UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

XXXX XX, 2011

EPA-SAB-11-xxx

The Honorable Lisa P. Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: Peer Review of EPA's Draft National-Scale Mercury Risk Assessment

Dear Administrator Jackson:

EPA's Office of Air and Radiation requested that the Science Advisory Board (SAB) review a draft *Technical Support Document: National-Scale Mercury Risk Assessment Supporting the Appropriate and Necessary Finding for Coal and Oil-Fired Electric Generating Units - March 2011*. This draft document has the goal of characterizing human health exposure and risk associated with U.S. electrical generating unit (EGU) mercury emissions with a focus on a highly exposed subpopulation, subsistence fishers. An SAB Panel held a public meeting on June 15-17, 2011 to peer review this document and held a public teleconference on July 20, 2011 to discuss the Panel's draft report.

The SAB was asked to comment on the risk assessment, including the overall design and approach, as well as various technical aspects. The SAB was also asked to comment on the extent to which specific facets of the assessment were well characterized in the Technical Support Document. SAB reviewers found it difficult to evaluate the risk assessment based solely upon information provided in the Technical Support Document. Important elements of the methods and findings are missing or poorly explained. Presentations by Agency staff and subsequent dialog during the public meeting were extremely valuable and allowed the SAB to gain an understanding of the risk assessment sufficient to conduct its review.

The SAB founds that the risk assessment provides an objective, reasonable, and credible determination of the potential for a public health hazard from mercury emitted from U.S. EGUs. The SAB approved of the overall design and general approach and considered the spatial resolution of the modeling of mercury deposition to watersheds to be appropriate for the analysis. There was agreement that the approach used to identify watersheds to include in the assessment was reasonable. This approach was based upon the availability of fish tissue methylmercury data and census data on target populations with potential subsistence fishers. The

SAB agreed that EPA's calculation of a hazard quotient for each watershed included in the assessment is appropriate as a principal means of expressing risk. The SAB expressed concern regarding the relative insensitivity of IQ loss as a second public health endpoint for methylmercury. The Board recommended that this aspect of the study be de-emphasized by placing it in an appendix along with discussion of other potential endpoints for neurodevelopmental effects not evaluated quantitatively in the risk assessment. Although the number of watersheds included in the assessment was considered adequate, the SAB noted that watersheds in some states with areas with relatively high mercury deposition from U.S. EGUs were omitted due to lack of fish tissue methylmercury data. The SAB encouraged the Agency to contact these states to determine if additional fish tissue methylmercury data are available to improve coverage of the assessment. The SAB discussed sources of variability and uncertainty in the risk assessment, as well as limitations imposed by the availability of data. The uncertainties were viewed as consistent with what is essentially a screening level public health assessment, and the SAB regarded the risk assessment as suitable for its intended purpose, to support the appropriate and necessary finding required for regulation of hazardous air pollutants from coal and oil-fired EGUs.

Review of the Technical Support Document itself was not so favorable. The Technical Support Document needs to do a much better job of explaining what was done and why, what the results represent, and where the uncertainties lie. The SAB report contains numerous recommendations for improving the clarity of the Technical Support Document. The SAB views the overall credibility of the risk assessment to be dependent in part on a transparent description of the methods and findings. This does not exist in the current draft, and SAB support for the risk assessment is contingent upon development of a revised document that addresses these issues.

We appreciate the opportunity to review the mercury risk assessment. We look forward to your response.

Sincerely,

Dr. Deborah L. Swackhamer
Chair
Science Advisory Board

Dr. Stephen M. Roberts
Chair
SAB Mercury Review Panel

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Peer Review of EPA's Draft National-Scale Mercury Risk Assessment.

Executive Summary

EPA has proposed National Emission Standards for Hazardous Air Pollutants (NESHAP) for coal- and oil-fired Electric Utility Steam Generating Units (EGUs) requiring them to decrease emissions of mercury and other hazardous air pollutants (HAP). In order to regulate HAP emissions under the Clean Air Act, Section 112(b), the Agency must make a determination that such regulation is appropriate and necessary based upon a study of the hazards to public health reasonably anticipated from HAP emissions. As part of this determination, hazards to public health from U.S. EGU mercury emissions were evaluated in a national-scale risk assessment.

The risk assessment considered hazards from mercury released from U.S. EGUs depositing in watersheds within the continental U.S. Mercury deposition was estimated using the Community Multi-scale Air Quality (CMAQ) model for watersheds classified using 12-digit Hydrologic Unit Codes (HUC12). The risk assessment focused on hazard from consumption of methylmercury in self-caught fish by subsistence fishers, specifically hazard to children born to subsistence fisher mothers exposed during pregnancy. Exposure from fish consumption was estimated for watersheds with data on methylmercury concentrations in fish tissue, and a hazard quotient (HQ) was calculated based upon the current reference dose (RfD) for methylmercury. The contribution of U.S. EGUs to the HQ for each watershed was calculated by comparing U.S. EGU deposition rates with total deposition to the watershed, including other sources, assuming that the contribution of U.S. EGUs to fish tissue concentrations and risk is proportional to their contribution to total emissions. IQ loss was also modeled as a health endpoint, with a loss of 1 or more points from methylmercury exposure considered as a public health concern. Estimated hazards associated with U.S. EGU emissions in 2005 were compared with estimated hazards expected to remain in 2016 "after imposition of the requirements of the Act."

The SAB Mercury Review Panel was asked to comment on the risk assessment, including the overall design and approach as well as various technical aspects. The Panel was also asked to comment on the extent to which specific facets of the assessment were characterized in the Technical Support Document. The Panel reviewed background materials provided by the Office of Air Quality Planning and Standards, as well as public comments on the topic. A public meeting of the Panel was held on June 15-17, 2011 to provide peer review, respond to charge questions, and discuss preparation of a report capturing the Panel's comments and recommendations. A public teleconference was held July 20, 2011 to review the draft report.

In general, the Panel found the Technical Support Document to be cursory, lacking critical details regarding both the methods used and the results presented. This made the document difficult to review and, the Panel believes, unsuitable in its present form to support Agency decision-making. Presentations by Agency staff and subsequent dialog between the staff and the Panel at the public meeting were critical in helping the Panel understand how the risk assessment was conducted, the rationale for some of the decisions made in approach and use of data, and what the results are intended to represent. With this understanding, the Panel viewed the risk assessment favorably, concluding that it provides an objective, reasonable, and credible determination of the potential for a public health hazard from mercury emitted from U.S. EGUs. However, the Panel considers the integrity of the risk assessment to be dependent in part on a transparent description of the analysis and findings. The Technical Report is wholly inadequate in providing this. Responses to charge questions indicate where improvements need to be made, and the Panel's support for the risk assessment is contingent upon these issues being addressed.

In response to the first charge question, the Panel found the overall design and general approach used in the risk assessment to be scientifically credible. The Technical Support document, however, needs a more detailed description of the modeling methods and data sources, and the report's introduction should make clear up front that the analysis is a determination of potential exposure at watersheds.

In response to charge questions regarding health endpoints to consider, the Panel supported the use of the HQ approach in the risk assessment. They noted that a number of measures of potential neurodevelopmental effects of methylmercury exist, some of which have greater sensitivity than IQ loss. However, none are viewed by the Panel as suitable for quantitative risk estimation with a reasonable degree of scientific certainty at the present time, and consequently none were recommended for incorporation into the analysis. The Panel had little enthusiasm for the use of IQ loss in the risk assessment and recommended that this aspect of the analysis be de-emphasized, moving it to an appendix where IQ loss is discussed along with other possible endpoints not included in the primary assessment. While the Panel agreed that the concentration-response function for IQ loss used in the risk assessment is appropriate, and no better alternatives are available, IQ loss is not a sensitive response to methylmercury and its use likely underestimates the impact of reducing methylmercury in water bodies. The Panel agreed that if IQ loss is retained in the risk assessment despite these reservations, a loss of 1 or 2 points would be an appropriate benchmark. The Panel agreed that fish nutrients can potentially influence neurologic effects associated with methylmercury, but there is not sufficient information to recommend a quantitative adjustment in health endpoint measures.

The Panel agreed that HUC12 watersheds provide the appropriate level of spatial resolution and offer advantages over previous assessments at lower resolution (e.g., HUC8). The comparability of this scale to CMAQ output makes the transferability and applicability of deposition modeling to the watershed scientifically robust. Further, the finer resolution of HUC12 watersheds is better able to follow deposition patterns of a single source, such as an EGU, and provides greater likelihood that deposition within a watershed is relatively homogeneous. The Panel noted that one disadvantage of smaller watershed size is that the number of fish samples with methylmercury data is diminished. The Panel questioned some of the figures with maps showing modeled deposition across the United States. Some areas showed intense deposition with no obvious source, leading Panel members to question the accuracy of the modeling or data presentation.

The Panel agreed that fish tissue methylmercury data are an appropriate basis for the mercury risk assessment. Although fish data were only available for 2,461 HUC12 watersheds out of 88,000 HUC12 watersheds in the continental United States, this was viewed as sufficient for the goals of the risk assessment. The Panel noted advantages and disadvantages of the Agency decision to limit fish tissue concentration data to the period after 1999, but agreed with this approach given that older data might not be representative of conditions during the 2005 reference deposition year. The Panel was concerned that the absence of fish tissue concentration data prevented inclusion in the analysis of watersheds in some states with higher mercury deposition rates from EGUs, such as Pennsylvania, New Jersey, Kentucky, and Illiniois. The EPA was encouraged to contact these states to determine whether additional fish tissue data are available to improve coverage of the analysis. The use of modeling to estimate fish methylmercury concentrations was discussed as a means to include more watersheds. The Panel thought that with further development, this approach could be used for a national scale assessment such as this in the future, but did not recommend it for the current assessment.

As a means of selecting methymercury fish concentrations representative of larger, but not the largest, edible fish, the 75th percentile fish concentration was selected for watersheds with more than one fish concentration value. The Panel considered this percentile reasonable, but expressed concern that over half of the watersheds in the assessment have only one fish sample with methylmercury concentration available. The Panel noted that when only a few fish samples are available, the 75th percentile concentration will be underestimated, and that the 75th percentile concentration is a source of considerable uncertainty given the data limitations. The Panel recommended that the report provide more detail concerning the source of fish methylmercury concentrations that were obtained and details regarding the sampling program (such as goals of the sampling program, types and sizes of fish obtained, etc.).

The Panel found that the consumption rates and locations for fishing activity for high-end, self-caught fish consuming populations modeled in the analysis were supported by the data presented in the document and were generally reasonable and appropriate given the data available. A diverse range of susceptible populations was represented in the assessment. There are caveats, however, associated with the sources of fish consumption data, the data sets selected for inclusion, and the suitability of data for inclusion in the risk assessment (e.g., in terms of providing annual average intakes of fish "as consumed") that should be acknowledged more fully in the document.

The Panel agreed that the criterion of using at least 25 persons per census tract from a given target subsistence fisher population was a reasonable approach. While other approaches are possible, none was viewed as being more effective or feasible. The Panel recommended that the document clarify how many watersheds were eliminated due to this inclusion criterion.

The Panel agreed with the Mercury Maps approach used in the analysis and cited additional work that supports a linear relationship between mercury loading and accumulation in aquatic biota. The Panel noted other modeling tools available to link deposition to fish concentrations, but did not consider them to be superior for this analysis or recommend their use. The integration of CMAQ deposition modeling to produce estimates of changes in fish tissue concentrations was considered to be sound. Although the Panel was generally satisfied with the presentation of uncertainties and limitations associated with the application of the Mercury Maps approach in qualitative terms, it recommended that the document include quantitative estimates of uncertainty that are available in the existing literature.

In order to reduce uncertainty associated with the Mercury Maps approach, watersheds with significant non-air loadings of mercury were excluded from the analysis. The Panel agreed with the exclusion criteria used by the Agency. Additional exclusion criteria were discussed (e.g., watersheds with existing fish advisories), but their application would be unlikely to substantially change the results of the assessment.

