

Appendix E-2.38: Evidence Portfolio

Part D. Chapter 5: Food Sustainability and Safety

Seafood and Sustainability

SYSTEMATIC REVIEW QUESTION 1: What are the comparative nutrient profiles of current farm-raised versus wild caught seafood?

Conclusion Statement: For commonly consumed fish species in the United States, such as bass, cod, trout, and salmon, farmed-raised fish have as much or more of the omega-3 fatty acids EPA and DHA as the same species captured in the wild. In contrast, farmed low-trophic species, such as catfish and crawfish, have less than half the EPA and DHA per serving than wild caught, and these species have lower EPA and DHA regardless of source than does salmon. Farm-raised fish have higher total fat than wild caught. Recommended amounts of EPA and DHA can be obtained by consuming a variety of farm-raised fish, especially high-trophic species, such as salmon and trout.

Not Graded

Key Findings:

- The U.S. population should be encouraged to eat a wide variety of seafood that can be wild caught or farmed, as they are nutrient dense foods that are uniquely rich sources of healthy fatty acids.
- It should be noted that low trophic fish such as catfish and crayfish have lower EPA and DHA levels than wild-caught.
- Nutrient profiles in popular low trophic level farmed species should be improved through feeding and processing systems that produce and preserve nutrients similar to those delivered by wild capture in the same species.

Background

The terms “seafood” and “fish” are used interchangeably in this report to refer to animal-based foods harvested from aqueous environs. There are more than 500 species in the major groups commonly referred to as finfish, shellfish, and crustaceans and thus generalizations to all seafood must be made with caution. Seafood is recognized as an important source of key macro- and micronutrients. The health benefits of seafood, including optimal neurodevelopment and prevention of cardiovascular disease, are likely due in large part to long-chain n-3 polyunsaturated fatty acids (PUFA), docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), although fish are good sources of other nutrients including protein, selenium, iodine, vitamin D, and choline (FAO/WHO report). Currently, seafood production is in the midst of rapid expansion to meet growing worldwide demand, but the collapse of some fisheries due to

overfishing in past decades raises concerns about the ability to produce safe and affordable seafood to supply the population and meet current dietary intake recommendations of 8 ounces per week. Capture fisheries (wild caught) production has stabilized in the proportion of fully exploited stocks, and this is due in part to national and international efforts to fish sustainably, e.g., the U.S. Magnuson-Stevens Fishery Conservation and Management Act (2006) mandating annual catch limits, managed by the U.S. National Oceanographic and Atmospheric Administration. In contrast, the increased productivity of worldwide aquaculture (farm-raised) is expected to continue and will play a major role in expanding the supply of seafood (FOA/WHO report). Growing aquaculture has the potential to provide for Americans consuming the recommended amount of seafood, without running out of the recommended amounts (NOAA). Productivity gains should be implemented in a sustainable manner with attention to maintaining or enhancing the high nutrient density characteristic of captured seafood. Consistent with this, finfish aquaculture is more sustainable than terrestrial animal production in terms of GHG emissions and land/water use (Hall et al 2011; Bouman et al 2013). Currently, the US imports the majority of its seafood (~90%), and approximately half of that is farmed (NOAA).

Description of the Evidence

The USDA-Agricultural Research Service (ARS) National Nutrient Database (NND) for Standard Reference, Release 27 was used to address this question (<http://www.ars.usda.gov/ba/bhnrc/ndl>). The section on finfish and shellfish products included nutrient profiles for both farm-raised and wild-caught seafood for some species. This data was augmented using a USDA-funded report on fatty-acid profiles of commercially available fish in the US that assessed more farmed species and compared results with the USDA-ARS NND (Cladis 2014).

The NND provides nutrient profiles for six seafood species with data on both wild-caught and farm-raised versions: four finfish (Rainbow Trout, Atlantic and Coho Salmon, catfish), eastern Oysters, and mixed species crayfish. Data from both sources on different species comparisons is compiled in Figure A. Key nutrients EPA and DHA are on average comparable or greater for farmed trout, salmon, and oysters than for wild capture. On the other hand, low trophic level species catfish and crayfish, when farmed, were lower in EPA and DHA compared to wild capture (Figure A, *). In general, wild low trophic species have lower EPA and DHA than carnivorous fish but those harvested by wild capture have EPA and DHA that support existing DGAC recommendations for consumption of a variety of fish. Cladis et al (Cladis 2014) determined EPA and DHA levels for five finfish (rainbow trout, white sturgeon, chinook salmon, Atlantic cod, striped bass) and presents similar results for these carnivorous species.

