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Docket ID No. EPA-HQ-OAR-2018-0794

RE: Comments on Proposed Revocation of the 2020 Reconsideration, and Affirmation of the Appropriate and Necessary Supplemental Finding, 87 Fed. Reg. 7624 (Feb. 9, 2022)

On behalf of Elsie M. Sunderland, Charles T. Driscoll, Jr., Joel Blum, and Celia R. Chen,[1] the Emmett Environmental Law & Policy Clinic submits these comments on the National Emission Standards for Hazardous Air Pollutants: Coal- and Oil-Fired Electric Utility Steam Generating Units—Revocation of the 2020 Reconsideration, and Affirmation of the Appropriate and Necessary Supplemental Finding, 87 Fed. Reg. 7624 (Feb. 9, 2022) (the "Proposal"). Collectively, the signatories possess expertise in the atmospheric transport, aquatic fate, bioaccumulation, human exposures, and health outcomes associated with mercury contamination of the environment and have authored many of the papers cited in this comment. Several of the signatories contributed to a white paper being issued today, *A Template for a State-of-the-Science Assessment of the Public Health Benefits associated with Mercury Emissions Reductions for Coal-fired Electricity Generating Units*, which outlines recommendations for conducting a state-of-the-science analysis of the benefits of regulating mercury emissions from coal-fired electric steam generating units ("EGUs"), as well as to an earlier white paper exploring these issues.[2]

[1] Each signatory's area of expertise is identified in the signature block at the end of this document.

[2] Elsie Sunderland, et al., *A Template for a State-of-the-Science Assessment of the Public Health Benefits associated with Mercury Emissions Reductions for Coal-fired Electricity Generating Units* (Apr. 11, 2022), https://cdn1.sph.harvard.edu/wp-content/uploads/sites/2343/2022/04/MATSTemplateAnalysis_041122b.pdf [hereinafter Sunderland, *Template*"]; Elsie Sunderland, et al., *Mercury Science and the Benefits of Mercury Regulation* (2021), https://cdn1.sph.harvard.edu/wp-content/uploads/sites/2343/2021/12/Mercury_WhitePaper_121621.pdf.

We strongly support the Environmental Protection Agency's ("EPA") proposal to revoke the 2020 reconsideration,[3] and to affirm the 2016 supplemental finding[4] that it is appropriate and necessary to regulate hazardous air pollutant ("HAP") emissions from EGUs. In particular, we agree with EPA that the 2020 Reconsideration was based on a methodology that was "ill-suited to the appropriate and necessary determination" because, among other reasons, it did not give appropriate weight to the "many adverse health and environmental effects of EGU HAP emissions that cannot be quantified or monetized."[5] We also appreciate and agree with EPA's preferred "totality of the circumstances" methodology, which gives due weight to the myriad, unquantified benefits of reducing HAPs. At the same time, it is also important to quantify as many benefits as possible; to that end, we appreciate EPA's inclusion of some post-2012 data and its conclusion that it is appropriate and necessary to regulate EGU HAP emissions based either on the original rulemaking record or on an updated record.

However, the Proposal's analysis of the quantified benefits of regulating EGU mercury emissions can be further strengthened in several respects. In particular, EPA should:

- use best-available data on U.S. mercury emissions sources and speciation from the National Emissions Inventory ("NEI") rather than a model projection for 2016;
- include a state-of-the-science assessment of mercury deposition in the United States attributable to U.S. EGUs by relying on best-available understanding of emissions, transport and atmospheric chemistry in recent rather than outdated atmospheric models;
- improve the quantification of the methylmercury exposure pathways for the general U.S. population by linking emissions and deposition data with detailed fish consumption data for the entire U.S. population including locations and species of fish harvested from U.S. coastal waters, rather than conducting a simple bounding analysis based on atmospheric emissions;
- consider how EGU-derived mercury emissions affect individuals' cumulative exposure to methylmercury;
- expand the cardiovascular impacts assessed to include all-cause mortality rather than only acute myocardial infarction and consider the increasing risks for exposed individuals above the health threshold identified in the literature, rather than assuming the lower bound for exposure;
- quantify neurocognitive outcomes other than IQ, update the dose-response relationship between IQ and methylmercury, and quantify impacts of IQ loss other than reductions in future earnings; and
- more fully consider the environmental justice implications of mercury emissions and exposures by identifying communities that are disproportionately impacted by EGU mercury emissions, including indigenous people and Pacific Islanders (who have high

[3] National Emissions Standards for Hazardous Air Pollutants: Coal- and Oil-Fired Electric Utility Steam Generating Units—Reconsideration of Supplemental Finding and Residual Risk and Technology Review, 85 Fed. Reg. 31,286 (May 22, 2020).

[4] Supplemental Finding That It Is Appropriate and Necessary To Regulate Hazardous Air Pollutants From Coal- and Oil-Fired Electric Utility Steam Generating Units, 81 Fed. Reg. 24,420 (Apr. 25, 2016).

[5] 87 Fed. Reg. at 7627.

exposures because of cultural seafood consumption practices) and people of limited economic means.

