Draft initial response to charge questions for the SAB Review of EPA's *Technical Support Document: National-Scale Mercury Risk Assessment Supporting the Appropriate and Necessary Finding for Coal- and Oil-Fired Electric Generating Units (March 2011)*

Purpose and Scope of the Analysis

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 is scientifically credible. The panel did, however, have a number of suggestions for enhancing the assessment, some of which are expanded on in responses to subsequent charge questions. 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, they have linked a series of models and data in order to estimate and then compare Hg exposure via fish consumption with a toxicological benchmark. The series of models allows for the estimation of deposition of mercury emitted, by US electricity generating units, into watersheds. The assessment uses estimates of Hg deposition into watersheds, which have measurements of fish MeHg 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 is then assessed by examining the main exposure pathway of ingestion of self-caught fish from inland water bodies for maximally exposed individuals (subsistence fishers).

- The assessment could be enhanced in a number of ways, as described in responses to subsequent charge questions. Specifically:
- population risks would be more desirable than estimated risks associated with highly exposed individuals, however, the panel recognized that current data would not support such an assessment.
- the limited number of fish samples from many of the watersheds and suggests that the estimates of 75th and higher percentiles of MeHg concentrations in fish from these watersheds may be underestimated.
- the form of the dose response relationship for MeHg, and the confounding effects of Se and the beneficial impacts of fish oil consumption should be recognized to the extent possible.
- details of assumptions and uncertainties regarding the emissions inventory for 2005 and 2016 of Hg from EGUs, Hg from other anthropogenic sources, and Hg from natural sources, and other atmospheric species that affect atmospheric Hg oxidation and deposition, because of the suspected high uncertainty in the non-EGU inventories. Appreciating the non-EGU Hg sources is important because the risk assessment looks at the incremental contribution of EGU Hg to total fish Hg from all sources.

We should likely highlight additional issues here that will be covered in the responses to subsequent charge questions

The panel also noted that, in general, the Technical Support Document (TSD) would benefit from a more detailed description of the modeling methods and data sources, and the Introductory section should make clear, at the earliest possible point, that the analysis is a determination of watersheds and highly exposed individuals at risk, and is not an assessment of population risks.

Overview of Risk Metrics and the Risk Characterization Framework

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: No, there are no additional health endpoints that can be quantitatively estimated to supplement the mercury risk assessment document. There are significant concerns that the use of IQ could underestimate the number of watersheds having at risk populations. This seems to be the case when comparing the results using IQ with those using the HQ.. While several alternative approaches were discussed that might supplement IQ scores, it was the consensus of the four committee members charged with discussing this measure that no substitute can be quantitatively estimated with a "reasonable degree of confidence." There were, however, doubts that IQ met this standard. .It may be preferable to reframe the document's discussion of IQ and incorporate IQ and other neuropsychological measures as supplemental, focusing on HQ, rather than as primary analyses. These issues are discussed in order.

The use of IQ. The loss of IQ points is likely to underestimate the impact of this rule. The reason is that IQ score has not been the most sensitive indicator of MeHg's neurotoxicity in the populations studies that have been published. Overall, domain-specific tests have proven to be especially sensitive. A global measure like IQ draws from several subdomains and if only those domains are affected then these effects will be diluted by tests that are not affected.

As noted in the document, 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), neuropschological 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.

Alternatives. One alternative that was suggested was 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 CVLT or reaction time was estimated based on regression coefficients describing the relationship among, age, MeHg 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 values for 26 endpoints, including IQ and other neuropsychological measures from the literature. This paper could usefully be cited in a discussion of markers of health impacts of lowering mercury deposition and reducing intake by subsistence fishers.

A third alternative that was suggested by one panel member the use of blood markers of selenium function. It was noted that methylmercury's mode of action involves irreversible inhibition of selenium-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 expected to be transitory. The use of this measure was a minority view among the panel members addressing this charge question.

The use of IQ, or any neuropsychological measure, may distract from the main goal of the document. The analysis in the document emphasizes the number of water bodies that will be affected by this rule in such a way that subsistence fishers would consume sufficient mercury that they exceed the RfD by a factor of 1.5. The more sensitive measure of this impact thus seems the effect on mercury intake by subsistence fishers. This is especially evident Tables 2-9 to 2-11 [perhaps just focus on 2-11?].

It is not suggested that the analyses of IQ be removed but rather that they be framed as a secondary analysis of impact that uses potential health-related outcome. Such a discussion could also include other potential effects on other potential measures, like developmental delays or neuropsychological tests (as reviewed by van Wijngaarden et al., 2006), but without selecting one for detailed quantitative analysis presented in the overall context of the weight of evidence..

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.

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.

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: No, 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 while its applicability to MeHg is questionable, the size of the decrement is justified based on the extensive analyses available from that literature. The support from this comes from Axelrad and Bellinger (2007) and from a whitepaper produced by Bellinger to EPA. {need Bellinger Citationn} . It was noted that the 1-2 point decrease reflects the mean response but that a mean 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.

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.

Overview of Analytical Approach

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 use of the HUC12 watersheds in this case is a significant improvement over previous studies by EPA, including Mercury Maps, which used the larger HUC8 delineation of the contiguous United States. In addition, HUC8s are a "cataloguing unit" delineation and do not represent actual watersheds. Thus, calculations and applications making use of mass balances, such as Mercury Maps, are not properly conducted using HUC8 delineations, but are appropriate using HUC12s.

HUC12's are also of a comparative physical scale to the spatial resolution of the CMAQ output, which increases the transferability of deposition modeling to the watershed. The CMAQ runs produce 12 km-square grid output and the HUC12 watersheds are typically about 5-10 km on a side. The use of finer scale watersheds enables modeling and deposition runs that have the detail to follow deposition patterns from a single source, including EGU's. The fine-scale watershed resolution decreases the likelihood that there is a significant deposition gradient across 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 authors acknowledge, and our subgroup agrees, that the fish distribution data is highly skewed toward the Eastern US. 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 which are not ground-truthed in MDN deposition measurement, we are concerned not only about the reality of the identified intense deposition zones, but also whether these watersheds were included in this report's analysis. used in the deposition to fish modeling runs. Fish distribution data appear to overlap in some of these zones of modeled high mercury deposition, and with 300 samples from the Western US, there is a high probability for overlap.