SYSTEMATIC REVIEW QUESTION 2: What are the comparative contaminant levels of current farm-raised versus wild caught seafood?

Conclusion Statement: The DGAC concurs with the Joint WHO/FAO Consultancy that, for the majority of commercial wild and farmed species, neither the risks of mercury nor organic pollutants outweigh the health benefits of seafood consumption, such as decreased cardiovascular disease risk and improved infant neurodevelopment. However, any assessment evaluates evidence within a time frame and contaminant composition can change rapidly based

on the contamination conditions at the location of wild catch and altered production practices for farmed seafood.

DGAC Grade: Moderate

Key Findings

- Based on risk/benefit comparisons, either farmed or wild-caught seafood are appropriate choices to consume to meet current Dietary Guidelines for Americans for increased seafood consumption.
- The DGAC supports the current FDA and EPA recommendations that women who are pregnant (or those who may become pregnant) and breastfeeding should not eat certain types of fish—tilefish, shark, swordfish, and king mackerel—because of their high methyl mercury contents.
- Attention should be paid to local fish advisories when eating fish caught from local rivers, streams, and lakes.

Description of the Evidence

To address the question, the DGAC used the Report of the Joint United Nations Food and Agriculture Organization/World Health Organization Expert Consultation on the Risks and Benefits of Fish Consumption, Rome, 25–29 January 2010. FAO Fisheries and Aquaculture Report No. 978

The Report of the FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption was used to address this question. This report was chosen as the most current and comprehensive source on contaminants in wild-caught and farm-raised fish, and the DGAC focused on data that addressed the specific comparison between the two. The sections of the report that were used to address the question were “Data on the composition of fish” and “Risk-benefit comparisons.” The consultancy took a net effects approach, balancing benefits of seafood, especially benefits associated with EPA and DHA, against the adverse effects of mercury and persistent organic pollutants (POPs), including polychlorinated biphenyls, polychlorinated dibenzo-*p*-dioxins, and polychlorinated dibenzofurans, collectively referred to as dioxins. The Expert Consultancy compiled EPA and DHA, mercury, and dioxins compositional data from national databases of the United States, France, Norway, and Japan, as well as an international database. Together, these provided information on total fat, EPA and DHA, total mercury, and dioxins for a large number of seafood species, including three farmed and wild species (salmon, rainbow trout, and halibut). Two specific outcomes were considered for risk/benefit: 1) prenatal exposure and offspring neurodevelopment, and 2) mortality from cardiovascular diseases and cancer.

Overall, for the species examined, levels of mercury and dioxins were in the same range for farmed and wild fish. Related to risk/benefit, at the same level of mercury content (lowest [≤ 0.1 mg/g] and 2nd lowest [0.1 - 0.5 mg/g] levels), farmed fish had the same or higher levels of EPA and DHA as wild-caught. At the same level of dioxin content (2nd lowest [0.5 – 4 pg toxic equivalents (TEQ)/g] level), farmed fish had the same or higher levels of EPA and DHA as wild-

caught. Only wild-caught Pacific salmon had the lowest level of dioxins (<0.5 pg TEQ/g). Overall, the quantitative risk/benefit analysis was not different for farmed compared to wild-caught fish. For both, using the central estimate for benefits of DHA and for harm from mercury, the neurodevelopmental risks of not eating fish exceeded the risks of eating fish. Similarly, for coronary heart disease (CHD) in adults, there were CHD mortality benefits from eating fish and CHD risks from not eating fish, except for fish in the highest dioxin category and lowest EPA and DHA category, which did not include any of the farm-raised species considered.

Albacore tuna, produced only from wild marine fisheries, is a special case of a popular fish highlighted by the 2004 FDA and EPA advisory.^{61, 62} For all levels of intake including more than double the 12 ounces per week recommendation, all evidence was in favor of net benefits for infant development and CHD risk reduction.

Limitations in the evidence included the small number of farmed and wild seafood species comparisons considered by the Expert Consultancy, and the possibility of rapid change that may occur in the concentration of contaminants locally. In addition, seafood contaminants are closely linked to levels of contaminants in feed.

For additional details on this body of evidence, visit: Report of the Joint Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) Expert Consultation on the Risks and Benefits of Fish Consumption, 2011.

<http://www.fao.org/docrep/014/ba0136e/ba0136e00.pdf>

SYSTEMATIC REVIEW QUESTION 3: What is the worldwide capacity to produce farm-raised versus wild-caught seafood that is nutritious and safe for the U.S. population?

