Comparative Dietary Risks: Balancing the Risks and Benefits of Fish Consumption

Results of a Cooperative Agreement between

The U.S. Environmental Protection Agency

and

Toxicology Excellence for Risk Assessment (TERA)

Final
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<tbody>
<tr>
<td>AA</td>
<td>Arachidonic Acid</td>
</tr>
<tr>
<td>ADI</td>
<td>Allowable Daily Intake</td>
</tr>
<tr>
<td>AFS</td>
<td>American Fisheries Society</td>
</tr>
<tr>
<td>AOC</td>
<td>Areas of Concern</td>
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<tr>
<td>ARIC</td>
<td>Arteriosclerosis Risk in Communities</td>
</tr>
<tr>
<td>AR</td>
<td>Attributable Risk</td>
</tr>
<tr>
<td>ATSDR</td>
<td>Agency for Toxic Substances and Disease Registry</td>
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<tr>
<td>ChE</td>
<td>Cholinesterase</td>
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<tr>
<td>CSF</td>
<td>Cancer Slope Factor</td>
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<tr>
<td>B&lt;sub&gt;i&lt;/sub&gt;</td>
<td>Background incidence of health endpoint i</td>
</tr>
<tr>
<td>BMD</td>
<td>Benchmark Dose</td>
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<tr>
<td>BMDL</td>
<td>Lower confidence limit on a benchmark dose</td>
</tr>
<tr>
<td>BMDL&lt;sub&gt;10&lt;/sub&gt;</td>
<td>Lower bound on dose corresponding to 10% risk (used to be explicit that the lower bound and not the maximum likelihood estimate is being used)</td>
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<tr>
<td>BMI</td>
<td>Body Mass Index</td>
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<tr>
<td>BMR</td>
<td>Benchmark Response</td>
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<tr>
<td>BW</td>
<td>Body Weight</td>
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<tr>
<td>CHD</td>
<td>Coronary Heart Disease</td>
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<tr>
<td>CNS</td>
<td>Central Nervous System</td>
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<tr>
<td>COPD</td>
<td>Chronic Obstructive Pulmonary Disease</td>
</tr>
<tr>
<td>CSF</td>
<td>Cancer Slope Factor</td>
</tr>
<tr>
<td>CSFII</td>
<td>Continuing Survey of Food Intakes by Individuals</td>
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<tr>
<td>DHA</td>
<td>Docosahexanoic Acid</td>
</tr>
<tr>
<td>DL</td>
<td>Detection Limit</td>
</tr>
<tr>
<td>ECG</td>
<td>Electrocardiogram</td>
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<tr>
<td>ED</td>
<td>Effective Dose</td>
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<td>Eicosapentanoic Acid</td>
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<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
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<tr>
<td>FA</td>
<td>Fatty Acid</td>
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<tr>
<td>Trans-FA</td>
<td>Trans-fatty Acid</td>
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<tr>
<td>FCI</td>
<td>Fish Consumption Index</td>
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<tr>
<td>FDA</td>
<td>Food and Drug Administration</td>
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<tr>
<td>FEL</td>
<td>Frank Effect Level</td>
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<tr>
<td>FEV</td>
<td>Forced Expiratory Volume</td>
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<tr>
<td>FVC</td>
<td>Forced Vital Capacity</td>
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<td>HDL</td>
<td>High Density Lipoprotein</td>
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<tr>
<td>HHP</td>
<td>Honolulu Heart Program</td>
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<tr>
<td>HI</td>
<td>Hazard Index</td>
</tr>
<tr>
<td>IRIS</td>
<td>Integrated Risk Information System</td>
</tr>
<tr>
<td>LDL</td>
<td>Low Density Lipoprotein</td>
</tr>
<tr>
<td>LOAEL</td>
<td>Lowest Observed Adverse Effect Level</td>
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<tr>
<td>MeHg</td>
<td>Methylmercury</td>
</tr>
<tr>
<td>MI</td>
<td>Myocardial Infarction</td>
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<tr>
<td>MOE</td>
<td>Margin of Exposure</td>
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MRL  Minimal Risk Level
NEJM  New England Journal of Medicine
NIDDM  Non-insulin-dependent diabetes mellitus
NTP  National Toxicology Program
NOAEL  No Observed Adverse Effect Level
NOEL  No Observed Effect Level
PAH(s)  Polyaromatic Hydrocarbon(s)
PCB(s)  Polychlorinated Biphenyl(s)
PCDD(s)  Polychlorinated dibenzodioxin(s)
PCDF(s)  Polychlorinated dibenzofurans(s)
ppm  Parts Per Million
PUFA  Polyunsaturated Fatty Acid
QALY  Quality Adjusted Life Years
R  Risk
RQ  Reportable Quantity
RR  Relative Risk
RRi  Relative Risk of health endpoint i at a given consumption rate
RfC  Reference Concentration
RfD  Reference Dose
RSD  Risk Specific Dose
S  Severity
Si  Severity of health endpoint i
SFA  Saturated Fatty Acid
UF  Uncertainty factor
WHO  World Health Organization
Foreword