Two charge questions were posed regarding characterization of variability and uncertainty in the Technical Support Document, stimulating considerable discussion. Sources of variability and uncertainty in the assessment are summarized in Appendix F of the document. The qualitative nature of this presentation was considered appropriate, but the identification of important sources of variability and uncertainty was considered incomplete. Inclusion of several specific sources of variability and uncertainty was recommended. The Panel noted that the degree of uncertainty associated with the analysis is consistent with a screening level analysis, and despite the various sources of uncertainty inherent in the approach, the analysis is sound and reasonable.

The Panel found that observations in five areas (Mercury deposition from U.S. EGUs, Fish tissue methylmercury concentrations, Patterns of mercury deposition with mercury fish tissue data, Percentile risk estimates, and Number and frequency of watersheds with populations potentially at risk due to U.S. EGU mercury emissions) were generally supported by the analytical results presented in the document. However, there were many examples where results were poorly presented, and in most areas the uncertainties, variability, and data limitations were not well characterized. The Panel had numerous specific recommendations to improve presentation of findings and observations.

The section of the document on Summary of Key Observations did not encapsulate well the critical issues and significant results of the analysis, in the opinion of the Panel. The Panel recommended revising this section to link back directly with the goals of the studies as articulated on Page 13 of the document, i.e., (a) what is the nature and magnitude of the potential risk to public health posed by current U.S. EGU mercury emissions; (b) what is the nature and magnitude of the potential risk posed by U.S. EGU mercury emissions in 2016 considering potential reductions in EGU Hg emissions attributable to CA [Clean Air Act] requirements; and (c) how is risk estimated for both the current and future scenario apportioned between the incremental contribution from U.S. EGUs and other sources of mercury?

1. Introduction

EPA's Office of Air and Radiation requested peer review of a *Technical Support Document: National-Scale Mercury Risk Assessment Supporting the Appropriate and Necessary Finding for Coal and Oil-Fired Electric Generating Units - March 2011*, developed to support a proposed rule published in the Federal Register on March 16, 2011 to regulate emissions of hazardous air pollutants from for coal- and oil-fired Electric Utility Steam Generating Units (EGUs). Section 112(n)(1) of the Clean Air Act requires EPA to determine whether it is "appropriate and necessary" to regulate hazardous air pollutants emissions from EGUs under section 112. The "appropriate and necessary" finding requires EPA to perform a study of the hazards to public health reasonably anticipated to occur as a result of hazardous air pollutant emissions, including mercury.
The Science Advisory Board formed an expert *ad hoc* Panel to peer review the draft Technical Document. The Panel addressed fourteen Agency charge questions and developed the responses below.

2. General Comments

The Panel had difficulty evaluating the Technical Support Document because it is much too cursory. During the public meeting, presentations by Agency staff and subsequent dialog were extremely valuable in understanding technical aspects of the analysis, and with many answered questions and clarifications, the Panel was able to view the risk assessment positively. However, the Panel considers the integrity of the risk assessment as dependent in part on a transparent description of the methods and findings. The Technical Support Document needs to do a much better job of explaining what was done and why, what the results represent, and where the uncertainties lie. The Panel's support for the risk assessment is contingent upon a development of a revised document that addresses these issues. Specific suggestions are found in the responses to the Charge Questions.

3. Purpose and Scope of the Analysis

3.1. **Question 1.**

Please comment on the scientific credibility of the overall design of the mercury risk assessment as an approach to characterize human health exposure and risk associated with U.S. EGU mercury emissions (with a focus on those more highly exposed).

Response: The Panel found that the overall design and general approach used in the assessment are scientifically credible.

The overall approach used in the study is to estimate risk at a national scale, attributable to mercury released from EGUs for current (2005) and future (2016) conditions. To accomplish this, the analysis links a series of models and data in order to estimate mercury exposure via fish consumption and then compare the exposure with a toxicological benchmark. The series of models allows for the estimation of deposition of mercury emitted by U.S. EGUs into watersheds. The assessment uses estimates of mercury deposition into a subset of watersheds that have measurements of fish methylmercury concentrations to estimate the number and percentage of watersheds where populations may be at risk. Human exposure and potential health effects in these at risk watersheds are then assessed by examining the main exposure pathway of ingestion of self-caught fish from inland water bodies for maximally exposed individuals (subsistence fishers).

While the overall design and general approach are scientifically credible, the Panel had a number of suggestions for enhancing the assessment, which are expanded upon in responses to subsequent charge questions. It will be important for EPA to address these issues. The Technical Support Document (TSD) would benefit from a more detailed description of the modeling methods and data sources, and results need to be presented more clearly. The Introductory section should make clear, at the earliest possible point, that the analysis is a determination of potential exposure at watersheds. Despite weaknesses in the Technical Support Document and uncertainties inherent in an analysis such as this, the Panel believes that the risk assessment makes an objective and reasonable determination of the potential for a public health hazard from mercury emitted from U.S. EGUs.

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4. Overview of Risk Metrics and the Risk Characterization Framework

4.1. **Question 2**

Are there any additional critical health endpoint(s) besides IQ loss which could be quantitatively estimated with a reasonable degree of confidence to supplement the mercury risk assessment (see section 1.2 of the Mercury Risk TSD for an overview of the risk metrics used in the risk assessment)?

Response: While several alternative approaches were discussed that might supplement IQ scores, no substitute can be quantitatively estimated with a "reasonable degree of confidence." Moreover, there were doubts that IQ met this standard. There are significant concerns about the use of IQ for identifying the impact of consuming fish from water bodies with unacceptable levels of methylmercury because it will likely result in an underestimation (as explained in greater detail below). Evidence for this can be seen in comparisons of the results using IQ with those using the hazard quotient (HQ). It may be preferable to reframe the document's discussion of IQ, incorporating IQ and other neuropsychological measures as supplemental information and focusing on HQ as the primary critical health endpoint. These issues are discussed further below.

The use of IQ. EPA has done a considerable amount of work in analyzing methylmercury's impact on IQ. After extensive discussion, the Panel recommended that the appropriate approach would be to mention the IQ analysis in the body of the TSD and to discuss the uncertainties involved with the use of the analysis, offering the conclusion that it would be a less sensitive endpoint than the Hazard Quotient (HQ), which is based on the current reference dose (RfD) for methylmercury. The remainder of the IQ discussion could be moved to an appendix to show a fairly complete analysis of the use of a decrement in IQ as an adverse endpoint.

The loss of IQ points is likely to underestimate the impact of reducing methyl mercury in water bodies. The reason is that IQ score has not been the most sensitive indicator of methylmercury's neurotoxicity in the populations studied. As noted in the TSD, in the Faroe Island study the most sensitive indicators were in the domains of language (Boston Naming), attention (continuous performance) and memory (California Verbal Learning Test), neuropsychological tests that are not subtests of IQ tests and are not highly correlated with global IQ. In the Seychelles study, the Psychomotor Development Index has been most sensitive measure and, while this is a component of the Bailey Scales of Infant Development, it is not highly correlated with cognitive measures.

The use of IQ, or any neuropsychological measure, distracts from the main goal of the document. The analysis in the document emphasizes the number of water bodies from which subsistence fishers would be at-risk based on an elevated HQ. As is clear in Tables 2-9 to 2-11 in the TSD, an analysis based on IQ identifies far fewer water bodies than one based on the HQ. This is because IQ underestimates hazard, as noted above.

It is not suggested that the analyses of IQ be removed altogether but rather that they be framed as a secondary analyses of impact of reduced exposure on potential health-related outcome. Such a discussion should also include potential effects on other measures like developmental delays

(Grandjean et al., 1997) or neuropsychological tests (as reviewed by van Wijngaarden et al., 2006), presented in the overall context of the weight of evidence.

Alternative quantitative measures. One alternative is developmental delay as described by Grandjean et al., 1997). Here, an estimate of the number of months of delay in verbal skills as tapped by the Boston Naming Test or in learning and short-term memory as tapped by the California Verbal Learning Test was made based on regression coefficients describing the relationship among age, methylmercury exposure, and scores on these tests. The delays were on the order of five to seven months associated with a 10-fold increase in cord blood mercury.

A recent analysis by van Winjngaarden et al. (2006) derived BMDL (Benchmark Dose Level-Lower 95% confidence interval) values for 26 endpoints, including IQ and other neuropsychological measures from the literature. This paper could be cited in a discussion of markers of health impacts of lowering mercury deposition and reducing intake by subsistence fishers.

One Panel member suggested the use of blood markers of selenium (Se)-dependent enzyme function, noting that methylmercury irreversibly inhibits Se-dependent enzymes that are required to support vital-but-vulnerable metabolic pathways in the brain and endocrine system. Impaired selenoenzyme activities would be observed in the blood before they would be observed in brain, but the effect is also expected to be transitory. The use of these measures was a minority view among the Panel members.

The Panel recommends that the TSD acknowledge and discuss alternatives, but does not recommend a re-analysis based on these measures.

4.2. **Question 3**

Please comment on the benchmark used for identifying a potentially significant public health impact in the context of interpreting the IQ loss risk metric (i.e., an IQ loss of 1 to 2 points or more representing a potential public health hazard). Is there any scientifically credible alternate decrement in IQ that should be considered as a benchmark to guide interpretation of the IQ risk estimates (see section 1.2 of the Mercury Risk TSD for additional detail on the benchmark used for interpreting the IQ loss estimates).

Response: There is no credible alternate decrement in IQ that should be used. The consensus was that if IQ must be used, then a loss of 1 or 2 points was a credible decrement to use for this risk assessment. This metric seems to be derived from the lead literature and was peer-reviewed by the Clean Air Scientific Advisory Committee (CASAC). While its applicability to methylmercury is questionable, the size of the decrement is justified based on the extensive analyses available from that literature (U.S. EPA CASAC, 2007). The support for the model of the relationship between IQ and methylmercury exposure comes from Axelrad and Bellinger (2007) and from a whitepaper produced by Bellinger (2005). It was noted that the 1-2 point decrease reflects the mean response, but that a decrease of 1-2 points at the mean results in a much larger decrease at the tails of the distribution. This can result in a greater impact on those with IQ’s that are much lower or higher than the mean.

The analysis in Table 2-10 showing the effect of using a 1- or 2-point loss was helpful in evaluating the sensitivity of this measure to the magnitude of the decrement. Overview of Analytical Approach

4.3. **Question 4**

Please comment on the spatial scale used in defining watersheds that formed the basis for risk estimates generated for the analysis (i.e., use of 12-digit hydrologic unit code classification). To what extent do HUC12 watersheds capture the appropriate level of spatial resolution in the relationship between changes in mercury deposition and changes in MeHg fish tissue levels? (see section 1.3 and Appendix A of the Mercury Risk TSD for additional detail on specifying the spatial scale of watersheds used in the analysis).

Response: The choice of using the HUC12 (Hydrologic Unit Code) watershed delineation of the contiguous 48 United States for this risk assessment is more appropriate and offers at least two distinct advantages over the 2001 Mercury Maps study report that employed the larger-scale HUC8 delineation. First, HUC8s are “cataloguing units” delineation and do not actually represent true watersheds (areas of land where surface water drainage accumulates to an outflow location). Instead, many HUC8 areas have flow lines that cross the unit boundaries, thus making this larger scale delineation not technically correct for any mass accounting procedure like Mercury Maps. The use of HUC12s, which are true watershed delineations, does not violate this mass accounting assumption. A second strength of the use of HUC12’s is that they have a similar physical scale to the spatial resolution of the CMAQ output (12 km CMAQ square grid compared to the HUC12 watersheds that are typically about 5-10 km on a side). Comparable scales make the transferability and applicability of deposition modeling to the watershed more scientifically robust. The use of finer scale watersheds enables modeling and deposition runs that have the detail to follow deposition patterns from a single source, including EGUs. The fine-scale watershed resolution decreases the likelihood that there is a significant deposition gradient within the HUC. Further, the relative biogeochemical and ecological homogeneity of an individual HUC12 watershed allows better validity for ascribing fish concentrations to a specific watershed, and that those fish will respond in proportion to changes in atmospheric mercury deposition. The Panel notes, however, that one potential disadvantage of HUC12 exists in that a number of HUC12 watersheds contain a very limited number of fish samples because of their inherent small size, but other factors described in this response override this concern.