Conclusion Statement: The DGAC concurs with the FAO report that consistent evidence demonstrates that capture fisheries increasingly managed in a sustainable way have remained stable over several decades. However, on average, capture fisheries are fully exploited and their continuing productivity relies on careful management to avoid over-exploitation and long-term collapse.

DGAC Grade: Strong

The DGAC endorses the FAO report that capture fisheries production plateaued around 1990 while aquaculture has increased since that time to meet increasing demand. Evidence suggests that expanded seafood production will rely on the continuation of a rapid increase in aquaculture output worldwide, projected at 33 percent increase by 2021, which will add 15 percent to the total supply of seafood.²⁰ Distributed evenly to the world's population, this capacity could in principle meet DGA recommendations for consumption of at least 8 ounces of seafood per week. Concern exists that the expanded capacity may be for low-trophic level fish that have relatively low levels of EPA and DHA compared to other species. Under the current production, Americans who seek to meet U.S. Dietary Guidelines recommendations must rely on significant amounts of imported seafood (~90%).

DGAC Grade: Moderate

Key Findings

- Both wild and farmed seafood are major food sources available to support DGAC recommendations to regularly consume a variety of seafood.
- Responsible stewardship over environmental impact will be important as farmed seafood production expands.
- Availability of these important foods is critical for future generations of Americans to meet their needs for a healthy diet.
- Therefore, strong policy, research, and stewardship support are needed to increasingly improve the environmental sustainability of farmed seafood systems.
- From the standpoint of the dietary guidelines this expanded production needs to be largely in EPA and DHA rich species and supporting production of low-trophic level species of similar nutrient density as wild-caught.

Description of the Evidence

The DGAC used the United National (UN) Food and Agriculture Organization (FAO) report on *The State of World Fisheries and Agriculture* to address this question. The UN FAO report on *The State of World Fisheries and Agriculture* issued in 2012 formed the basis of the DGAC's evidence review on this topic. The FAO report addresses a wide variety of issues affecting capture fisheries and aquaculture, including economics, infrastructure, and labor and government policies. The DGAC focused on matters that directly address the world production of one important food—seafood—as a first attempt by a DGAC committee to consider the implications of dietary guidelines for production of a related group of foods.

The production of capture fisheries has remained stable at about 90 million tons from 1990-2011. At the same time, aquaculture production is rising and will continue to increase. FAO model projections indicate that in response to the higher demand for fish, world fisheries and aquaculture production is projected to grow by 15 percent between 2011 and 2021. This increase will be mainly due to increased aquaculture output, which is projected to increase 33 percent by 2021, compared with only 3 percent growth in wild capture fisheries over the same period. It is predicted that aquaculture will remain one of the fastest growing animal food-producing sectors and will exceed that of beef, pork, or poultry. Aquaculture production is expected to expand on all continents with variations across countries and regions in terms of the seafood species produced. Currently, the United States is the leading importer of seafood products world-wide, with imports making up about 90 percent of seafood consumption. Continuing to meet Americans needs for seafood will require stable importation or substantial expansion of domestic aquaculture.

For additional details on this body of evidence, visit: UN FAO report on *The State of World Fisheries and Agriculture*, 2012. <http://www.fao.org/fishery/sofia/en>

Overview Figure and Tables

Figure 1. Comparison of EPA and DHA in Seafood from USDA-ARS National Nutrient Database, Release 27 and from updated 2014 survey (Cladis *et al.*, 2014)