We are also 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 Environmental Science & Technology 20:6281-6286), indicating that even lakes nearby each other can bioaccumulate mercury to greatly differing degrees. In HUCs with multiple lakes, we caution against using a single fish Hg value to describe the HUC. We recommend that an attempt be made to determine to what degree multiple water bodies exist within single HUC12 watersheds, and that the implications of this on the analysis results be described.Characterizing measured fish tissue Hg concentrations (presented within section 1.3)

This section describes the fish tissue MeHg sampling data used in the risk assessment, including the underlying sources of data used in developing the dataset and factors considered in developing the dataset (e.g., inclusion of data sampled between 2000 and 2009). This section also provides the rationale for using the 75th percentile fish tissue MeHg value (within a given watershed) as the basis for exposure and risk characterization.

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?

Response: 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 which influence fish mercury concentrations and human exposure to mercury by the target populations. The sample of 2,461 of the nation's 88,0000 HUC12 watersheds is sufficient for the goals of the risk assessment. For purposes of hazard assessment, it is also 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 mercury 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 changes since the 1990s. As a result the committee 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 which receive elevated mercury deposition from EGU emissions in the US and have limited fish mercury measurements. These states include Pennsylvania, New Jersey, Kentucky, and Illinois. The committee suggests that the EPA contact these states to investigate if additional recent (since 1999) fish mercury 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 mercury content of recreational sportfish, with samples collected from 1979-2007.

The National Listing of Fish Advisory (NFLA) and USGS compilation of mercury data sets are largely comprised of data collected by state agencies with various sampling designs and sampling efforts. Most of the data are not from probability-based sampling designs, so it is not entirely clear what population the fish tissue samples represent. Moreover, some states are more extensively sampled 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, the risk assessment in the TSD focuses on hazard in the fish-sampled watersheds, and not on the population of all 88,000 HUC12 watersheds.

Although probably not relevant for the current risk assessment, researchers have developed reasonably strong empirical relationships for fish mercury concentrations using water chemistry and land cover data. These empirical relationships have been used to estimate mercury concentrations for different fish species across states and regions. Such an empirical approach could be used to provide more comprehensive estimates of fish mercury concentrations across water resources and potentially improve the extent of future mercury risk assessments.

The low sample size of the fish data that are used in the analysis is an item of concern, since ~60% of the watersheds analyzed had fish data with samples sizes of only 1. The bias toward such small sample sizes also has the potential to bias the average concentrations of fish in the watersheds with these low fish sample sizes to be lower than those with higher sample numbers. The larger sample sizes would likely be a better representation of the distribution of fish taxa and sizes in the actual population of fish in the watersheds. Smaller sample sizes could disproportionately samples smaller more abundant taxa that have lower Hg concentrations. This being the case, the 75th percentile (or any percentile) concentrations calculated in the report would be biased low and result in an underestimate of mercury exposure and risk. Given that fish sizes are likely a variable in most datasets, the report should include information on the sizes of fish of the Hg data that were analyzed and in doing so quantify the impact of any bias of potentially smaller sized fish sampled in the smaller samples.

<u>Question 6:</u> *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: Consumption of larger but not the largest fish is a reasonable assumption among sport and subsistence fishers 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 methyl mercury 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 fish sample available with fish tissue mercury concentration. Thus, the estimate of the 75th percentile has considerable uncertainty. The use of only one tissue value for a given watershed would likely underestimate fish tissue levels if the single fish collected on average was smaller than the true 75th percentile, as would occur if the collection were random. The panel recommended inclusion of a graph depicting the number of tissue samples available for analysis by tissue concentration. It is also possible that the collection focused on larger predator fish and areas where higher Hg levels tend to be found, as this is the objective of most state health department's sampling programs. The bias is therefore somewhat difficult to predict. Rather than doing sensitivity analyses in this regard (e.g., by limiting estimates to watersheds with larger fish tissue sample sizes), the committee recommended that the document should discuss this source of uncertainty (including adding a table with the distribution of number of available fish samples across watersheds to indicate the extent of the problem) and describe in more detail why it is likely to result in a conservative estimate of the number of watersheds at risk. It was also suggested that in addition to the 75th percentile, sensitivity analyses should be conducted using different percentile cut-points, such as the mean or 90th percentile. EPA indicated that this could be done fairly easily and plans to do so. Other concerns were raised about to what extent the 75th percentile in the available fish samples actually represents the 75th percentile in the watersheds. This depends on how the fish samples were collected and what type of fish was sampled. The committee recommended that the document provide more detail (preferably in tabular form) concerning the source of the fish Hg concentrations that were obtained, including information on the scope and purpose of each sampling program, the methods used, the types of fish obtained, contribution of each program to the overall data set. There are other sources of fish tissue data that could also be included if more thorough coverage is desired. 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.

Defining subsistence fisher scenarios

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.?

Response: It was noted that the fish consumption data used in the TSD analysis was generally appropriate and reasonable given the limited data available. The risk assessment conducted a thorough literature review and used sources that reported daily consumption for populations of low socioeconomic status (SES) African- and European-Americans as well as low SES females- the target population for the risk assessment. In addition, a study that targeted Laotian and Vietnamese populations, previously identified in the central valley of California, was included in the assessment, as well as a study of Great Lakes Tribes. Thus, a diverse range of susceptible populations were represented in the assessment. The committee indicated that a few caveats should be acknowledged more fully in the document. The main consumption estimates came from a relatively small survey of 149 female sport fishers attending a very sport fishing convention in SC, so the estimates may be imprecise and the population surveyed may not be representative of subsistence fishers. The TSD document should also better acknowledge that the mean fish consumption estimates reported by Burger and relied used in the TSD analysis were well above the median values. Thus, there appears to be a very skewed consumption distribution, which should be noted in the document. It should also be acknowledged that the survey was conducted in 1998, and that fish consumption rates even in subsistence populations may have changed since then (possibly in response to the variety of advisories that have been published in the past decade, resulting in overestimation of risk). Another issue raised by the panel focused on the seasonality of fish consumption; consumption rates in northern tribal communities may be overestimated since fishing may be less prevalent in the winter. This possibility should be addressed in the risk assessment through the use of annualized fish consumption rates. As an alternative approach, 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 (Knoblach et al Env Res 2005; Moya et al Sci Tot Envir, in press). This would result in risk underestimates and would not be consistent with the TSD objective to target sensitive, highly exposed individuals.