The authors of the TSD acknowledge, and this Panel agrees, that the fish distribution data are highly skewed toward the Eastern United States. That said, the legend of Figure 2-6 indicates that almost 300 samples are from Western sites. Given the apparent distribution of high deposition zones in CMAQ modeling runs displayed in Figures 2-1 and 2-2 that are not ground-truthed in MDN deposition measurement, the Panel is concerned not only about the reality of the identified intense deposition zones (i.e., whether they are truly intense deposition zones; for example, in the state of Nevada), but also whether these watersheds were included in this report’s analysis. Fish distribution data appear to overlap with some of these zones of modeled high mercury deposition, and with 300 fish samples from the Western United States, there is a high probability for overlap.

The Panel was concerned about the possibility that in some watersheds, multiple small lakes may be included within a single HUC12. In some cases, lakes within a small geographic zone have been shown to have quite different chemistry and biological productivity. For instance, within Voyageurs National Park in northern Minnesota, the mercury content of similarly-sized fish of a given species in about 20 lakes range by a factor of 10 (Wiener et al. 2006), indicating that even lakes nearby each other can bioaccumulate mercury to greatly differing degrees. In HUCs with multiple lakes, the Panel cautions against using a single fish mercury value to describe the HUC. In response to this concern and other charge questions, the Panel recommends that the authors provide a summary table describing the characteristics of the watersheds where fish were collected. That is, what fraction was collected from rivers, lakes, number of multiple lakes, lakes and rivers, etc?

4.4. **Question 5**

Please comment on the extent to which the fish tissue data used as the basis for the risk assessment are appropriate and sufficient given the goals of the analysis. Please comment on the extent to which focusing on data from the period after 1999 increases confidence that the fish tissue data used are more likely to reflect more contemporaneous patterns of mercury deposition and less likely to reflect earlier patterns of mercury deposition. Are there any additional sources of fish tissue MeHg data that would be appropriate for inclusion in the risk assessment?

<u>Response:</u> The measured fish tissue data serve as an appropriate basis for the mercury risk assessment because they are widely available and reflect the actual environmental conditions that influence fish mercury concentrations and human exposure to mercury by the target populations. While it is always desirable to have a larger sample size, the sample size of 2,461 HUC12 watersheds is adequate for the goals of the risk assessment. However, as detailed below, the Panel is concerned about the sources of bias and uncertainty resulting from the state sampling designs used to select watersheds where fish tissue samples were obtained. For purposes of hazard assessment, it is reasonable to have an over-representation of HUC12s in the eastern part of the country given the prevalence of EGUs in the East. However, the description of the character of the data, as well as the selection of analyzable data (e.g., sizes, distribution of fish sizes across watersheds), should be better detailed in the report.

There are advantages and disadvantages to using fish methylmercury data prior to 1999 for the risk assessment. The advantage is that considerable fish data were obtained prior to 1999 and the use of these data could increase the information available for the national risk assessment. The disadvantage is that fish mercury concentrations may have changed since 1999 and these older data may not be representative of conditions during the 2005 reference deposition year. Unfortunately, there are few high quality time series data of fish mercury concentrations so it is difficult to quantify the extent to which fish mercury concentrations have changed since the 1990s. As a result, the Panel recommends that the EPA utilize fish mercury data collected since 1999 for the risk assessment.

Given the spatial distribution of mercury deposition from EGUs and the density of fish mercury measurements (Figure 2-15), there are some states that receive elevated mercury deposition from U.S. EGU emissions and have limited fish methylmercury measurements. These states include

Pennsylvania, New Jersey, Kentucky, and Illinois. The Panel suggests that the EPA contact these states to investigate if additional recent (since 1999) fish methylmercury data are available to improve the coverage for the mercury risk assessment. For example, the Pennsylvania Department of Environmental Protection, Pennsylvania Fish Monitoring Program has 700 sites for the measurement of the methylmercury content of recreational sport fish, with samples collected from 1979-2007.

The reliance of the National Listing of Fish Advisory (NFLA) and U.S. Geological Survey (USGS) compilation of mercury data sets on data collected by state agencies with various sampling designs and state protocols contributes to uncertainty in the risk assessment. Most of the data are not from probability-based sampling designs, so it is not entirely clear what population the fish tissue samples represent. The direction of impact on the risk assessment of this variation in sampling designs is uncertain. Moreover, some states have greater sampling efforts than others; particularly strong sampling efforts were observed in South Carolina, Louisiana, Indiana, Iowa, West Virginia, and Virginia. As a consequence of this variability in fish-tissue sampling effort, the risk assessment will be strongly influenced by states with high sampling efforts. Moreover, Figure 2-18 suggests that the sample is biased in favor of watersheds with higher mercury deposition and higher EGU-attributable deposition as predicted by the CMAQ model. This bias could in part be due to the over-representation of HUC12s in the East, but could also occur if states with high deposition also have high fish-tissue sampling effort. Nevertheless, as per the limitations of the available data, the risk assessment focuses on that portion of the fish-sampled watersheds at risk, rather than attempting to make inferences to the larger population of all 88,000 HUC12 watersheds.

Researchers have developed empirical relationships for fish methylmercury concentrations using water chemistry and land cover data. These empirical relationships have been used to estimate methylmercury concentrations for different fish species across states and regions. Such an empirical modeling approach could be used to provide more comprehensive estimates of fish methylmercury concentrations across water resources and potentially improve the extent of future mercury risk assessments. However, if this empirical modeling approach was to be used in a risk assessment such as this, it would need to be developed and evaluated at a national scale. Moreover, the use of empirical models contributes additional uncertainty in the estimation of fish methylmercury concentration. The Panel is not recommending that this approach be used for the current risk assessment. Rather, the EPA might consider use of empirical modeling to improve the density of fish mercury concentrations in future assessments.

4.5. **Question 6**

Given the stated goal of estimating potential risks to highly exposed populations, please comment on the use of the 75th percentile fish tissue MeHg value (reflecting targeting of larger but not the largest fish for subsistence consumption) as the basis for estimating risk at each watershed. Are there scientifically credible alternatives to use of the 75th percentile in representing potential population exposures at the watershed level?

Response: Using the 75th percentile of fish tissue values as a reflection of consumption of larger, but not the largest, fish among sport and subsistence fishers is a reasonable approach and is consistent with published and unpublished data on predominant types of fish consumed. While on the surface the choice of the 75th percentile is a reasonable estimation for the methylmercury levels of consumed fish, the appropriateness of this approach depends on the data from which the value was derived. Much concern was raised about the fact that over half of watersheds have only one fish sample with a fish tissue methylmercury concentration available. Figure 1 below shows a plot of the number of fish tissue samples available for lakes and rivers using data provided to the Panel by EPA. There is clear evidence of a very high proportion of samples with only one fish.

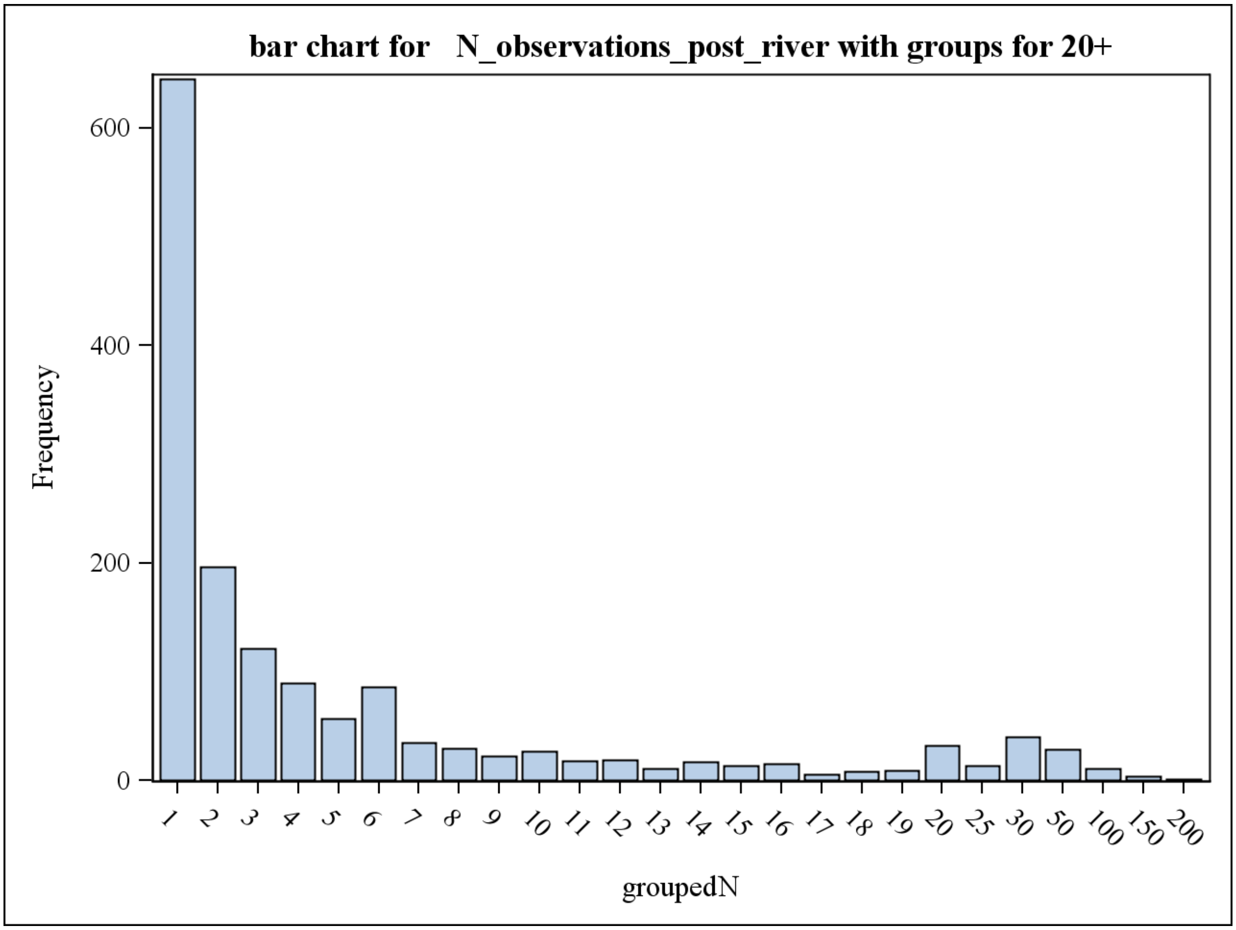


Figure 1. Sample size plot for lakes and rivers using Excel data provided to the panel

Thus, the estimate of the 75th percentile has considerable uncertainty. The use of only one tissue value for a given watershed is likely to underestimate fish tissue levels if the single fish collected was, on average, smaller than the true 75th percentile, as would occur if the collection were random. Support for this notion is provided by Figure 2 below, which relates the 75th percentile fish tissue methylmercury concentration (on y axis) to the number of fish samples available for any given watershed. The estimate of the 75th percentile appears to increase with increasing sample size, thus suggesting that the 75th percentile fish tissue concentration for watersheds with few fish samples is underestimated.