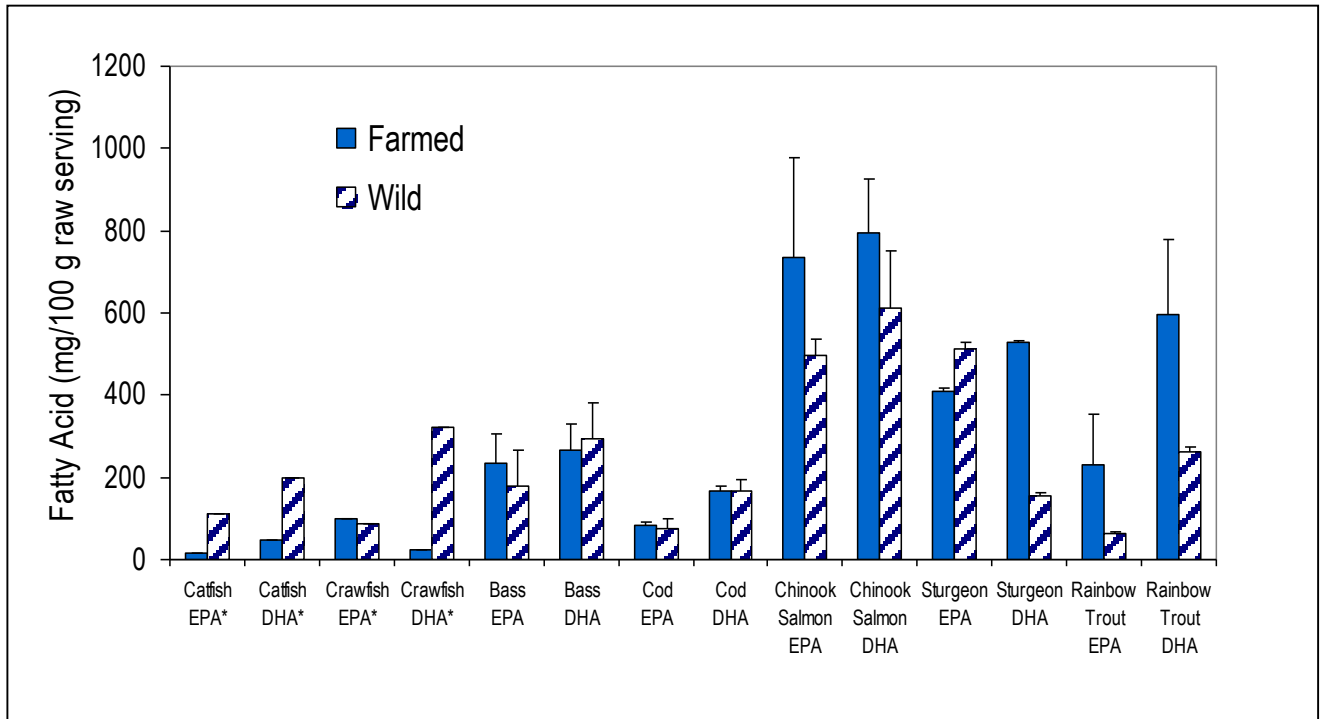


Table 1. Summary of Contaminants in Farm-raised and Wild-Caught Seafood

Topic	Evidence	Mercury <i>[Mean concentration per gram fresh weight]</i>	Dioxins <i>[Mean concentration per gram fresh weight]</i>	Report Statement/ Other
Contaminants in fish: Mercury and Dioxins	4 seafood composition databases were available from France, Japan, Norway and the US, together with one published international database	Halibut Wild (Greenland): [Hg] = 0.23 µg/g Halibut Farmed (Atlantic): [Hg] = 0.14 µg/g Salmon Wild (Atlantic): [Hg] = 0.07 µg/g Salmon Farmed (Atlantic): [Hg] = 0.05 µg/g Salmon Wild (Pacific): [Hg] = 0.04 µg/g Rainbow Trout Farmed: [Hg] = 0.05 µg/g	Halibut Wild (Greenland): [Dioxin] = 3.70 pg TEQ/g Halibut Farmed (Atlantic): [Dioxin] = 2.65 pg TEQ/g Salmon Wild (Atlantic): [Dioxin] = 1.36 pg TEQ/g Salmon Farmed (Atlantic): [Dioxin] = 1.63 pg TEQ/g Salmon Wild (Pacific): [Dioxin] = 0.25 pg TEQ/g Rainbow Trout Farmed: [Dioxin] = 1.02 pg TEQ/g	Levels of mercury and dioxins are in the same range for farmed and wild fish
Risk/Benefit: Mercury and Dioxins by EPA+DHA levels	Analyzed composition of fish by comparing levels of LCn3PUFA as DHA+EPA with levels of total mercury and dioxins The matrix categorized fish species by one of four levels of each of these substances Databases provided information on the content of total fat, EPA plus DHA, total mercury and dioxins (defined to include PCDDs, PCDFs and dioxin-like PCBs)	Mercury: ≤ 0.1 µg/g + EPA + DHA: 8 -15 mg/g Salmon, Atlantic (Wild) Salmon, Pacific (Wild) ≥15 mg/g: Salmon, Atlantic (Farmed) Rainbow Trout (Farmed) Mercury: 0.1 - ≤0.5 µg/g + EPA + DHA: 8 -15 mg/g Halibut (Wild) Halibut (Farmed)	Dioxins: ≤ 0.5 pg TEQ/g + EPA + DHA: 8 -15 mg/g Salmon, Pacific (Wild) Dioxins: 0.5 - ≤4 pg TEQ/g + EPA + DHA: 8 -15 mg/g Salmon, Atlantic (Wild) Halibut (Farmed) ≥15 mg/g: Salmon, Atlantic (Farmed) Rainbow Trout (Farmed)	At the same level of mercury content (lowest and 2nd lowest levels), farmed fish have the same or higher levels of EPA + DHA as wild-caught At the same level of dioxin content (2 nd lowest level), farmed fish have the same or higher levels of EPA + DHA as wild-caught Only wild-caught Pacific salmon has lowest level of dioxins