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 committee agreed that the criterion of using at least 25 persons per census tract from a given target population (Laotian, poor Hispanic, American Indian etc) was a reasonable approach. The approach is driven by the necessity of using existing data to characterize susceptible populations proximal to impacted watersheds. While the source population selected is somewhat arbitrary, the committee 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 individuals at risk in this population could be characterized. 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.

<u>Apportioning total MeHg exposure between total and U.S. EGU-attributable exposure</u>

<u>Question 9:</u> *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>

<u>On limitations/uncertainty associated with Mercury Maps (MMaps) approach and proportionality assumption)</u>

Overall Comment:

The risk assessment's characterization of the limitations and uncertainty in the application of MMaps approach is appropriate in qualitative terms. It would be useful if quantitative estimates of the uncertainty had been provided (e.g., in Table F-2).

Specific Comments:

Mercury Maps (MMaps) is a national-scale tool that relates changes in mercury air deposition rates to changes in mercury fish tissue concentrations. It was first developed in 2001 and was peer-reviewed at that time (EPA-823-R-01-009, September 2001). The MMaps 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. In other words themodel predicts that fish tissue concentrations will be zero if there is no atmospheric deposition. This proportionality assumption was extended for the TSD study so that MeHg 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 models 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, MMaps 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 and mercury cell chloralkali facilities, 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 MMaps 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 (*Environ. Sci. Technol.* 2007, *41,* 4952-4958) adding isotopically enriched Hg (II) (90.9% 202Hg) to 10-m diameter mesocosms in a boreal lake. They measured concentrations of experimentally added Hg in zooplankton, benthic invertebrates, and fish. Some Hg (II) added to the mesocosms was methylated and incorporated into the food web within weeks, demonstrating that Hg(II) deposited directly to aquatic ecosystems can become quickly available to biota. Relationships between Hg(II) loading rates and spike MeHg concentrations in zooplankton, benthic invertebrates, and fish were linear and significant. Furthermore, spike MeHg concentrations in the food web were directly proportional to Hg(II) loading rates (i.e., a percent change in Hg(II) loading rate resulted in, statistically, the same percent change in MeHg concentration). This same group added a different stable isotope spike to the mesocosms the following year (*Environmental Pollution 154* (2008) 77-88) and found that although inorganic Hg and methylmercury (MeHg) continued to accumulate in sediments throughout the experiment, the availability of MeHg to the food web declined within one year. This decrease was detected in periphyton, zooplankton, and water mites, but not in gomphid larvae, amphipods, or fish. The authors suggested that reductions in atmospheric Hg deposition should lead to decreases in MeHg concentrations in biota, but that changes will be more easily detected in short-lived pelagic species than long-lived species associated with benthic food webs.

In a whole-ecosystem experiment (Harris et al., PNAS, October 16, 2007, vol. 104, no. 42) increasing the mercury load to a lake and its watershed by the addition of enriched stable mercury isotopes found that fish methylmercury concentrations responded rapidly to changes in mercury deposition over the first three years of study. Essentially all of the increase in fish methylmercury concentrations came from mercury deposited directly to the lake surface. In contrast, <1% of the (different) mercury isotope deposited to the watershed was exported to the lake over the three year observation. After three years lake mercury isotope concentrations were still rising in lake biota, and watershed mercury isotope exports to the lake were increasing slowly. The authors predicted that mercury emissions reductions will yield rapid (years) reductions in fish methylmercury concentrations and will result in concomitant reductions in risk. However, a full response will be delayed by the gradual export of mercury stored in watersheds. The rate of response will vary among lakes depending on the relative surface areas of water and watershed.

It is concluded that the assumption of proportionality between air deposition changes and fish tissue MeHg level changes is well supported by peer-reviewed literature. However, since the extension of proportionality assumption to exposure and risk may also be influenced by the catchment profile and existing fish concentrations, analysis examining the sensitivity via a limited case study on a temperate drainage lake with a fully developed trophic hierarchy would be useful to test the overall underpinnings of the assumption.

Regarding the limitations and uncertainty associated with application of MMaps, it is acknowledged that the MMaps 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 MMaps: (1) concerns over including watersheds that may be disproportionately impacted by non-air mercury sources, and (2) application of the MMaps to both flowing and stationary freshwater bodies to verify if the two scenarios would produce different results.

The first area of uncertainty was addressed by two analyses: (a) constraining the risk analysis to only include those watersheds in the upper 25^{th} percentile with regards to total Hg deposition (i.e., watersheds with relatively elevated levels of total Hg deposition to assure that this source of loading played a relatively larger role), and (b) excluding four states in which there were concerns over the potential for non-air mercury playing a greater role (ME, MN, SC and LA).

The results of the risk analysis found that:

- Focusing on those watersheds with relatively greater total Hg deposition would result in a slightly larger fraction of “at risk” watersheds.
- Excluding the four states does reduce the percent of watersheds with potentially at risk populations included in Stage 2, there is still a notable fraction representing a potential health concern.
- Focusing only on stationary waterbodies (lakes and ponds) and excluding flowing waterbodies did result in notably lower U.S. EGU-incremental risk on average for the waterbodies, however risk estimates for upper end watersheds were not substantially affected.

In summary, the sensitivity analyses suggest that uncertainty related to the MMaps approach is unlikely to substantially alter the assessment result that mercury emissions from U.S. EGUs potentially constitute a public health concern.