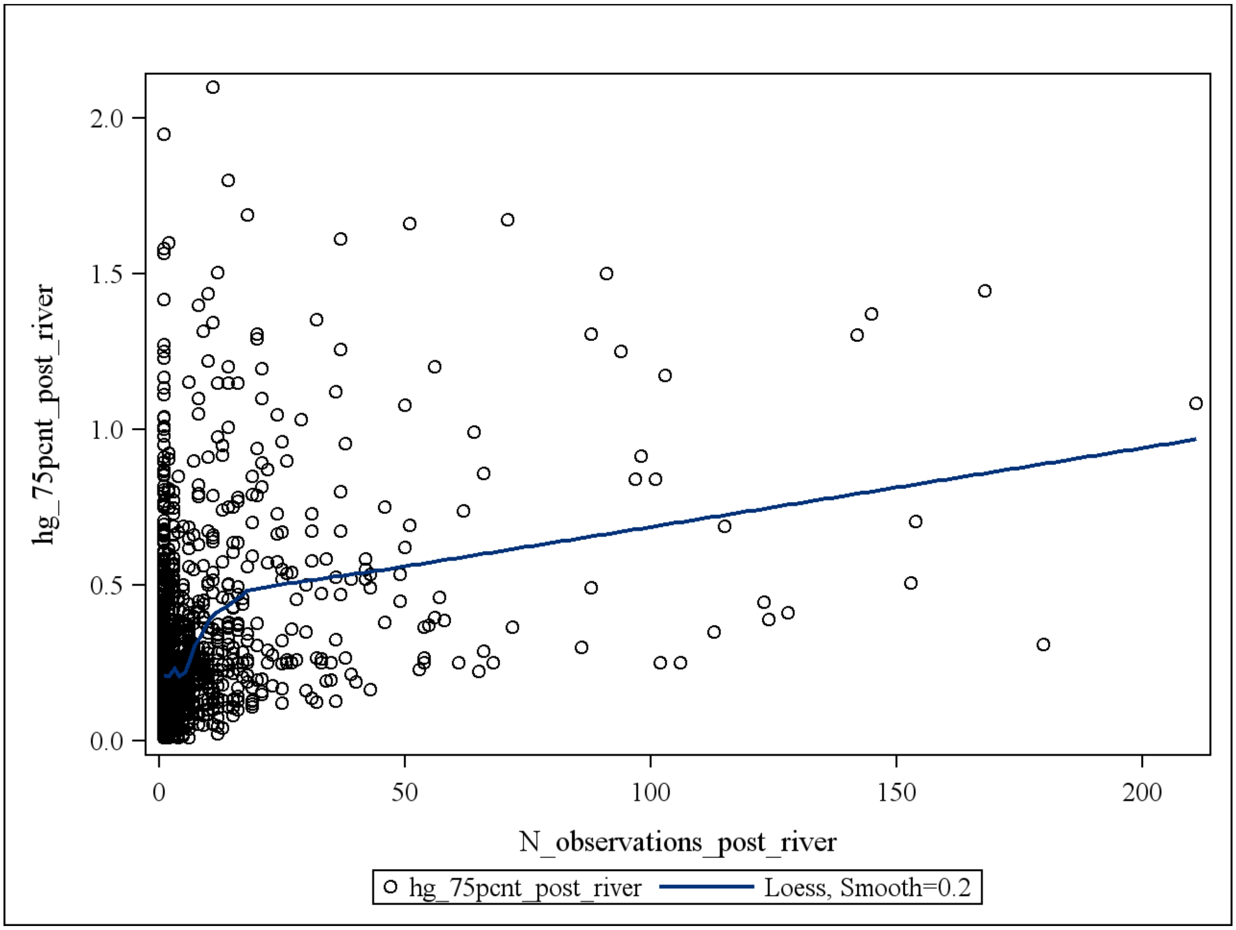


Figure 2: Comparison of mercury concentrations in fish as it relates to sample size in river and lakes combined using Excel data provided to the panel. The fitted curve is based on a loess smoother with smoothing parameter 0.2.

The Panel recommended inclusion of a graph depicting the number of tissue samples available for analysis by tissue concentration. The Panel also recommended that the document discuss this source of uncertainty, including adding a table with the distribution of number of available fish samples and the fish size from which they were obtained across watersheds to indicate the extent of the problem. The TSD should describe in more detail why including fish tissue concentrations from one fish sample is likely to result in a conservative estimate of the number of watersheds at risk. Furthermore, the Panel recommends that, EPA should also conduct a sensitivity analysis using the median fish tissue concentration to better represent the distribution of fish tissue methylmercury levels where the sample size is one and provide a bound on the risk assessment,. The use of other percentiles in the sensitivity analysis was not recommended given the limitations of the fish tissue data available.

The Panel acknowledged that fish sampling programs can result in the collection of fish sizes that can be either larger or smaller than the actual ecosystem distribution depending on sample collection methods and objectives (e.g., states may focus on collection of larger predator fish and areas where higher mercury levels tend to be found). The Panel recommended that the document provide more detail (preferably in tabular form) concerning the source of the fish methylmercury concentrations that were obtained, including information on the scope and purpose of each sampling program, the methods used, the types of fish obtained, and contribution of each program to the overall data set. Given that fish sizes are likely a variable in most datasets, the report should also include information on the sizes of fish that were analyzed. In doing so, the TSD may be able to quantify the impact, if any, of the size of fish sampled in watersheds with few fish tissue samples available on estimated mercury concentrations. It was also requested that the TSD clarify that the 75th percentile represents available fish tissue data, not of the fish in the watershed or the fish consumed.

5. Defining subsistence fisher scenarios

5.1. **Question 7**

Please comment on the extent to which characterization of consumption rates and the potential location for fishing activity for high-end self-caught fish consuming populations modeled in the analysis are supported by the available study data cited in the Mercury Risk TSD. In addition, please comment on the extent to which consumption rates documented in Section 1.3 and in Appendix C of the Mercury Risk TSD provide appropriate representation of high-end fish consumption by the subsistence population scenarios used in modeling exposures and risk. Are there additional data on consumption behavior in subsistence populations active at inland freshwater water bodies within the continental U.S.?

<u>Response:</u> The Panel found that the consumption rates and locations for fishing activity were supported by data presented in Section 1.3 and in Appendix C of the TSD. In addition, the targeted locations and fish consumption data used in the TSD analysis were generally appropriate and reasonable given the available data. The risk assessment provided a thorough literature review and used sources that reported daily consumption for populations of low socioeconomic status (SES) African- and European-Americans females as the target population for the risk assessment. In addition, consumption rates from a study that targeted Laotian- and Vietnamese-Americans, previously identified in the central valley of California, were included in the assessment, as well as those from a study of Great Lakes tribes. Thus, a diverse range of susceptible populations was represented in the assessment.

The Panel indicated that a few caveats should be acknowledged more fully in the document. The main consumption estimates came from a relatively small survey of individuals attending a fishing convention in South Carolina, so the consumption estimates reported in the Burger study may be imprecise, in particular for women. The Panel suggested that the TSD acknowledge that while several estimates of fish consumption rate were used in the risk assessment, other estimates reported by Burger could have been used. For example, median fish consumption estimates may better represent the distribution of fish consumption data than mean estimates. It should also be acknowledged that the Burger survey was conducted in 1998, and that fish consumption rates even in subsistence populations may have changed.

Another issue raised by the Panel focused on the seasonality of fish consumption. Fish-derived mercury exposure could be overestimated if fishing is less prevalent in the winter. This issue applies to the communities from which the consumption rates were derived as well as populations potentially residing close to the targeted watersheds. It was unclear whether the risk assessment used annualized fish consumption rates and whether fish consumption was based on concentrations that were 'as caught' or 'as prepared', and the Panel requested that this information be clarified in the TSD. There was a general agreement that the TSD adequately utilized existing data to identify consumption rates and target populations that were representative of the most highly exposed susceptible populations.

Regarding alternative approaches, the Panel noted that population-based fish consumption rates could be applied, although these data tend to show lower fish consumption rates than surveys focusing on subsistence and sport caught fish (Knobelach et al., 2005; Moya et al., in press).

This would tend to underestimate risks and would not be consistent with the TSD objective to target sensitive, highly exposed individuals. Therefore, this alternative was not recommended.

5.2. **Question 8**

Please comment on the approach used in the risk assessment of assuming that a high-end fish consuming population could be active at a watershed if the "source population" for that fishing population is associated with that watershed (e.g. at least 25 individuals of that population are present in a U.S .Census tract intersecting that watershed). Please identify any additional alternative approaches for identifying the potential for population exposures in watersheds and the strengths and limitations associated with these alternative approaches (additional detail on how EPA assessed where specific high-consuming fisher populations might be active is provided in section 1.3 and Appendix C of the Mercury Risk TSD).

Response: Overall, the Panel agreed that the criterion of using at least 25 persons per census tract from a given target population (Laotian, poor Hispanic, American Indian populations, amongst others) was a reasonable approach. The approach is driven by the necessity of using existing data to identify watersheds with susceptible proximal populations. While the source population selected is somewhat arbitrary, the Panel agreed that it is a reasonable approach, and that other approaches may not be as effective or feasible. Regardless of what number is chosen, it remains unknown what the prevalence of subsistence fishing is in the target communities. EPA indicated that a sample of 25 individuals or greater was selected to be reasonably certain that at least one subsistence fisher was potentially active at the watershed. No major concerns were raised by the Panel concerning this issue. However, it was recommended that the TSD should clarify how many census tracts were eliminated due to the use of this cut point. The TSD should also include information on the relative distribution of the sample size of the susceptible populations in the census tracts that were targeted. That is, an absolute sample of 25 may represent different proportions of the total target population in a given census tract, which may reflect differences in subsistence fishing behavior.

6. Apportioning total methylmercury exposure between total and U.S. EGU-attributable exposure

6.1. **Question 9**

Please comment on the draft risk assessment's characterization of the limitations and uncertainty associated with application of the Mercury Maps approach (including the assumption of proportionality between changes in mercury deposition over watersheds and associated changes in fish tissue MeHg levels) in the risk assessment. Please comment on how the output of CMAQ modeling has been integrated into the analysis to estimate changes in fish tissue MeHg levels and in the exposures and risks associated with the EGU-related fish tissue MeHg fraction (e.g., matching of spatial and temporal resolution between CMAQ modeling and HUC12 watersheds). Given the national scale of the analysis, are there recommended alternatives to the Mercury Maps approach that could have been used to link modeled estimates of mercury deposition to monitored MeHg fish tissue levels for all the watersheds evaluated? (additional detail on the Mercury Maps approach and its application in the risk assessment is presented in section 1.3 and Appendix E of the Mercury Risk TSD).

<u>Response:</u> *Limitations/uncertainty associated with Mercury Maps (MMaps) approach and proportionality assumption.* The risk assessment's characterization of the limitations and uncertainty in the application of Mercury Maps approach is appropriate in qualitative terms. The Panel recommended that the quantitative estimates of the uncertainty published in the existing literature be summarized in Appendix F of the TSD. There are quite a few comparisons, for example, between mercury wet deposition as modeled by CMAQ and as observed by the Mercury Deposition Network. A similar search of the literature for other components of this risk assessment would allow at least partial quantification of the variability or uncertainty in this risk assessment.

The Mercury Maps model states that for steady-state conditions, reductions in fish tissue concentrations are expected to track linearly with reductions in air deposition to a watershed with an intercept of zero for watersheds receiving mercury input exclusively via atmospheric deposition. This proportionality assumption was extended for the TSD study so that methylmercury levels in fish could be apportioned among mercury sources based on the associated apportionment of mercury deposition within a given watershed. The model is a reduced form of the IEM-2M watershed model used in the *Mercury Study Report to Congress* (MSRC) (US EPA, 1997b), whereby the equations of these models are reduced to steady state and consolidated into a single equation relating the ratio of current/future air deposition rates to current/future fish tissue concentrations.

Given these assumptions, Mercury Maps will work only with watersheds in which air deposition is the sole significant source of mercury and steady-state conditions are assumed. This indicates that the extension of the proportionality is valid only when other factors influencing methylation potential and catch profiles (species and trophic levels) remain relatively constant in a given watershed. Watersheds in which mercury input sources other than air deposition, such as mineral recovery operations using mercury, mercury cell chloralkali facilities and geologically high mercury inputs, are present and contribute loads that are significant relative to the air deposition load to that watershed are set aside from analysis in this risk assessment.