This document is the result of a cooperative agreement between Toxicology Excellence for Risk Assessment (TERA) and the U.S. Environmental Protection Agency (U.S. EPA), Office of Water. TERA formed a Research Team of scientists to collectively develop knowledge of problems regarding assessing health risks and benefits posed by consumption of chemically contaminated fish and determine a method to evaluate both risks and benefits together. The final outcome of this cooperative agreement is this report, which summarizes what is known about health risks from consumption of contaminated fish, health benefits from consuming fish, and general problems associated with comparisons of these risks and benefits. Moreover, this report proposes a framework for comparing the health benefits and health risks in a quantitative fashion.

The results of this research are intended to lead to a better understanding of the relative health risks and benefits of consumption of contaminated fish. The authors of this report anticipate that the proposed framework will be used by local risk managers and fish consumers to further evaluate health benefits, health risks and other dietary information on contaminated fish. Furthermore, states and tribes may use the results of this or subsequent work in assessing local conditions and developing policies towards site-specific fish consumption advisories. An Advisory Committee of state, local, tribal, industry and environmental scientists provided input during the course of this research on the design and use of the framework. This Advisory Committee reviewed a draft of this document and suggested improvements.

Funding for this work was provided by the U.S. EPA under Cooperative Agreement number CX825499-01-0 and by TERA. Mr. Jeffrey Bigler of the U.S. EPA Office of Water was the Project Officer. Although the information in this document has been funded in large part by the United States Environmental Protection Agency, it does not necessarily reflect the views of the Agency and no official endorsement should be inferred.

We would welcome your comments on this document. Please contact Toxicology Excellence for Risk Assessment (TERA) at 513-542-7475 (RISK), or tera@tera.org (e-mail).
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To conduct this research and write this document, Toxicology Excellence for Risk Assessment (TERA) formed a Research Team of scientists from a number of key disciplines, including risk assessment, nutrition science, environmental anthropology, medicine and public health, risk communication and toxicology. The Research Team members each contributed knowledge and inspiration from their respective fields to write or contribute to specific chapters, as well as collaborate on the quantitative framework outline.

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An Advisory Committee was formed in 1997 at the beginning of this project to provide advice and assistance to TERA and the Research Team by identifying target and countervailing risks, suggesting case study ideas and providing comments on the practicality and usefulness of the framework. The Advisory Committee met in February 1999 to review a draft of this document. The Committee members provided many helpful and constructive suggestions for revisions; many of which are reflected in the final document. TERA and the Research Team greatly appreciated the input and suggestions of the Advisory Committee. Their comments have significantly strengthened this document.

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A number of TERA staff assisted in this endeavor. Ms. Joan Dollarhide provided initial thinking and scoping of the project and Dr. Lynne Haber provided scientific review and input of the final document. We thank both of them. We also appreciate the patience and perseverance of Ms. Meg Poehlmann and Ms. Caitlin McArleton in finalizing the text and references.