<u>On integration of CMAQ data to HUC12 watersheds for estimating changes in fish MeHg, exposures and risks</u>

Overall Comment:

The use of 12-km spatial resolution in CMAQ modeling is a significant refinement of the previous analysis conducted using 36-km resolution. This integration of CMAQ data into the analysis for estimating changes in fish tissue MeHg levels is sound provided that the proportionality assumption holds true (discussed in the previous response to this charge question).

Specific Comments:

CMAQ modeling at a 12-km spatial resolution was used to estimate total annual Hg 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 12-digit Hydrologic Unit Codes (HUC12) (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 Hg deposition and changes in MeHg levels in aquatic biota. The area-weighted deposition calculated by CMAQ in each grid cell is distributed area-proportionally to multiple underlying HUC12 grid cells. Since every HUC12 segment is overlain by one or more CMAQ cells, the data processing is mass-conserving. Although interpolating the deposition data from a coarser model grid (CMAQ) to a finer watershed grid (HUC12) will somewhat dilute 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 CAMR rule (36-km resolution). The coarser grid was not able to adequately capture local impacts as emissions were artificially diluted. The modeling results at finer resolution can be used to better resolve deposition pattern near point sources. The confidence in applying the 12-km resolution CMAQ results for estimating fish tissue MeHg changes and its associated exposure/risk is heavily dependent on the robustness of the proportionality assumption in the MMaps approach. The limitation and uncertainty of this assumption has been elaborated on in the response to the first part of this charge question.

<u>On alternatives to Mercury Maps approach linking modeled deposition to monitored MeHg fish tissue levels</u>

Overall Comment:

There are other modeling tools capable of making a national scale assessment, such as the Regional Mercury Cycling Model (R-MCM). However, the results produced by the two model approaches would be equivalent.

Specific Comments:

The R-MCM, a steady-state version of the time-dependent Dynamic Mercury Cycling Model, has been publicly available to, and used by EPA (Region IV, 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 MMaps 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 MMaps "base case" approach was a valid one, it is unlikely that substantial additional insight would be gained with the alternative model framework.

<u>Question 10</u>: 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: Overall Comment:

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.

Specific comments:

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 TRI-net query for 2008 or 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 US-EGU mercury emission value as characterized in the 2005 NATA. The EPA team considered the 25th percentile US-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.

The impact of including watersheds with a small number of fish samples should be evaluated. At a minimum, the number of these watersheds should be discussed and the impact of using different fish concentration percentiles for these watersheds should be investigated.
Other criteria that should be considered for exclusion of particular watersheds are:

- Watersheds that are near urban areas since those may have significant Hg 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 would deter consumer fishing.
- Watersheds with existing fish advisories that may deter consumer fishing, perhaps by employing a weighted number of these based on studies of the effectiveness of fish advisories.

Estimating risk including HQ and IQ loss

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).*

<u>Response: </u>This item contains three questions pertaining to the concentration response function for IQ. The response to the first question is that the rationale for the concentration-response function is appropriate, as qualified 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 item is that masking by fish nutrients could influence the shape of the concentration response function. These three responses are expanded upon in order below. The main concentration-response function is between MeHg exposure and IQ and, as noted, however, in the response to questions 2 and 3, the data on IQ should assume a far less important role in the final document than in the present one.

The specification of the concentration-response function.

The rationale for using developing this function is based on the paper by Axelrad and Bellinger (2007) that seeks to define just such a relationship. In addition, a whitepaper by Bellinger {need citation} describes the sequence of steps in relating MeHg exposure to maternal hair mercury and then that to IQ. The document also notes that such an analysis is of value because of its utility in describing the health effect of other neurotoxicants. These are appropriate bases for examining a potential impact of reducing MeHg on IQ, but the subcommittee felt that it is not a sufficiently compelling basis 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.

We endorse the use of the concentration-response function derived by Axelrod and Bellinger, as used in the document. 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 questions 2 and 3.

One reason is that drawing from animal studies conducted under highly controlled exposure conditions, 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 of 1.3 (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 MeHg exposures. Davidson et al. (2008), Strain et al. (2008) and Stokes-Riner et al. (2011), demonstrated that maternal hair Hg was associated with PDI only after controlling for the effects of maternal LCPUFA status. These nutrients are rich in marine fish but not in freshwater fish. The concentration-effect relationship used in the document's analysis derives from the consumption of marine fish but it is applied to the consumption of freshwater fish. This suggests that the concentration-effect relationship would be steeper. That is, the analysis may underestimate the impact of the proposed rule on consumers of freshwater fish.   It would be important to acknowledge the recent literature addressing this charge question, even if it does not address IQ specifically.

The study by Oken et al. (2005, 2008) demonstrates the benefits of fish consumption as contrasted with the hazards associated with MeHg exposure. It also provides further evidence that the benefits of consuming marine fish may mask MeHg's effects, a conclusion that is directly relevant to freshwater fish.

It was also noted that since selenium levels can vary across watersheds, and selenium and mercury form a bimolecular relationship. There is good evidence that selenium binds with methylmercury and thereby reduces MeHg's bioavailability. This, too, could mitigate the effect of MeHg.

Additional Point.

Finally, the following statement on Page 84, Table F-2 should be corrected (pertains to New Zealand study, not Seychelles study): "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 discussion section on limitations and uncertainties that risk assessment estimates would be reduced by 25%.

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.

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.

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.

Stokes-Riner, 2011. Neurotoxicology and Teratology. (insert complete citation).

Discussion of key sources of uncertainty and variability

<u>Question 12</u>: 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.

<u>Response:</u> The technical support document (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, an expanded discussion of variability and uncertainty would be beneficial. This discussion could be both qualitative and quantitative in nature and could be organized according to the new diagrams that will be added to the report.

In addition to the explicit discussion of variability and uncertainty, the committee suggests that language be used throughout the TSD that clarifies the scope of the results vis-a-vis data and methodological sources variability and uncertainty. However, the variability and uncertainty should not overwhelm the strength of the results and conclusions.