Since the Mercury Maps approach was developed, several recent publications have supported the finding of a linear relationship between mercury loading and accumulation in aquatic biota (Orihel et al., 2007; Orihel et al., 2008; Harris et al., 2007). These studies suggested that that mercury(II) deposited directly to aquatic ecosystems can become quickly available to biota and accumulated in fish, and reductions in atmospheric mercury deposition should lead to decreases in methylmercury concentrations in biota. These results substantiate that the assumption of proportionality between air deposition changes and fish tissue methylmercury level changes is sufficiently robust for its application in this risk assessment.

Regarding the limitations and uncertainty associated with the application of Mercury Maps, it is acknowledged that the Mercury Maps approach (i.e., the assumption of proportionality between input changes and fish response) represents both a critical element of the analysis and a potentially important source of uncertainty. The sensitivity analyses conducted in the risk assessment addressed two specific uncertainties related to application of Mercury Maps: (1) concerns over including watersheds that may be disproportionately impacted by non-air mercury sources, and (2) application of the Mercury Maps to both flowing and stationary freshwater bodies to verify if the two scenarios would produce different results. The results of these sensitivity analyses suggest that uncertainty related to the Mercury Maps approach is unlikely to substantially alter the assessment result that mercury emissions from U.S. EGUs potentially constitute a public health concern.

Integration of CMAQ data to HUC12 watersheds for estimating changes in fish MeHg, exposures and risks). The use of 12-km spatial resolution in CMAQ modeling is a significant refinement of the previous analysis, which was conducted using 36-km resolution. The integration of CMAQ data at this finer resolution into the analysis for estimating changes in fish tissue methylmercury levels is sound provided that the proportionality assumption holds true (discussed in the previous response to this charge question).

CMAQ modeling at a 12-km spatial resolution was used to estimate total annual mercury deposition caused by U.S. and non-U.S. anthropogenic and natural sources over each watershed. For the purposes of the risk analysis, watersheds were classified using HUC12 codes (USGS, 2009), representing a fairly refined level of spatial resolution with watersheds generally 5 to 10 km on a side, which is consistent with research on the relationship between changes in mercury deposition and changes in methylmercury levels in aquatic biota. Although interpolating the deposition data from a coarser model grid (CMAQ) to a finer watershed grid (HUC12) will somewhat diffuse the peak deposition near large point sources, the data integration approach is sound.

The CMAQ modeling at 12-km resolution is a considerable (nine-fold) spatial refinement of the modeling conducted to support the Clean Air Mercury Rule (36-km resolution). The modeling results at finer resolution can be used to better resolve deposition patterns near point sources. The confidence in applying the 12-km resolution CMAQ results for estimating fish tissue methylmercury changes and its associated exposure/risk is heavily dependent on the robustness of the proportionality assumption in the Mercury Maps approach. The limitation and uncertainty of this assumption has been elaborated on in the response to the first part of this charge question.

Alternatives to the Mercury Maps approach linking modeled deposition to monitored MeHg fish tissue levels. The Panel agrees with the application of Mercury Maps in this assessment. There are other modeling tools capable of making a national scale assessment, such as the Regional Mercury Cycling Model (R-MCM). However, the R-MCM is more data intensive and the results produced by the two model approaches would be equivalent.

The R-MCM, a steady-state version of the time-dependent Dynamic Mercury Cycling Model, has been publicly available to and used byEPA (Region 4, Athens, Environmental Research Laboratory) for a number of years. R-MCM requires more detail on water chemistry, methylation potential, etc., but yields more information as well. There is substantial data that support the Mercury Maps and the R-MCM steady-state results, so that the results of the sensitivity analysis and the outcomes from using the alternative models would be equivalent between the two modeling approaches. Though running an alternative model framework would provide additional reassurance that the Mercury Maps “base case” approach was a valid one, it is unlikely that substantial additional insight would be gained with the alternative model framework.

6.2. **Question 10**

Please comment on the EPA’s approach of excluding watersheds with significant non-air loadings of mercury as a method to reduce uncertainty associated with application of the Mercury Maps approach. Are there additional criteria that should be considered in including or excluding watersheds?

Response: The technique used to exclude watersheds that may have substantial non-air inputs is sound. Although additional criteria could be applied, they are unlikely to substantially change the results.

EPA excluded those watersheds that either contained active gold mines or had other substantial non-U.S. EGU anthropogenic releases of mercury. Identification of watersheds with gold mines was based on a 2005 USGS data set characterizing mineral and metal operations in the United States. The data represent commodities monitored by the National Minerals Information Center of the USGS, and the operations included are those considered active in 2003. The identification of watersheds with substantial non-EGU anthropogenic emissions was based on a Toxic Release Inventory (TRI) net query for 2008 non-EGU mercury sources with total annual on-site Hg emissions (all media) of 39.7 pounds or more. This threshold value corresponds to the 25th percentile annual U.S. EGU mercury emission value as characterized in the 2005 National Air Toxics Assessment. The EPA team considered the 25th percentile U.S. EGU emission level to be a reasonable screen for additional substantial non-U.S. EGU releases to a given watershed.

This appears to be a sound approach. The caveat is that TRI reporting may be biased high or low by the reporting entities, so it is not possible to judge whether the exclusion is reasonably conservative or not. There is no particular step EPA can take to rectify this uncertainty, although sensitivity tests could be run on different reporting thresholds and the number (and area) of excluded watersheds that result. As a minimum the uncertainty in the TRI should be acknowledged, and the number of watersheds excluded in the base case and the uncertainty analysis should be explicitly stated.

Other criteria that could be considered for exclusion of particular watersheds are:

- Watersheds that are near urban areas, since those may have significant mercury inputs from runoff which are not included in the TRI reporting database.
- Watersheds that are excessively polluted, for example by sanitary sewer discharges or highly anoxic conditions that might deter overall consumer fishing by many users.
- Watersheds with existing fish advisories (whether for mercury or other contaminants) that may deter consumer fishing. Because of the questions about fish advisory effectiveness, this screening criterion could be applied by employing a weighting on the number and location of excluded waterways based on effectiveness studies.

7. Estimating risk including HQ and IQ loss

7.1. **Question 11**

Please comment on the specification of the concentration-response function used in modeling IQ loss. Please comment on whether EPA, as part of uncertainty characterization, should consider alternative concentration-response functions in addition to the model used in the risk assessment. Please comment on the extent to which available data and methods support a quantitative treatment of the potential masking effect of fish nutrients (e.g. omega-3 fatty acids and selenium) on the adverse neurological effects associated with mercury exposure, including IQ loss. (detail on the concentration-response function used in modeling IQ loss can be found in section 1.3 of the Mercury Risk TSD).

Response: As noted in the response to questions 2 and 3, the analyses of IQ should assume a less important role in the final document than in the present one. Question 11 contains three questions pertaining to the concentration-response function describing methylmercury's effect on IQ. The response to the first question is that the rationale for the concentration-response function is appropriate, but with qualifications noted below. The response to the second question is that there is no alternative concentration response function that should be considered, but the analysis should be tempered, qualitatively, by factors that could influence the shape of the concentration function. The response to the third question is that masking by fish nutrients could influence the shape of the concentration response function, but there is not sufficient information to recommend a quantitative adjustment. These three responses are expanded upon in order below.

The specification of the concentration-response function. The function used came from a paper by Axelrad and Bellinger (2007) that seeks to define a relationship between methylmercury exposure and IQ. A whitepaper by Bellinger (Bellinger, 2005) describes the sequence of steps in relating methylmercury exposure to maternal hair mercury and then that to IQ. The TSD furthers notes that IQ has shown utility in describing the health effects of other neurotoxicants. These are appropriate bases for examining a potential impact of reducing methylmercury on IQ, but the Panel believes that these are not compelling reasons for using IQ as a primary driver of the risk assessment. Instead, IQ should serve as a secondary measure along with other measures discussed in the responses to questions 2 and 3. The modeling of the impact of IQ should be placed in the appendix and accompanied by the qualifications noted below.

Alternative Concentration Response functions. The concentration-response function derived by Axelrad and Bellinger (2007) is acceptable for use in supplementary analyses in the TSD. It should be noted, however, that this function is likely to underestimate the effect on IQ of reducing mercury deposition for the reasons itemized here and in the response to charge question 2.

There is another reason that a model based on a linear relationship between exposure and neurobehavioral effect may underestimate the true effect of reducing exposure. It is evident from animal studies conducted under highly controlled conditions that the relationship between daily intake and brain mercury (the most suitable biomarker of exposure) is not linear, but rather is a power function with a slope that is greater than 1.0; the slope was 1.3 in a review of animal studies (Newland et al., 2008). This means that a decrease in intake will produce a greater-than-linear decrease in brain concentration. Thus, the impact of any reductions produced by reducing mercury emissions could be underestimated by the model used in the document. However, this observation is not intended to suggest that a new model be used, only that a qualitative argument should be made that the potential health impact may be underestimated.

A quantitative treatment of the mitigating impact of nutrients. There is evidence from the Seychelles study that nutrients can mask effects of prenatal methylmercury exposures. Davidson et al. (2008), Strain et al. (2008) and Stokes-Riner et al. (2011), demonstrated that maternal hair mercury was associated with PDI only after controlling for the effects of maternal n-3 polyunsaturated fatty acid (PUFA) status. Controlling for n-3 PUFAs steepened the slope of the concentration effect relationship (Strain et al., 2008). These nutrients are found in many marine fish species, but less is known about their concentration in freshwater fish and the concentrations may be lower. This issue is important because the concentration-effect relationship used in the TSD analysis derives from the consumption of marine fish but it is applied to the consumption of freshwater fish. Since the slope might be steeper with freshwater fish, it is possible that the analysis in the TSD underestimates the impact of reducing mercury deposition on consumers of freshwater fish

Not only do n-3 PUFAs mask methylmercury's neurotoxicity, but they confer benefits of their own that are of direct interest in considering the health impact of fish consumption. The studies by Oken et al. (2005, 2008) directly compared the benefits of fish consumption with the hazards associated with methylmercury exposure. These provide further evidence that the benefits of consuming marine fish may mask methylmercury's effects, a conclusion that is directly relevant to freshwater fish.

Since methylmercury is an irreversible selenium-dependent enzyme inhibitor, high exposures are expected to be non-linearly related to toxicity risks. In particular, adverse effects of high methylmercury exposures may be accentuated among populations with poor selenium nutritional intakes. Since the subsistence fish consumers that form the focus of this study are at notable risk of having poor nutritional intakes, it will be important to consider the selenium status of the exposed populations.

Furthermore, since selenium binds with methylmercury to reduce its bioavailability, but selenium availability can vary greatly between even in adjacent regions, diminishments in fish methylmercury concentrations may not be uniform across watersheds. A series of EPA-funded studies that have assessed mercury selenium molar ratios in fish across the United States, providing information regarding watersheds containing fish that could pose accentuated risks to consumers as well as indicate those that may be more amenable to rapid reductions in fish methylmercury contents. Selenium's inverse relationships to methylmercury bioaccumulation and toxicity may synergistically influence exposure risks in certain watersheds.

The factors listed in this section could mitigate the concentration-effect relationship and should be mentioned in the TSD, but there is not enough known about their quantitative impact to support a recommendation of a re-analysis.

Additional Point. Finally a statement on Page 84, Table F-2 references the Seychelles study instead of the New Zealand study. This should be corrected.

The statement is: "Regarding outliers, when an outlier data point from the New Zealand study was included in the integrated derivation of the IQ loss slope factor, the factor was reduced by 25 percent (from -0.18 IQ points per unit ppm hair mercury, to -0.125)." This uncertainty should be acknowledged more explicitly in the body of the document rather than being merely mentioned in detail in a table in the Appendix. No additional analyses in the TSD are necessary; it could just be mentioned in the section on limitations and uncertainties that risk assessment estimates would be reduced by 25%.

8. Discussion of key sources of uncertainty and variability

8.1. **Question 12**

Please comment on the degree to which key sources of uncertainty and variability associated with the risk assessment have been identified and the degree to which they are sufficiently characterized.