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Executive Summary

A comparative dietary risk framework (hereafter referred to as the framework) has been developed under this Cooperative Agreement for comparing the possible health risks of consuming contaminated fish, while considering the potential health benefits lost by not eating fish. The result of using the framework is a crude quantitative representation of the risk and benefit associated with eating contaminated fish. The output of the framework is referred to as the fish consumption index (FCI).

The FCI is an estimate of relative risk. It is not an estimate of absolute risk. In other words, it does not provide users of the framework with an estimate of their increased or decreased incidence of a particular health outcome. It simply provides a mechanism by which users can weigh the possible health risks versus the possible health benefits of eating contaminated fish. Cultural benefits of catching and eating fish (or detriments of not being able to fish or consume fish) may also be considered, however the current version of the framework does not attempt to quantify these benefits.

Before considering risks and benefits, a determination should be made that alternatives to contaminated fish are not available. Perhaps lower contaminated fish sources are available sufficient to maintain the individual’s desired level of fish consumption. Situations where the weighing of benefits and risks may be necessary may include subsistence populations where alternatives to contaminated locally caught fish are limited.

The framework is designed to provide information for a range of fish consumption rates, allowing a user to roughly estimate the range of consumption rates at which people may have a net benefit, a net risk, and the consumption rate at which no net change in the health index would be likely. However, the suggested framework has a number of significant data gaps. These gaps are sufficiently large so as to prevent any definitive conclusions. Moreover, these gaps prevent making any overall recommendations on the existing fish consumption advisory programs of the U.S. or other countries. Further study is needed to confirm and extend the preliminary findings discussed in this document.

Use of the framework and FCI does not imply the proper choice is simply achieving a situation in which the net risks and benefits are zero. Nor is it a justification for accepting fish consumption risks as long as there is a net benefit. Rather, the framework helps make the risks and benefits transparent. Decisions about acceptable risks and distribution of risks and benefits throughout society should be made collectively by the communities affected, and are not a focus of this text. That the FCI may demonstrate cases in which fish consumption benefits may outweigh the risks is not a license to pollute. Rather, society must determine policy about long-term goals for minimizing environmental pollution based on a range of ethical, economic, social, and other criteria. Again, the purpose of this text is to discuss the underlying scientific issues associated with comparing the risks and benefits of fish consumption. It does not address the social, economic or ethical considerations.

There is some evidence for an association between decreased risk of coronary heart disease (CHD) or myocardial infarction (MI) and consumption of small amounts of fish, including
mainly lean (non-fatty) fish. In addition, other health endpoints have been examined and some research suggests that eating fish may be associated with reduced incidences or severity of a number of other endpoints. This evidence, along with the superior nutritional value of fish, is strong enough that public health officials routinely encourage the public to eat more fish.

Consuming uncontaminated fish (or at least fish that are smaller, younger, or in general less contaminated) may provide health benefits as mentioned above, but without the potential health risks associated with contamination. The eating of such “cleaner” fish rather than more contaminated fish, would maximize the net benefit of fish consumption, as we show specifically for low versus high concentrations of chemicals in fish, for those chemicals that either bioaccumulate or not, or for fish contaminated with more that one chemical.

This framework is an initial attempt to evaluate risks and benefits (qualitatively and quantitatively) on a common scale. Constructing this framework has identified numerous areas that need further research and development. Two needs seem paramount. First, better estimations of benefits are needed for the general population and its sensitive subgroups. Although information in this text is highly suggestive of the protective effects of eating fish and allows some quantification, more definitive work is needed to support or modify our chosen quantitative values. Second, better risk information is needed on the chemicals that commonly contaminate fish. Sufficient knowledge on the toxicity of most of these pollutants exists, on which noncancer risks could be quantified. Both sets of information are essential for this framework to be most effective.