Perspective on potential benefits and harms of fish consumption

Emily Oken, MD, MPH
Weighing fish consumption

Alternatives

DHA

Other nutrients (Vit D, Iodine)

Other toxicants

Hg

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 lifecourse
  – Fetus especially susceptible
  – US EPA/FDA advice specific to pregnancy, no advice for non-pregnant adults
  – Very limited information about effects on children

• Confounding by nutritional benefits
Fish is the primary dietary source of omega-3 long-chain polyunsaturated fatty acids

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

“With all these omega-3 fatty acids, you’d think I’d feel better.”
Maternal mercury and child cognition with low exposure

<table>
<thead>
<tr>
<th>Child test score</th>
<th>Age and sex</th>
<th>MV</th>
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<tbody>
<tr>
<td><strong>Peabody Picture Vocabulary Test</strong></td>
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</tr>
<tr>
<td>Hair Hg &gt;1ppm</td>
<td>-5.3 (-10.1, -0.5)</td>
<td>-4.0 (-8.0, 0.0)</td>
</tr>
<tr>
<td>Hg &lt; 90th %ile</td>
<td>Referent</td>
<td>Referent</td>
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</table>

| **Wide Range Assessment of Visual Motor Abilities** |                |                |
| Hair Hg >1ppm  | -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.

Oken, et al. AJE 2008
# Maternal fish intake and child cognition – Project Viva

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<tr>
<th>Child Test Score</th>
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<tr>
<td><strong>Peabody Picture Vocabulary Test</strong></td>
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<tr>
<td>Fish &gt; 2x/wk</td>
<td>-1.5 (-7.3, 4.4)</td>
<td>1.2 (-3.5, 6.0)</td>
</tr>
<tr>
<td>Fish &lt;= 2x/wk</td>
<td>-2.2 (-6.5, 2.2)</td>
<td>-2.1 (-5.7, 1.4)</td>
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<tr>
<td>Fish never</td>
<td>Referent</td>
<td>Referent</td>
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</tbody>
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| **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.*

Oken, et al. AJE 2008
Danish National Birth Cohort

Odds Ratio (95% CI) for higher total development

Quintile of maternal prenatal fish intake

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

DHA Supplementation in Pregnancy, Birth Outcomes & Bayley Scores
(Makrides et al, JAMA 2011)

<table>
<thead>
<tr>
<th>Birth outcomes</th>
<th>RR (95% CI)</th>
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</thead>
<tbody>
<tr>
<td>Birth &lt;34wks</td>
<td>0.5 (0.3, 0.94)</td>
</tr>
<tr>
<td>Birth wt &lt;2500 g</td>
<td>0.7 (0.4, 0.96)</td>
</tr>
<tr>
<td>NICU admission</td>
<td>0.6 (0.3, 0.97)</td>
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<table>
<thead>
<tr>
<th>Cognition at 18 months</th>
<th>Beta (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognition</td>
<td>0.01 (-1.4, 1.4)</td>
</tr>
<tr>
<td>Language</td>
<td>-1.4 (-3.1, 0.2)</td>
</tr>
<tr>
<td>Motor</td>
<td>0.08 (-1.2, 1.3)</td>
</tr>
<tr>
<td>Adaptive behavior</td>
<td>-1.5 (-3.2, 0.1)</td>
</tr>
</tbody>
</table>
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.

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

<table>
<thead>
<tr>
<th></th>
<th>Hair mercury &lt;= 1.2 ppm</th>
<th>Hair mercury &gt; 1.2 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;2 weekly fish servings</td>
<td>72 (n=7)</td>
<td>55 (n=2)</td>
</tr>
<tr>
<td>&lt;= 2 weekly fish servings</td>
<td>60 (n=114)</td>
<td>53 (n=12)</td>
</tr>
</tbody>
</table>

Unadjusted analysis, n=135

# Adjustment for nutrients and contaminants

<table>
<thead>
<tr>
<th></th>
<th>Maternal 2\textsuperscript{nd} tri fish intake (per svc/wk)</th>
<th>Maternal hair mercury at delivery (per ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Change in 6 month VRM score</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td>2.8 (0.2, 5.4)</td>
<td>---</td>
</tr>
<tr>
<td>Mercury</td>
<td>---</td>
<td>-4.0 (-10.0, 2.0)</td>
</tr>
<tr>
<td>Fish &amp; mercury</td>
<td>4.0 (1.3, 6.7)</td>
<td>-7.5 (-13.7, -1.2)</td>
</tr>
</tbody>
</table>

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
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 is a guide that helps consumers and businesses make ocean-friendly choices. Share the guide 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 trol/pole)

## GOOD ALTERNATIVES
- Basa/Panga/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 (trol/pole)

## AVOID
- Caviar, Sturgeon* (imported wild)
- Chilean Seabass/Toothfish*
- Cobia (imported farmed)
- Cod: Atlantic (towed, 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 trol/pole)
- Tuna: Bluefin*
- Tuna: Canned (except trol/pole)
What is Optimal Fish Consumption Advice?

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

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
Decline in fish consumption
After federal mercury advisory 1/01

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
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- 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.

http://www.washingtonpost.com/national/health-science/2012/04/03/gIQABd16sS_graphic.html
The Press

Grenier et al, Public Health Nutr 2010
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.”

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

<table>
<thead>
<tr>
<th>Source</th>
<th>Target population</th>
<th>Contaminant exposure</th>
<th>Fatty acid/ nutrient intake</th>
<th>Ecological impact</th>
<th>Economic influences</th>
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<td>2004 FDA/EPA</td>
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<td>Monterey Bay</td>
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<td>Dietary Guidelines</td>
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<td>Fish for your health</td>
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<td>Mercury Policy Project</td>
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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).
  
  ❍ And

■ 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?
**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.

---

**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.

---

**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.

---

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.
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

**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
- flounder
- sole

These fish have less DHA, but they are still a good source of protein and other nutrients:
- whiting
- scallops
- octopus
- haddock
- cod
- clams
- shrimp
- tilapia
- catfish
- eel
- crayfish
- crab (includes imitation crab)
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
- tilapia (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

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.
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
- tuna steak

Eat these fish, because they are low in mercury and high in DHA:

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

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

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

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

For more information, please contact us:

Email: FoodforThought@harvardpilgrim.org
Phone: (617) 509-9903

If you eat tuna, choose chunk light tuna.
Fish Intake

Change in intake of fish (g/day)

Control
Advice
Advice + Gift Card

Ref
12
22

Oken et al. Nutrition Journal 2013, 12:33
DHA Intake

![Graph showing change in DHA intake (mg/day) across different groups: Control, Advice, and Advice + Gift Card.]

Oken et al. Nutrition Journal 2013, 12:33
Mercury Intake

How much fish do people eat?
Depends on how you ask

<table>
<thead>
<tr>
<th></th>
<th>1 question</th>
<th>4 questions</th>
<th>36 questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish (sv/wk)</td>
<td>0.28</td>
<td>0.9</td>
<td>1.4</td>
</tr>
<tr>
<td>DHA (mg/d)</td>
<td>22</td>
<td>69</td>
<td>97</td>
</tr>
<tr>
<td>Hg (mcg/d)</td>
<td>0.42</td>
<td>1.25</td>
<td>1.60</td>
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<tr>
<td>200 mg/d DHA</td>
<td>0%</td>
<td>27%</td>
<td>36%</td>
</tr>
</tbody>
</table>