Response: To answer this question, the Panel has defined variability and uncertainty according to EPA's standard usage, which is consistent with the definitions given by Cullen & Frey, 1999. These definitions are as follows:

> "Variability refers to temporal, spatial, or interindividual differences (heterogeneity) in the value of an input. In general, variability cannot be reduced by additional study or measurement."
>
> "Uncertainty may be thought of as a measure of the incompleteness of one's knowledge or information about an unknown quantity whose true value could be established if a perfect measuring device were available."

The TSD presents a qualitative overview of variability and uncertainty in Appendix F. The qualitative nature of the discussion is appropriate since this is a conditional analysis. However, the Panel recommends an expanded discussion in Appendix F of variability and uncertainty. This discussion could be organized according to the figures depicting sample calculations of high and low EGU impact that were provided at the Panel's public meeting on June 15, 2011 and reproduced below. The Panel recommends that these figures be added to the report.

Figure 1: Schematic showing sample calculation – high U.S. EGU impact

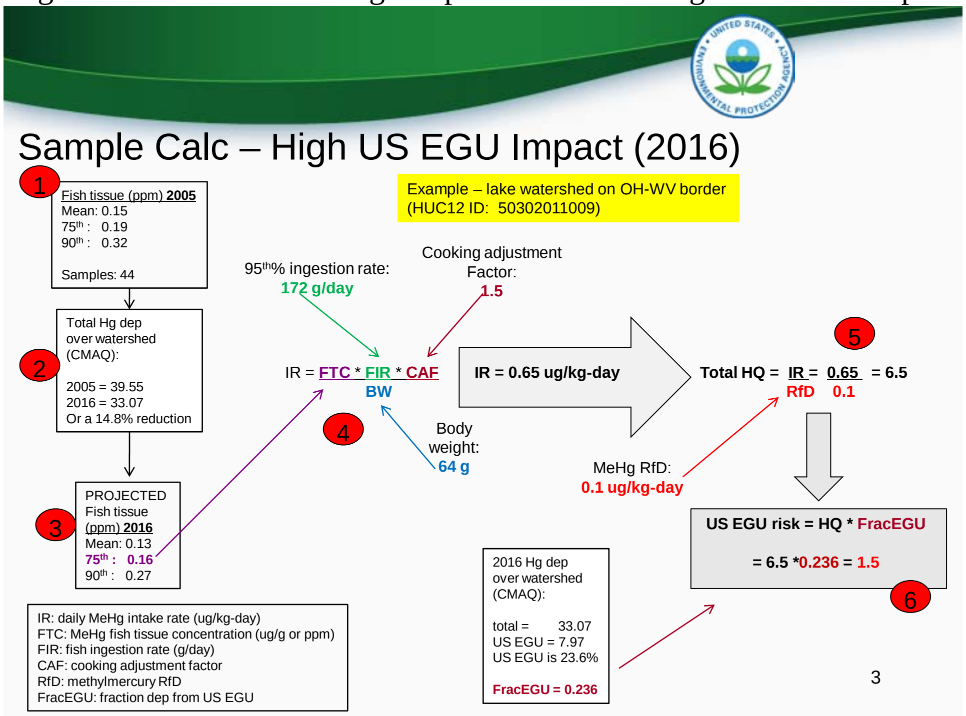
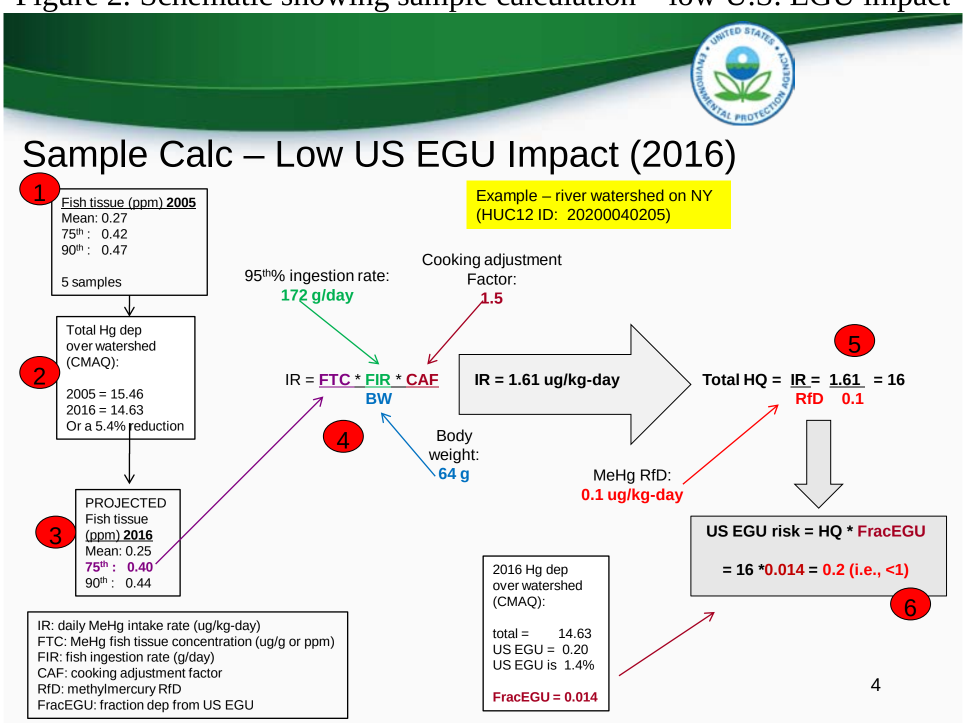


Figure 2: Schematic showing sample calculation – low U.S. EGU impact



In addition to the explicit discussion of variability and uncertainty, the Panel suggests that language be used throughout the TSD that clarifies the scope of the results vis-à-vis data and methodological sources variability and uncertainty. For example, the TSD should cite the evaluation of uncertainty in the CMAQ and MMAPs source documents. Notwithstanding the sources of uncertainty inherent in the approach, the Panel was of the opinion that the analysis presented in the TSD is sound and reasonable.

Variability. The Panel noted the topics covered in Appendix F regarding variability. The clarity of the documentation of the impact of individual sources of variability could be improved. Carefully selected maps and additional figures could be particularly helpful in providing this clarity. The following sources of variability ought to be included in Appendix F to avoid misinterpretation of study results and outcomes.

- The effect of temporal variability in the following on estimates of mercury deposition
    - Appendix F should describe CMAQ boundary conditions that are necessary to establish in order to run the model for the 2 temporal scenarios
    - Appendix F should identify meteorology boundary conditions from the model GEOS-CHEM, which that provides input to CMAQ
- Variation in geographic patterns of populations of subsistence fishers.
    - Appendix F addresses geographic variability in total and U.S. EGU-attributable mercury deposition and fish tissue concentrations. Appendix F should be expanded to discuss spatial variability populations of subsistence fishers, noting the limited geographic coverage of watersheds with fish tissue concentrations.
- Variability in nature and protocols of state collection of fish data (see the response to Question 5, also mentioned below).
- Variation in fisher populations; for example, variation in body weights (potentially across race/ethnicities) and fishing and consumption habits.
- Variability in the factor used to translate mercury concentration measured at time of collection (i.e., expressed per unit wet weight) in comparison to mercury concentration at point of consumption following cooking.

Uncertainty. Appendix F defines sources of uncertainty for several components of the overall approach and selected parameter characterizations. The level of uncertainty is consistent with a screening level analysis.

The Panel has discussed some sources of uncertainty in responses to other Charge Questions (e.g., Question 9). To summarize, the Panel recommends that Appendix F be expanded to provide a more complete listing and discussion of key uncertainties associated with the assessment. Additional sources of uncertainty that should be considered for expanded discussion include:

- Overall emission inventories, especially the non-EGU inventory derived as a modified version of the National Emissions Inventory (NEI). Appendix F should discuss the uncertainties in inventory components; whether and how the uncertainty changes between the 2005 to 2016 scenarios, including uncertainties in the TRI database; whether there is bias in the EGU and non-EGU components of the inventory; and whether the EGU emission estimates were derived from the best performing facilities or from the complete set of facilities.

- Alternative future scenario forecasts. Appendix F should more clearly describe the variables that were held constant versus factors was varied between the two scenarios.
- Estimate of location-specific EGU fraction. The uncertainty in locations propagates into uncertainties in the fractional change in mercury deposition that by EPA to adjust the fish mercury level in the 2016 scenarios. Appendix F should discuss the other factors that could also influence this fraction.
- Use of CMAQ and performance evaluation of CMAQ. Appendix F should provide:
  - More detailed description of uncertainty in CMAQ, including references to existing evaluations of the model.
  - More information to characterize the performance of the CMAQ-GEOS-Chem system in simulating wet deposition of mercury. Appendix F should describe the information included in the Air Quality Modeling TSD (Air Quality Modeling Technical Support Document: Point Source Sector Rules, Table III-3), identify whether that information is adequate, and address any apparent efforts (e.g., negative values for wet deposition).
  - Reemission of mercury previously deposited on vegetation, soils and water treated by CMAQ, and how might this re-emission change the mercury deposition patterns
- Hot spots.
  - Appendix F should address whether the Mercury Maps approach, as implemented, is adequate to characterize mercury hot spots.
- Impacts of excluding watersheds from the analysis.
  - Appendix F should detail the criteria used for excluding watersheds, characterize the watersheds excluded by different criteria, and describe the estimated deposition n these watersheds.
- Representativeness of approximately 2,500 watersheds compared to 88,000 HUC12 nationwide.
  - Appendix F should characterize any bias introduced by looking at this subset of watersheds (e.g., some states are over-represented, such as Indiana and Minnesota, while others are under-represented such as Pennsylvania).
- Fish populations and fish tissue database (see Panel responses to questions 5, 6 and 13 for more detail). Appendix F should include discussion of:
  - Sample size for characterization of Implications of a data set with a low number of fish per watershed. Appendix F should identify the distribution of fish samples

    per watershed and the possible implications of this distribution, including the implications of sample size for characterization of 75th percentile fish tissue concentration
  - Uuncertainty in methylmercury fish tissue concentrations from differences in sampling and analytical protocols used by States that contribute data and errors introduced by potential misidentification of locations, etc.
- Adjustment between wet and cooked weight of fish.
  - Appendix F should note that this is a constant value applied in the calculation and thus does not bias but could skew the results.
- Uncertainty of the assumption of proportionality and the MMAPs approach (see Panel response to Question 9).
- Characterization of susceptible human populations (see Panel responses to Questions 7 and 8)
  - Characterizing subsistence fishing activity within high EGU deposition sites.
  - Implications of choosing subsistence fishers and excluding high-end sport fishers.
  - Census information that may exclude groups such as students, immigrants)
- Fish consumption rates (see Panel Response to Question 7)
  - Limitations of the single study used to support the TSD's fish consumption rate for female subsistence fishers
- Derivation of the concentration-response relationship and RfD based on data from marine fish and mammal species, not inland freshwaters.
  - Appendix F should discuss the uncertainty introduced by not using RfDs derived based on studies of consumption of fish from inland freshwaters. (see Panel response to Question 11).
- Applicability of the concentration-response relationship and RfD for low socio-economic status populations. This relationship has not been examined.
  - Appendix F should discuss how this relationship may bias the report toward underestimating risk.
- Effect of the nutritional benefits of fish consumption in comparison to risks from mercury. Appendix F should address how the lack of consideration of this factor that may bias the analysis toward underestimating risk. (see Panel response to Question 11)

9. Discussion of analytical results

9.1. **Question 13**

Please comment on the draft Mercury Risk TSD's discussion of analytical results for each component of the analysis. For each of the components below, please comment on the extent to which EPA's observations are supported by the analytical results presented and whether there is a sufficient characterization of uncertainty, variability, and data limitations, taking into account the models and data used.

9.1.1. Mercury deposition from U.S. EGUs

Response: EPA's observations are generally supported by the data presented in the assessment report. The Panel recommended that the spatial patterns of simulated deposition shown in Figure 2-1 to 2-4 be better explained and that EPA should characterize data limitations more effectively. The Panel provided additional references that it believes will enhance the discussion of model uncertainty and data limitations.