The topics covered in Appendix F include variability in the spatial patterns of Hg deposition, variations in Hg in fish tissue within specific watersheds, variations in the response of mercury levels to changes in mercury deposition, the spatial distribution of subsistence fisher populations, and variations in the fish ingestion of subsistence fishers. 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 to avoid misinterpretation of study results and outcomes.

- Variation in geographic and spatial patterns of
  - EGU deposition
  - Fish tissue concentrations
  - Populations of subsistence fishers
- Estimate of reduction from inventory input to CMAQ in going from 2005 to 2016 scenarios
- Alternative future scenario forecasts (all other things being equal)
- Estimate of location specific EGU fraction. For 2016 the fractional change is used to adjust the fish mercury level. Other factors could influence this fraction.
- Variability in nature and protocols of state collection of fish data (also mentioned below). The data on fish mercury is compiled from different studies which have different protocols and objectives. One would expect differences to factors such as fishing gear (eletrofishing might result in smaller fish, nets reduce the number of smaller fish), selection of sites, sampling effort and location within lake or river.
- Variation in population of fishers , for example variation in body weights (potentially across race/ethnicities) and fishing and consumption habits
- Cooking weight adjustment
- Temporal variability
  - CMAQ boundary conditions

    - Meteorology
- Variance in RfD - both from an uncertainty view as well as variance

Specifically, Appendix F defines sources of uncertainty including parameter estimation for the CMAQ modeling, the characterization of fishing activity, the estimates of U.S. EGU contributions to fish MeHg levels and the use of IQ as an endpoint. The tenor of the discussion of uncertainty is consistent with a screening level analysis.

The committee has discussed some sources of uncertainty in previous Charge Questions (e.g., Question 9). Other sources of uncertainty that should be addressed include:

- Overall emission inventories, especially non-EGU inventory, i.e., uncertainty in TRI inventory and non-TRI inventory
- Use of CMAQ and performance evaluation of CMAQ
    - More detailed description of uncertainty in CMAQ
    - More information is needed to characterize the performance of the CMAQ-GEOS-Chem system in simulating wet deposition of mercury. No information on this issue is provided in the TSD, and the information included in the Air Quality Modeling TSD (Air Quality Modeling Technical Support Document: Point Source Sector Rules, Table III-3) is inadequate, and appears to contain errors (e.g., negative values for wet deposition).
    - Role of reemission from vegetation, soils and water of previously deposited Hg
- Changing the spatial scale from 36-12 km grids results in more hot spots. Would we see more hot spots at even greater spatial resolution? Is this an uncertainty?
- Is the model adequate to characterize hot spots?
- Some watersheds were excluded from the analysis. Was there under and over exclusion of watersheds? Explain why some watersheds were excluded that what the deposition was in them.
    - Representativeness of watersheds 2500 watersheds compared to 80000 nationwide. What (if any) bias is introduced by looking at this subset of watersheds? e.g., some states are over-represented such as Indiana and Minnesota while others are represented.
    - Exclusion of wetlands. Is this appropriate because minimal fishing takes place in wetlands?
- Fish populations.
    - Sample size for characterization of 75th percentile fish tissue concentration (not addressed)
    - Discuss the implications of having a low number of fish per watershed (how many watersheds had less than 5 fish?),
    - Differing variance in fish Hg concentrations in fish populations watershed-to-watershed.
    - There is considerable uncertainty in Hg fish tissue concentrations within the EPA fish tissue database arising from differences in sampling and analytical protocols used by States that contribute the data, and errors introduced by potential misidentification of locations, etc.

    - A large portion of database from state programs that have variable accuracy are biased towards those water bodies where there are consumption advisories
- Adjustment of between wet and cooked weight of fish. However, the committee noted 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.
- Characterization of susceptible human population
    - Characterizing subsistence fishing activity within high EGU deposition sites.
    - Discuss implications of choosing subsistence fishers and excluding high-end sport fishers. The choice translates into which watersheds are identified, not fish consumption rate. What if we included high-end sport fishers, how would the geographic coverage of watersheds differ? We would include more waterbodies but how do you identify watersheds frequented by high-end sport fishers? But distinction fades when you consider who consumes frequently – a subsistence fisher, not necessarily high-end sports fisher.
    - Census information may exclude groups (students, immigrants)
- Fish consumption rates
    - Fish consumption rate of female subsistence fishers was based on one study from South Carolina
    - Seasonality of fish consumption
- Dose-response relationship and RfD were developed for marine fish and mammal species, not inland freshwaters. The uncertainty introduced by not using RfDs for inlands freshwaters is unclear at this moment.
- The applicability of the dose-response relationship for low SES populations has not been examined.
    - The use of IQ as a sensitive endpoint.
- Uncertainty of the effect of the nutritional benefits of fish consumption in comparison to risks from Hg

Discussion of analytical results

<u>Question 13</u>: 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.

- *Mercury deposition from U.S. EGUs*

<u>Response:</u> <TO BE INSERTED>

- *Fish tissue methyl mercury concentrations*

<u>Response:</u> *The observations listed in section 2.4 of the TSD are generally supported by the analytical results, however, the text could be clarified to improve the description of the*

analytical results for each bulleted observation as suggested below (suggested changes to the TSD text are highlighted in yellow).

In addition, there is sufficient characterization of variability but not of uncertainty and data limitations. Specifically, the small samples sizes of Hg concentrations in fish (~60% of which have n=1) appear to result in lower estimates of Hg concentrations in the 75^th^ percentile.

Figures 1. Sample size plot for lakes and rivers using the Excel data provided to the panel. The results do not exactly match those in the report because there may be some slight differences in the data. There is clear evidence of a very high proportion of samples with only one fish (analysis provided by Eric Smith).

