:33



Mercury Intake



Oken E, Guthrie LB, Bloomingdale A, Platek DN, Price S, Haines J, Gillman MW, Olsen SF, Bellinger DC, Wright RO.. Nutrition Journal 2013, 12:33

How much fish do people eat?

Depends on how you ask

	1 question	4 questions	36 questions
Fish (sv/wk)	0.28	0.9	1.4
DHA (mg/d)	22	69	97
Hg (mcg/d)	0.42	1.25	1.60
200 mg/d DHA	0%	27%	36%