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<p>Mortality Risk</p>	<p>Estimated mortality per million people from consuming fish (2 serv/wk) with different dioxin and EPA + DHA levels</p>		<p>Dioxins: ≤ 1.0 pg/g + EPA + DHA: 8 -15 mg/g Salmon, Pacific (Wild) +100 Est lives lost* -39,800 Est lives saved[‡]</p> <hr/> <p>Dioxins: 1.0 - ≤ 4 pg/g + EPA + DHA: 8 -15 mg/g Salmon, Atlantic (Wild) Halibut (Farmed) +1,200 Est lives lost* -39,800 Est lives saved[‡]</p> <p>≥ 15 mg/g: Salmon, Atlantic (Farmed) Rainbow Trout (Farmed) +1,200 Est lives lost* -39,800 Est lives saved[‡]</p>	<p>There are CHD mortality benefits from eating fish and CHD risks from not eating fish, except for fish in the highest dioxin category and lowest EPA+DHA category</p>
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Table 2. Summary – The FAO Agricultural Outlook: Fish

Topic	Evidence	Projections 2012-2021 Aquaculture	Projections 2012-2021 Capture Fisheries
The Outlook Model	<p>To analyze the outlook of the fisheries and aquaculture sector in terms of future production potential, projected demand for fisheries products, consumption, prices and key factors that might influence future supply and demand</p> <p>Developed and integrated model with overall structure of an already existing and valid agricultural model, the OECD-FAO- AGLINK-COSIMO projection system</p> <p>The fish model is a dynamic, policy-specific, partial-equilibrium model w/ 2 types of supply functions: capture and aquaculture</p>	<p>Stimulated by higher demand for fish, world fisheries and aquaculture production is projected to reach about 172 million tonnes in 2021, a growth of 15 percent above the average level for 2009–11</p> <p>Increase should be driven by aquaculture, projected to reach ~79 million, rising by 33% over 2012-2021, compared with 3% growth for capture fisheries</p> <p>A slowing in aquaculture growth is anticipated, from an average annual rate of 5.8 percent in the last decade to 2.4 percent during the period under review</p> <p>Notwithstanding the slower growth rate, aquaculture will remain one of the fastest growing animal food-producing sectors. Thanks to its contribution, total fisheries production (capture and aquaculture) will exceed that of beef, pork or poultry</p> <p>Aquaculture production is expected to continue to expand on all continents, with variations across countries and regions in terms of the product range of species and product forms.</p> <p>Asian countries will continue to dominate world aquaculture production, with a share of 89 percent in 2021, with China alone representing 61 percent of total production</p>	<p>Portion of capture fisheries used to produce fishmeal will be about 17% by 2021, down ~6% from 2009-2011 due to growing demand for fish for human consumption</p>

Research Recommendations

1. Conduct research on methods to ensure the maintenance of nutrient profiles of high-trophic level farmed seafood and improve nutrient profiles of low-trophic farmed seafood concurrently with research to improve production efficacy.
2. Conduct research to develop methods to ensure contaminant levels in all seafood remain at levels similar to or lower than at present. Maintain monitoring of contaminant levels for capture fisheries to ensure that levels caused by pollution do not rise appreciably. This research should include developing effective rapid response approaches if the quality of seafood supply is acutely affected.

References

1. U.S. Department of Agriculture ARS. USDA National Nutrient Database for Standard Reference, Release 27. Nutrient Data Laboratory Home Page 2014.
2. Cladis DP, Kleiner AC, Freiser HH, Santerre CR. Fatty Acid Profiles of Commercially Available Finfish Fillets in the United States. *Lipids*. 2014. PMID: 25108414. <http://www.ncbi.nlm.nih.gov/pubmed/25108414>
3. Food and Agriculture Organization of the United Nations; Geneva WHO. Report of the Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption. Rome. 2011.
4. FAO Fisheries and Aquaculture Department Food and Agriculture Organization of the United Nations. The State of World Fisheries and Aquaculture Rome,2012. Available from: <http://www.fao.org/docrep/016/i2727e/i2727e.pdf>.

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