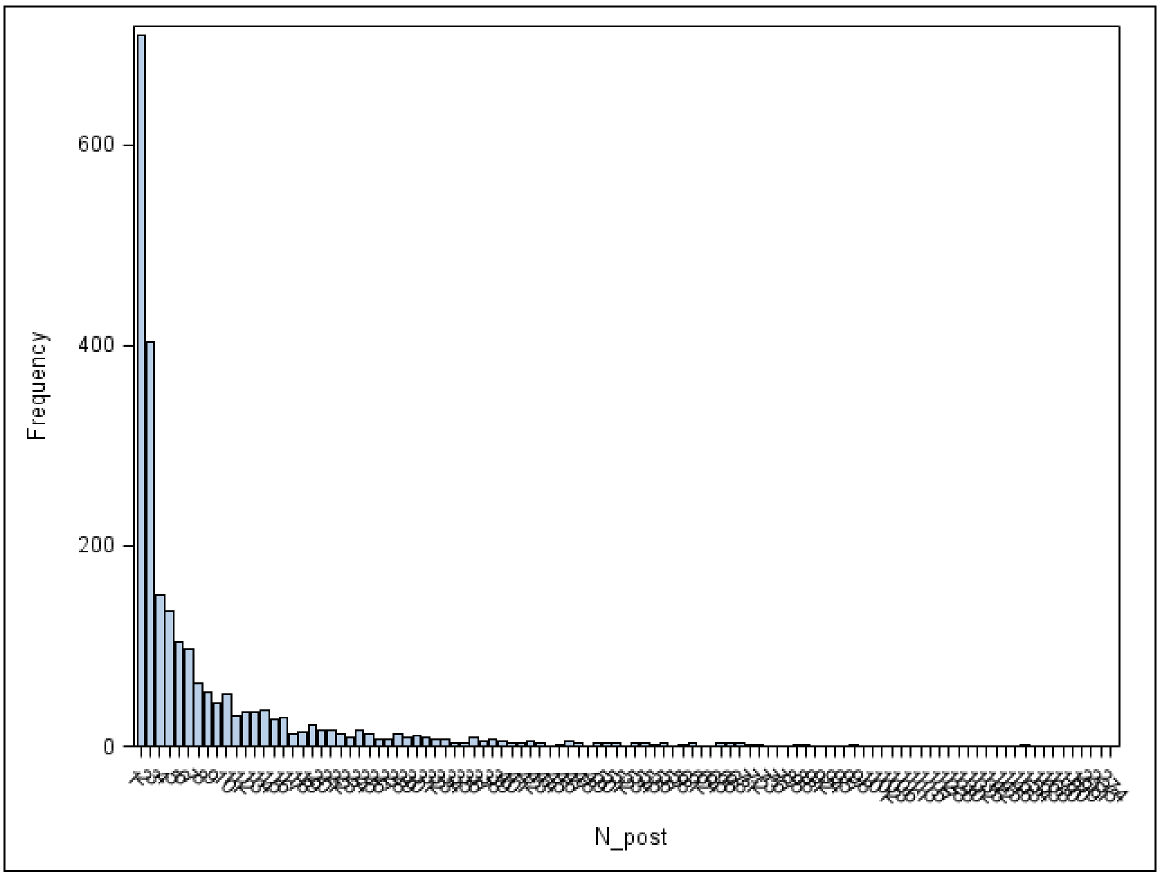
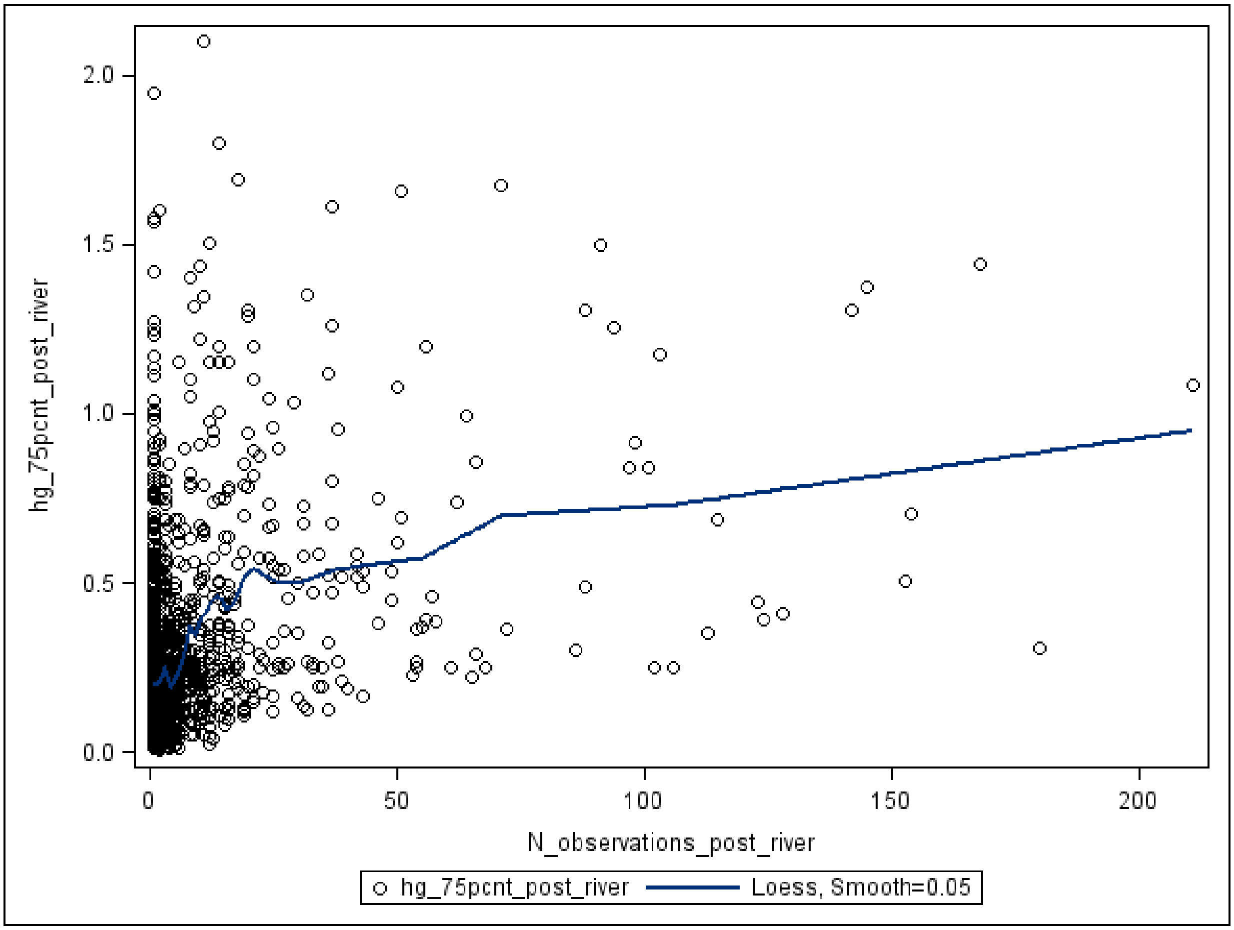