EPA's observations about mercury deposition as depicted in TSD Figures 2-1 to 2-4 are supported by analytical results. However the 12-km deposition maps are very different than previously produced maps on the 36-km scale (for example in Texas and Nevada). The Panel recommended that EPA explain these differences and that EPA consider including separate maps of wet and dry deposition and/or aggregating the results into an approximately 36 km grid scale for comparison to earlier maps and to data plots, such as national deposition maps from the Mercury Deposition Network.

In general, the uncertainties associated with these results are not well characterized nor adequately quantified. For example, there have been several intercomparison studies among numerical models for long-range transport of mercury and studies on model uncertainty evaluation that are not discussed or referenced. A summary of these references (Bullock, 2009; Pongprueksa et al., 2008; Lin et al, 2007; and Ryaboshapko, 2007) would be a useful addition to help frame the overall uncertainty of the deposition estimates.

In addition, EPA should discuss more completely the inputs that were kept constant for the 2016 scenario and the inputs that were varied (and by how much). This information may merit discussion earlier in the report. In addition, the CMAQ results are very dependent on global boundary conditions that are supplied by the GEOS-Chem model. Uncertainty in those inputs will be carried through to the results. This should be noted.

9.1.2. Fish tissue methyl mercury concentrations

Response: The observations listed in section 2.4 of the TSD are generally supported by the analytical results. The Panel recommended that EPA clarify the text, to improve the description of the analytical results for each bulleted observation as described below.

There is sufficient characterization of variability but not of uncertainty and data limitations. Specifically, the small samples sizes of mercury concentrations in fish for the individual watersheds (~60% of watersheds have n=1) will result in lower estimates of mercury concentrations in the 75th percentile as shown earlier in Figures 1 and 2 in this document. This data limitation bias will be propagated to underestimate the hazard in the risk assessment.

The text in the observations should be modified to refer to tissue and mercury "concentrations" rather than "levels" to be more precise. "Level" is a generic term and can refer to any number of different metrics. In addition, where the text refers to mercury deposition, the source of U.S. EGUs should be specified. Finally, where the percentages of EGU-contribution to fish methylmercury are mentioned, EPA should clarify that those values pertain to only fish-sampled watersheds. Given the under-sampling in watersheds where there are high levels of deposition, the percentages indicated could be higher.

Some figures and tables would also benefit from modification or elimination. Figures 2-7 to 2-10 are difficult to interpret because the symbols do not reflect the number of observations for that site. Improved plots should display symbols proportional to sample size and provide color or shading of symbols to represent observed fish concentrations. In addition, the maps shown in Figures 2-7 to 2-14 need to include the western continental United States. These figures unnecessarily cut off the western continental United States. While the Panel understands the reason for this omission (there is minimal expected change in EGU emissions in the western United States), it is important to show the results for the entire United States in the figures of this national assessment. In the absence of national maps, the reader (especially someone with interest in the western United States) many be left wondering about current fish mercury concentrations in this region (see Figure 2-6), as well as the model predicted changes in fish mercury for the 2016 scenario.

The legend for Figure 2-8 should make it clear that the 2016 mercury tissue concentrations were computed by adjusted the 2005 concentrations to account for lower expected deposition as per the Mercury Maps approach. The third bullet item on page 36 of the TSD should be corrected to indicate that Figures 2-7 and 2-8 give concentrations of mercury in fish, not total mercury deposition. In addition, the figures showing the top 10th percentile (2-11 to 2-14) should be removed since the pattern of mercury is greatly affected by high sampling effort in South Carolina, Indiana, West Virginia, and Louisiana. The current maps could also result in undue public concern in those states. Finally, the text describing Table 2-5 needs to be clarified to state that the relationships are not causal.

9.1.3. Patterns of mercury deposition with mercury fish tissue data

Response: To answer this question, the Panel considered three summary points regarding this analysis:

- The fish tissue methylmercury sampling data (summarized at the watershed-level) provides limited coverage for areas with elevated U.S. EGU mercury deposition. Therefore, the number of "at risk" watersheds as characterized in this risk assessment may be substantially higher than estimated.

- Mercury fish tissue levels are not correlated with total mercury deposition (the relationship is highly dependent on methylation potential of individual waterbodies).

- Mercury fish tissue samples were generally collected in regions with elevated total mercury deposition

Overall, the Panel believed that these observations are supported by the analytical results presented and there is a sufficient characterization of uncertainty, variability, and data limitations. However, a number of changes are needed to better clarify these points. It should be clearly stated to what degree the non-uniform, state-specific data availability influences this analysis. For example, South Carolina, Louisiana, and Indiana all have abundant data availability compared to most states. EPA should discuss how this data availability bias affects the analytical results. The Panel recommends that this section be substantively rewritten to improve clarity, and to highlight the major relevant points. As discussed below, EPA should revise the text in footnote 36, which is critical to the understanding of Figures 2-15 and 2-16, and yet is not clearly enough written for the reader to understand the key information. Also, the figure legends within each of Figures 2-15 and 2-16 need to be changed because the "blue areas" are not "water bodies", but rather "watersheds," which include water bodies that sometimes are more obvious than their watersheds (e.g., the Minnesota portion of Lake Superior, Long Island Sound, and perhaps erroneously, the Canadian portion of Lake Champlain). The Panel suggests that these two maps possibly be replotted with a third color that clearly identifies the areas of overlap.

Figure 2-17 is critically important not only to this section, but to the overall document. The Panel suggests that this figure could be brought into this document much earlier because it adds value to understanding the lack of direct relationships between deposition and mercury in fish. In a sense, it frames the justification for the approach taken in the overall analysis. A more complete preamble accompanying Figure 2-17 would add significant value to the report, stating the important premises of the analysis applied in this risk assessment - that spatial variability of deposition rates is only one major driver of spatial variability of fish mercury and that variability of ecosystem factors that control methylation potential (especially wetlands, aqueous organic carbon, pH, and sulfate) also play a key role. Also, none of the panelists were aware of the role turbidity may play in methylation.

A question was also raised as to whether Figure 2-17 has been truncated, and if so did it need to be? That is, are there data above 1.0 ppm fish concentration and 40 ug/m2-yr deposition? The Panel suspects that there are.

Figure 2-18 could similarly be moved to an earlier section of the document because it indicates that the analysis identified watersheds with higher rates of deposition than the national (~88,000 HUC 12 watersheds) trend and that the watersheds with available fish data were in fact, those with higher EGU-derived mercury deposition rates.

The red areas of Figures 2-15 and 2-16 are labeled in each map's legend as "Watersheds with relatively elevated US EGU Hg dep." Footnote 36 explains how the red areas are identified, an explanation that is densely written, as follows:

> 36 Areas of "elevated U.S. EGU-related Hg deposition" refer to areas that are at or above the average deposition level seen in watersheds with U.S. EGU-attributable exposures above the

> MeHg RfD. Specifically, we used exposure estimates based on the 95th percentile fish consumption rate (for the female high consumer scenario assessed nation-wide) to identify watersheds with U.S. EGU-attributable exposures above the MeHg RfD and then queried for the average U.S. EGU-related Hg deposition across that subset of watersheds. This average deposition rate differed for the 2005 and 2016 Scenarios (i.e., 3.79 and 1.28 ug/m^2, respectively). These values were used as the basis for identifying watersheds with levels of U.S. EGU-related Hg deposition for the 2005 and 2016 Scenarios presented in Figures 2-13 and 2-14.

The Panel finds it troublesome that footnote 36 implies that the threshold for what constitutes "relatively elevated U.S. EGU Hg deposition" is different in the two maps: the red area in Fig 2-15 is characterized as an average deposition rate of 3.79 and for Fig. 2-16, 1.29 ug/m^2. The next, and last, sentence is confusing, and implies that 3.79 and 1.29 were used as thresholds for identifying the red areas: "These values were used as the basis for identifying watersheds..." This characterization may confuse readers, in that readers probably expect similarly colored geographic areas in adjacent similar maps to be presented as portraying quantitatively similar environmental information, an expectation that these maps apparently do not meet. But the Panel suspects that in fact the deposition rate threshold for inclusion in the map is probably relatively constant, and communicating the threshold would be a more useful characterization than describing the average deposition rates, which are different for understandable, but unexplained, reasons. For any given watershed the threshold is the EGU-attributable deposition rate that produces EGU-attributable exposure "above the MeHg RfD." In practical terms for this risk assessment of subsistence fishers, this threshold is a modeled EGU-attributable increment in fish concentration that is greater than 0.038 ppm mercury, a concentration that does not correspond to a constant mercury deposition rate because the concentration varies among watersheds in accordance with the proportionality principle described in the risk assessment. However, the Panel suspects that the average mercury deposition rate that produces this incremental mercury concentration will be similar between the 2005 and 2016 scenarios. If so, the red areas could then be characterized, for example, as "elevated U.S. EGU-related mercury deposition that refers to areas where deposition from EGU emissions has the potential, even in the absence of mercury from other sources, to cause exposures above the methylmercury RfD." The average threshold EGU-attributable mercury deposition rate for exceeding the threshold could be presented, along with the average deposition in the red area. It may be useful to note why the average deposition rate is lower in the 2016 scenario red area, rather than assuming that the reader will immediately know why.

However the red area is dealt with, a more complete and understandable explanation needs to be presented than the current explanation of footnote 36.

9.1.4. Percentile risk estimates

<u>Response</u>. Generally, the percentile risk estimates in 2.6.1 are calculated in a reasonable manner and the interpretations are appropriate. The TSD especially provides a useful discussion of the uncertainties of high values in Tables 2-5 and 2-7. The Panel had the following suggestions that would improve the presentation of the material and results for other parts of section 2.6.1:

1. The TSD should include an explanation of why the values in Tables 2-6 and 2-7 decrease when going from the 50th to 75th percentile. This is likely due to the fact that the ranked risk values are not the same as the ranked EGU contributions, but should be mentioned. Perhaps the tabled values should be referred to in some way as averaged.

2. The values in Tables 2-6 and 2-7 are based on averaging the values that are 2.5% below and 2.5% above. EPA should consider whether it is better to use a 2.5% range or use the 10 nearest values. EPA should also describe how the range is selected for the 99th percentile.

3 Section 2 page 54: the paragraph comparing "risks" for high-end females with other populations is oversimplified. Depending on the percentiles considered, "risks" for Laotians, Vietnamese and Tribal fish consumers can also be higher than for high-end females. The highest consumption rates may be summarized in an appendix.

4. Section 2 page 55: it would be helpful to have more information on the gold-mining impacted watersheds in the Southeast. For example, it seems that gold mining occurred historically in a relatively small region of South Carolina, and only a few mines have recently been re-activated. Is it really appropriate to discount or question concerns about EGU affected exposure across the whole Southeast on this basis?

5. In Tables 2-6 and 2-7, EPA should consider reporting consumption rates and putting the percentiles in parentheses rather than reporting the percentiles and having the rates in parentheses.

6. In Table 2-15 and other places, the mean is included. Since the mean is not a percentile, the table header should be changed or the median used.

9.1.5. Number and frequency of watersheds with populations potentially at risk due to U.S. EGU mercury emissions

<u>Response:</u> Specific to this charge question, the Panel expressed no significant concerns. It was recommended that language is added commenting on the change in the percentage of watersheds that continue to be above the RfD (or above a change in 1-2 IQ points after EGU emissions are removed, if this aspect of the risk assessment is retained). Furthermore, a suggestion was made on the first bullet point on page 57 to change the language “before taking into account deposition...” to something that does not imply temporality (e.g., “when you factor out other sources of mercury deposition”). It was also suggested that when the document discusses loss of IQ points, that it refers to this in relation to “populations living close to watersheds” rather than “watersheds”.