Figure 2: Comparison of Hg concentrations in fish as it relates to sample size in river and lakes combined. The estimate of the 75th percentile in the post period tends to increase with sample size. The fitted curve is based on a loess smoother with smoothing parameter 0.05. The curve is based on the values in the Excel file that was provided to the panel (analysis provided by Eric Smith).



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<u>Observation 1</u>

• Focus on U.S. EGU-attributable Hg fish tissue concentrations is in the eastern half of the U.S.: Given (a) that the number of watersheds with measured fish tissue MeHg data is substantially greater in the East (see Figure 2-5) and (b) more importantly, that the levels of Hg deposition from U.S. EGUs (that largely drives U.S. EGU-attributable Hg fish tissue concentrations) are much higher in the East (see Figures 2-3 and 2-4), trends in U.S. EGU attributable Hg fish tissue concentrations discussed here are driven by data in the eastern half of the U.S.

The maps shown in Figures 2-7 to 2-14 need to include the western US. In addition, the text should be modified as shown above.

Observation 2

• U.S. EGUs contribute a larger fraction to total Hg fish tissue levels in the U.S. than they do to total Hg deposition (in terms of percent), reflecting the fact that Hg fish tissue samples are focused in the East where Hg deposition derived from U.S. EGUs is greater. While U.S. EGUs contribute ~5% of total Hg deposition in the U.S. (for the 2005 scenario – see Table 2-2), their contribution to Hg fish tissue concentrations (summarized at the watershed-level) for the 2005 scenario is larger (~9% ,see Table 2-5). This reflects the fact that Hg fish tissue samples are heavily weighted in the eastern portion of the U.S. where U.S. EGU Hg deposition is typically higher than in the West.[35] By providing greater coverage for the eastern half of the country, the Hg fish tissue sampling data generally provides greater coverage for regions with potentially greater U.S. EGU-attributable risk.

Observation 2 is supported and there is sufficient characterization of uncertainty and variability.

Observation 3

• Relative to the combined impact of other sources, U.S. EGUs represent a smaller, but still potentially important contributor to total fish tissue MeHg concentrations: For the fish-sampled watersheds, U.S. EGUs contribute ~9% of Hg fish tissue concentrations on average under the 2005 scenario (see Table 2-5). Under the 2016 scenario, the U.S. EGU contribution decreases to ~ 4% on average (see Table 2-5) for the fish-sampled watersheds. While U.S. EGU-attributable Hg fish tissue decreases notably between the 2005 and 2016 scenarios, the impact on total Hg fish tissue concentrations is not substantial given that U.S. EGUs contribute a relatively small fraction on total Hg fish tissue concentrations in general (contrast the pattern of decreases seen in Figures 2-9 and 2-10 for U.S. EGU-attributable Hg fish tissue concentrations with the relatively smaller changes seen in Figures 2-7 and 2-8 for total Hg fish tissue concentrations).

Observation 3 needs to be clarified as suggested to reflect the fact that the percentages are based on the sampled fish in the watersheds. The 75th percentile of fish mercury concentration will be underestimated in watersheds where a small number of fish were sampled and this bias will be propagated to underestimate the hazard in the risk assessment. Therefore, the text should be changed to "9% in sampled watersheds" and "4% in sampled watersheds", as suggested above. In addition, 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 color or shading of symbols to represent observed fish concentrations.

Observation 4

• Despite the relatively small fraction of total fish tissue MeHg associated with U.S. EGUs on average, for a subset of watersheds this source can make a substantially larger contribution: Under the 2005 scenario, U.S. EGUs can contribute up to 40% of total Hg fish tissue concentrations for the sampled watersheds (for the 99$_{th}$% watershed). Under the 2016 Scenario, this pattern is reduced, but U.S. EGUs can still contribute up to 18% of total Hg fish tissue concentrations for the sampled watersheds (again, for the 99$_{th}$% watershed) (see Table 2-5).

Given the under-sampling in watersheds where there are high levels of deposition, the *percentages indicated could be higher. Therefore the wording in Observation 4 should be modified as suggested above to indicate that these percentages pertain to the available data only.*

In addition, the figures showing the top 10th percentile should be removed since the pattern of Hg is greatly affected by sampling effort in SC, IN, WV,and LA. The current maps could also result in undue public concern in those states.

- *Patterns of Hg deposition with HG fish tissue data*

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

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

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

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

Overall, we feel the results discussed in this section are supported by the analysis. However, we feel a number of changes are needed to better achieve this goal. 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. How does this data availability bias affect the analytical results? We recommend that this section be substantively rewritten to improve clarity, and to highlight the major relevant points. Included in this re-write is footnote 36, which is critical to the understanding of Figures 2-15 and 2-16, yet is not clearly written and difficult to extract the key information. Also, the figure legends within each of Figures 2-15 and 2-16 need to be changed because the "blue areas" and 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). We suggest that these two maps possibly be replotted with a third color that clearly identifies the areas of overlap.

Figures 2-15 and 2-16 unnecessarily cut off the western continental United States. While we understand why the authors did this (there is minimal expected change in EGU emissions in the western US), we still believe it is important to show the results for the entire U.S. in these figures. In the absence of national maps, the reader (especially someone with western U.S. interest) many be left wondering about current fish Hg content in this region (see Figure 2-6), as well as the model predicted changes in fish Hg for the 2016 scenario.

Figure 2-17 is critically important not only to this section, but to the overall document. We suggest 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 Hg 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, stateing the important premises of the analysis applied in this risk assessment—that spatial variability of deposition rates is not a major driver of spatial variability of fish Hg, but, rather, variability of ecosystem factors that control methylation potential (especially wetlands, aqueous organic carbon, pH, and sulfate). 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? We suspect that there are. Also, none of the panelists were aware of the role turbidity may play in methylation.

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 Hg 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:

> 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/m2, 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.

We find it troublesome that the threshold for what constitutes "relatively elevated US EGU Hg deposition" is different in the two maps, in that a) fish are responding to real mercury deposition, and do not differentiate mercury deposition that is "relatively elevated", and b) 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 do not meet (the red area in Fig 2-15 is characterized as average deposition of 3.79 and for Fig. 2-16 is 1.29 ug/m2). We suggest that some absolute metric be chosen to represent "elevated US EGU Hg deposition." One possible metric that would produce a map similar to that of Fig. 2-15: the mercury deposition attributable to EGUs that corresponds to producing, on average for the data available, a HQ of 1.0 (calculable as taking, for each fish watershed, the EGU-attributable deposition rate and dividing by the HQ). This metric would most likely produce a map with the same red area as in Fig. 2-15, but the red area could be characterized as "elevated U.S. EGU-related Hg deposition refers to areas where deposition from EGU emissions has the potential, on their own, to reach the MeHg RfD." The same metric could be used in Fig. 2-16.

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

- *Percentile risk estimates*

<u>Response:</u> The material below summarizes the discussion on percentile risk estimates.

The general view is percentile risk estimates in 2.6.1 are calculated in a reasonable manner however there were suggestions regarding improving the presentation of the material and results.

1. There are comments about uncertainty in the tables, especially for high values. This seems to be the only place where it is done.

2. The authors should add explanation as to why the values decrease when going from the 50th to 75th percentile. This is due to the fact that the ranked risk values are not the same as the ranked EGU contributions but this should be mentioned. Perhaps the tabulated values should be referred to in some way as averaged.

3. Is it better to use a 2.5% range or use the 10 nearest values? How is the range selected for the 99th percentile?

4. 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.

5. Section 2 page 55 it would be helpful to have more information on the gold-mining impacted watersheds in the SE. 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.

6. Consider reporting rates and put the percentiles in parentheses in tables 2-6 and 2-7.

7. On page 54 the statement on the main bullet (middle of page) suggests that there is a national-level summarization. Since the overall analysis is not national, this should be re-written.

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

- *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 committee 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. 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 consider in this risk assessment. However, this question is outside the scope of the data available for the risk assessment. Nonetheless, 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 Hg consumption in fish. There is scant evidence documenting the prevalence or extent of subsistence fishing in the US. 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 substantially expand 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 in the description of these watersheds and the associated uncertainties. In addition, the document should address the excluded watersheds within the context of predicted Hg deposition patterns. Some enumeration of the extent to which the target population would be expanded if these factors had been included in the analysis would help provide important additional information on the potential scope and magnitude of the hazards estimated in the assessment. Referral to tables, figures, or page numbers in the report supporting the conclusions in this section is also recommended.

<u>Question 14:</u> *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> General comments:
Emphasize the goals of the study by copying the goals presented on page 13 of the document (a,b and c) and respond to each of these points in a clear and understandable fashion.
Emphasize the important take home messages:

- A reduction in Hg emissions will translate to reductions in fish tissue MeHg 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.
- Some EGUs emit sufficient Hg that these emissions alone would result in Hg deposition that could possibly result in fish tissue concentrations that would put subsistence fishers at risk (i.e., generate a hazard quotient greater than one)
- EGU mercury accounts for a small portion of total Hg emissions country-wide, but two factors enter into this. First, EGU emissions are better quantified than poorly characterized non-EGU emissions, and second, certain watersheds have significantly higher Hg contributions from EGUs.

Other important points that emerged from the discussion:

- For a number of reasons there is not a strong correlation between amounts of mercury deposited in a watershed and the tissue levels of MeHg in fish.
- The agency should be careful when making statements about national implications of the analysis because the sample of sites with fish mercury is not representative of the United States.

- One can't really say that the relatively small number of watersheds analyzed results in an underestimation of hazard or risk, but that it does create an uncertainty because we are dealing with unknowns.
- Be careful about overstating results related to the 99th percentile as the estimate may have large variance (relative to other smaller percentiles). Reporting a range (95th to 99th) may be better.

EPA has done a considerable amount of work in analyzing Hg impacts on IQ. After considerable discussion the panel recommendation was that the appropriate approach would be to mention the IQ analysis in the TSD and to discuss the uncertainties involved with the use of the analysis but that offering the conclusion that it would be a less sensitive endpoint than HQ. 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.
Other discussion suggested that the analysis might be problematic because of the emphasis on the 2016 scenario that used information from a 2010 analysis. There may be evidence that emissions were underestimated because the inventory was from the best performing facilities rather than from the complete set of facilities.

<u>Question 15 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?

Response: Notwithstanding the uncertainties inherent in such an analysis, the analysis makes an objective, reasonable and credible determination of the potential for a public health hazard from mercury emitted from U.S. EGUs.

Other Issues:
- Uncertainties: Coal ash can act as a source of Hg in fish.
- Documentation: Inability to 'connect the dots' in the methods section
- Target population: It is difficult to accurately estimate the number of people potentially affected. There is overlap btwn subsistence & high-end sport fishers. Consideration of sport fishers could significantly expand the affected population.
- Uncertainties: There are other health endpoints that should be mentioned, but do not necessarily meet the 'reasonable degree of confidence' criterion (charge Q 2).
- General: Use the term 'hazard' rather than 'risk' and 'attributable hazard' rather than 'attributable risk'.
- General: There is no mention of mixed exposures, other agents emitted from EGUs could also contribute to health hazards elicited by Hg.