With regard to the target population in a broader context, the size of the potentially impacted population is a key factor to consider in this risk assessment. This issue is outside the scope of the data available for the risk assessment, even though it is very relevant to the objectives of the TSD and its application to public health policy. The document focuses on subsistence fishing populations as a target population that is likely to be the most severely impacted by mercury consumption in fish. There is scant evidence documenting the prevalence or extent of subsistence fishing in the United States. Some Panel members noted similarities in consumption rates among sport fishers and subsistence fishing populations. The inclusion of sport fishers with relatively higher fish consumption rates could expand the size and extent of the targeted susceptible population. Similarly, only limited information on the locations or characteristics of watersheds that were excluded from the analysis was provided (p. 63, bullet 4, Figs 2-15, 2-16). The Panel suggested that more detailed information be included regarding these watersheds and the uncertainties associated with their exclusion. In addition, the document should address the excluded watersheds within the context of predicted mercury deposition patterns. Some enumeration of the extent to which the target population would be expanded if these factors had been incorporated into the analysis would help provide important additional information on the potential scope and magnitude of the hazards estimated in the assessment.

9.2. **Question 14**

Does section 2.8 respond to the goals of the study and does it encapsulate the critical issues and the significant results of the analysis?

<u>Response:</u> Section 2.8 responds to goals of studies, but the manner in which it highlights the key findings could be improved. The section should be revised to explicitly respond to each of the goals of the study as set out on page 13 of the TSD.

The goals of the studies as stated on page 13 of the draft assessment are:

(a) What is the nature and magnitude of the potential risk to public health posed by current U.S. EGU mercury emissions?

(b) What is the nature and magnitude of the potential risk posed by U.S. EGU mercury emissions in 2016 considering potential reductions in EGU mercury emissions attributable to Clean Air Act requirements? and

(c) How is risk estimated for both the current and future scenario apportioned between the incremental contribution from U.S. EGU's and other sources of mercury?

The TSD does respond to the goals set out at the beginning of the document; however, this is not clear from the text. In response to these goals, the Panel sees that the major finding of the study is that a reduction in mercury emissions will translate to reductions in fish tissue methylmercury concentrations, and in turn, to a reduction in potential risk to subsistence fishers that would result with the consumption of self-caught fish from inland watersheds.

While there are numerous sources of variability and uncertainty that are contained in the numerical estimates of potential risk, he variability and uncertainty do not cloud this finding.

9.3. **Question 15**

<u>D</u>espite the uncertainties identified, is there sufficient confidence in the analysis for it to determine whether mercury emissions from U.S. EGUs represent a potential public health hazard for the group of fish consumers likely to experience the highest risk attributable to U.S. EGU?

[Note: This question was not among the charge questions. It was formulated by the Panel as an alternative to the second question posed in Charge Question 14.]
Response*:* Notwithstanding the uncertainties inherent in this analysis, the TSD, subject to the recommendations of the Panel, makes an objective, reasonable and credible determination of the potential for a public health hazard from mercury emitted from U.S. EGUs.

Appendix A: Editorial Suggestions Provided by Panel Members

<u>Comments from Dr. Jana Milford</u>

Section 1.1, p. 13 par. 2. The "policy-related questions" in this paragraph could be sharpened or narrowed to better characterize the analysis that was performed, recognizing key limitations up front. With respect to question (a), the TSD doesn't address "potential risk to public health" but more narrowly addresses potential risk to high-end self-caught freshwater fish consumers in the U.S. In question (b), it would be helpful if the footnote (fn 15) could also explain what is meant by CAA requirements, noting in particular whether the section 112 requirements for addressing mercury from EGUs are or are not included. For question (c), it seems important to recognize that the apportionment question is still restricted to apportionment for high-end self-caught freshwater fish consumers in the U.S.

Section 1.1, pp. 13 – 14. The limitations of considering fish consumption as the exposure route and focusing on neurological deficits in children are appropriate. However, other health endpoints in humans and mercury impacts on wildlife should also be acknowledged.

Section 1.1, p. 15, bullet 1. Clarification is needed on what is meant by "potential HAP emission reductions from CAA requirements" for the 2016 scenario. Also, the preamble for the mercury rule notes that 2010 mercury emissions may be underestimated, due to biased sampling (76 FR 25006). This should be mentioned here.

Section 1.1, p. 15, bullet 3. It seems misleading to characterize the TSD as "assess[ing] risk for a set of subsistence populations active at inland watersheds." Better wording might be to say the TSD "assesses potential risk of subsistence fishing at inland watersheds", since the size of the populations at issue is not considered.

Section 1.1, p. 16 fn, 22. Please do not say women of childbearing age would have to either fish themselves or be associated with <u>male</u> fishers. Women who eat non-commercially caught fish could be supplied by other women, too. Furthermore, the wording of this footnote inappropriately and unnecessarily undercuts the analysis in the TSD by saying the TSD analysis addresses "a subset of female subsistence consumers that *we believe (a) are reasonably likely to exist* at a subset of our watersheds …" In fact subsistence fishing is *known* to occur in inland water bodies in the U.S., so the existence of these consumers is not in question.

Throughout this section in the text and table captions, the term "potential risk estimates" should be used instead of "risk estimates," again reflecting the point that the size of the populations at issue hasn't been estimated and the analysis only attempts to estimate what might happen if fish were consumed at the levels seen in these populations.

Section 2, p. 52. It would be helpful to have risk estimates for 2016 for the full set of fishing populations (parallel to Table 2-8 for 2005), rather than be told we can "infer" them.

Section 2.8, p. 63, bullet 1. This bullet refers to U.S. EGUs contributing up to "11% of total mercury emissions" but this must be a typo. Apparently it should say "11% of total Hg deposition."

Section 2.8, p. 63, bullet 4. This bullet is poorly worded. The statement that "the actual number of 'at risk' watersheds … could be substantially larger than estimated" suggests the TSD tried to estimate the total number of at risk watersheds. In fact, the TSD can only be viewed as having tried to estimate the number of watersheds at risk out of the relatively small fraction for which recent fish tissue MeHg data are available.

Comments from Dr. Eric Smith

1. Introduce RfD in text early - it seems to appear as a footnote.
2. Acronyms - check they are spelled out (RfD, HAP, CMAQ, etc)
3. pg 2 bottom .
4. Tables ES1, ES2 clarify the difference in the calculations. ES1 is percentages but ES2 give ratios
5. page 18 middle 5% to 15% 20% clean up. Also after RfD
6. page 25 footnote 27 units do not change
7. pg 31 change emphasis to emphasize
8. page 35 change considerably to considerable
9. page 39 what is meant by total Hg (confuse with mean)
10. page 40 do you mean figure 2-9 not 2-7
11. figure 2-11 is it better to use scenario or case rather than simulation
12. figure 2-13 why does LA change so much, in the previous graphs there are many large circle but not in this figure.
13. page 44 middle change fis to fish
14. page 47 figure 2-17 isn't this data truncated at 40? If so, mention in text
15. I think I would add strongly to correlated in the second bullet, as there is evidence of an increase but a rather weak one.
16. check spelling in last sentence of 2nd bullet - espected tos. bottom.
17. page 49 towards bottom change rick to risk
18. page 64 - give the percentage for next to last bullet - what is a significant majority
19. page 77 BW not spelled out

TABLE OF ACRONYMS

CASAC,	Clean Air Scientific Advisory Committee
CMAQ	Community Multiscale Air Quality Modeling System
EGU	Electrical Generating Unit
Hg	Mercury
HUC	Hydrologic Unit Codes
MDN	Mercury Deposition Network
MeHg	Methylmercury
PUFA	Polyunsaturated Fatty Acid
RfD	Reference Dose
TSD	Technical Support Document

REFERENCES

Axelrad, D. A., D. C. Bellinger, et al. (2007). "Dose-response relationship of prenatal mercury exposure and IQ: an integrative analysis of epidemiologic data." Environ Health Perspect 115(4): 609-615.

Bellinger DC 2005. Neurobehavioral Assessments Conducted in the New Zealand, Faroe Islands, and Seychelles Islands Studies of Methylmercury Neurotoxicity in Children. Report to the U.S. Environmental Protection Agency. EPA-HQ-OAR-2002-0056-6045. Available: http://www.regulations.gov [accessed 20 January 2006].

Bullock, O. R., Jr., et al. (2009), An analysis of simulated wet deposition of mercury from the North American Mercury Model Intercomparison Study, J. Geophys. Res., 114, D08301, doi:10.1029/2008JD011224

Cullen, A.C. and Frey, H.C. Probabilistic Techniques in Exposure Assessment, Plenum Press, 1999.

Grandjean, P., P. Weihe, et al. (1997). "Cognitive deficit in 7-year-old children with prenatal exposure to methylmercury." Neurotoxicology & Teratology 19(6): 417-428.

Harris, R., et al. 2007. Whole-ecosystem study shows rapid fish-mercury response to changes in mercury deposition PNAS 104 (42) 16586-16591.

Lin C.-J., Pongprueksa P., Bullock O.R., Lindberg S.E., Pehkonen S.O., Jang C., Braverman T., Ho T.C., “Scientific Uncertainties in Atmospheric Mercury Models II: Sensitivity Tests over the Continental United States,” Atmospheric Environment 41, 6544-6560, 2007.

Newland, M. C., E. M. Paletz, et al. (2008). "Methylmercury and nutrition: adult effects of fetal exposure in experimental models." NeuroToxicology 29(5): 783-801.

Oken, E., J. S. Radesky, et al. (2008). "Maternal Fish Intake during Pregnancy, Blood Mercury Levels, and Child Cognition at Age 3 Years in a US Cohort." American Journal of Epidemiology 167(10): 1171-1181.

Oken, E., Wright, R.O., Kleinman, K.P., Bellinger, D., Amarasiriwardena, C.J., Hu, H., Rich-Edwards, J.W., gillman, M.W. (2005). Maternal fish consumption, hair mercury, and infant cognition in a U.S. cohort. Environmental Health Perspectives, 113 (10), 1376-1380.

Orihel, D. M.; Paterson, M. J.; Blanchfield, P. J.; Bodaly, R. A.; Hintelmann, H. Experimental evidence of a linear relationship between inorganic mercury loading and methylmercury accumulation by aquatic biota. 2007. Environment. Science & Technology. 41, 4952-4958. http://pubs.acs.org/doi/abs/10.1021/es063061r.

Orihel DM, Paterson MJ, Blanchfield PJ, Bodaly RA, Gilmour CC, Hintelmann. 2008. Temporal changes in the distribution, methylation, and bioaccumulation of newly deposited mercury in an aquatic ecosystem. H.Environ Pollut. 154(1):77-88.

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Pongprueksa P., Lin C.-J., Lindberg S.E., Jang C., Braverman T., Bullock O.R., Ho T.C., Chu H., "Scientific Uncertainties in Atmospheric Mercury Models III: Boundary and Initial Conditions, Model Grid Resolution, and Hg(II) Reduction Mechanism," Atmospheric Environment 42, 1828-18451, 2008.

Ryaboshapko, A.O. et al. 2007. Intercomparison study of atmospheric mercury models: 1. Comparison of models with short-term measurements and Intercomparison study of atmospheric mercury models: 2. Modelling results vs. long-term observations and comparison of country deposition budgets Science of the Total Environment 376 228–240.

Stokes-Riner, A., S. W. Thurston, et al. (2011). "A longitudinal analysis of prenatal exposure to methylmercury and fatty acids in the Seychelles." Neurotoxicology and Teratology 33(2): 325-328.

van Wijngaarden, E., C. Beck, et al. (2006). "Benchmark concentrations for methyl mercury obtained from the 9-year follow-up of the Seychelles Child Development Study." NeuroToxicology 27(5): 702-709.

Weiner et al. (2006). Environmental Science & Technology 20:6281-6286. Need complete citation.

U.S. EPA Clean Air Scientific Advisory Committee. 2007. Clean Air Scientific Advisory Committee's (CASAC) Review of the 1st Draft Lead Staff Paper and Draft Lead Exposure and Risk Assessments, (EPA-CASAC-07-003). p. 6.