We emphasize that none of these suggestions undermines EPA's reaffirmation of its 2016 supplemental finding that it is appropriate and necessary to regulate EGU HAP emissions. To the contrary, the additional evidence that we present here or that we recommend EPA develop only serves to strengthen that conclusion. By adopting some of the recommendations presented here, Sunderland et al. (2022) valued changes in premature cardiovascular mortalities between a 2008-2010 baseline and 2020 at $1.2 billion at a 3% discount rate and $1.5 billion at a 1% discount rate.[6] Both of these estimates exceed the upper bound for the Proposal's estimate of the benefits of avoided cardiovascular mortalities from EGU-attributable emissions at a 3% discount rate ($1.1 billion).[7]

I. EPA Can Consider Updated Information Under Section 112(n)(1)(A)

We agree with EPA's proposed determination that it can "consider the most up-to-date information" when affirming its prior "appropriate and necessary" finding.[8] Indeed, while it may be permissible to *reaffirm* a prior finding without considering updated data, it would be arbitrary and capricious to *reverse* a prior finding—as the agency did in the 2020 reconsideration—based on outdated information that did not reflect current understanding of EGU and global mercury emissions, and the transport, fate, and effects of those emissions. We explain in this section why it was inappropriate for the 2020 reconsideration to rely on eight-year-old data when significant new information regarding both benefits and the costs was available, and therefore why EPA is correct to propose reversing that decision while utilizing updated information.

As a matter of reasoned decision-making, EPA should rely on up-to-date information. "Federal administrative agencies are required to engage in reasoned decision-making. Not only must an agency's decreed result be within the scope of its lawful authority, but the process by which it reaches that result must be logical and rational."[9] An agency violates this duty when, for example, it "entirely fail[s] to consider an important aspect of [a] problem" or "offer[s] an explanation for its decision that runs counter to the evidence before the agency."[10] In addition, "when an agency decides to rely on a cost-benefit analysis as part of its rulemaking, a serious flaw undermining that analysis can render the rule unreasonable."[11]

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[6] Sunderland, *Template*, *supra* note 2.

[7] EPA, National-Scale Mercury Risk Estimates for Cardiovascular and Neurodevelopmental Outcomes for the National Emission Standards for Hazardous Air Pollutants: Coal- and Oil-Fired Electric Utility Steam Generating Units – Revocation of the 2020 Reconsideration, and Affirmation of the Appropriate and Necessary Supplemental Finding; Notice of Proposed Rulemaking 25 (Sept. 2, 2021), https://www.epa.gov/system/files/documents/2021-09/risk-tsd_mats-finding-2060-av12-proposed-rule_20210921_0.pdf

[8] 87 Fed. Reg. at 7635.

[9] *Michigan v. EPA*, 576 U.S. 743, 750 (2015) (citation and internal quotation marks omitted).

[10] *Motor Vehicle Mfrs. Ass'n of U.S., Inc. v. State Farm Mut. Auto. Ins. Co.*, 463 U.S. 29, 44 (1983).

[11] *Nat'l Ass'n of Home Builders v. EPA*, 682 F.3d 1032, 1040 (D.C. Cir. 2012).

The 2020 reconsideration committed all of these errors. It failed to consider updated evidence regarding the health impacts and the fate and transport of those emissions, as well as information on the actual costs of compliance for the electric utility industry, which are central aspects of the "problem" before the agency when it decides whether regulating power plant HAP emissions is "appropriate and necessary." The 2020 reconsideration also ran counter to the evidence before the agency. EPA's decision in 2020 to rely solely on the 2011 RIA "bears no rational relationship to the reality it purports to represent."[12]

As for the 2020 analysis, one of its "serious flaw[s]" was that it was based on outdated information. Courts have frequently held that using old data can render an agency action arbitrary and capricious, particularly when it is clear that more recent data are available. As the Ninth Circuit recently summed up the principle:

> [W]e should not silently rubber stamp agency action that is arbitrary and capricious in its reliance on old data without meaningful comment on the significance of more current compiled data. We hold that EPA's failure to even consider the new data and to provide an explanation for its choice rooted in the data presented was arbitrary and capricious.[13]

The 2020 reconsideration's failure to consider updated information regarding costs was particularly troubling because the distinction was not between relatively older and new predictions, but rather between a prediction and reality. Now that EPA has knowledge of the actual compliance costs, the outdated prediction from the 2011 RIA has little value. Therefore, EPA is correct now to confront the fact that $9.6 billion per year is a highly inflated cost figure.

EPA previously recognized the importance of using up-to-date science in making the section 112(n) "appropriate and necessary" determination. When promulgating the MATS Rule in 2012 EPA conducted "additional technical analyses" to build on its original finding from 2000.[14] According to EPA, although the agency was "not required to reevaluate the 2000 finding," it updated the risk assessments "[b]ecause over 10 years had passed since the 2000 finding, and

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[12] *Sierra Club v. EPA*, 167 F.3d 658, 662 (D.C. Cir. 1999) (quoting *Columbia Falls Aluminum Co. v. EPA*, 139 F.3d 914, 923 (D.C. Cir. 1998)).

[13] *Sierra Club v. EPA*, 671 F.3d 955, 968 (9th Cir. 2012); *see also Alvarado Cmty. Hosp. v. Shalala*, 155 F.3d 1115, 1122 (9th Cir. 1998), *amended*, 166 F.3d 950 (9th Cir. 1999) (finding that Medicare reimbursement decision was arbitrary and capricious because it was based on 1981 data when 1984 data were available); *Natural Resources Defense Council, Inc. v. Herrington*, 768 F.2d 1355, 1408 (D.C. Cir. 1985) (holding that in the Department of Energy's setting of appliance efficiency standards, "it would be patently unreasonable for DOE to begin further proceedings in the last half of 1985 based on data half a decade old"); *CPC Int'l, Inc. v. Train*, 515 F.2d 1032, 1051 (8th Cir. 1975) (holding that EPA's consideration of costs when promulgating a new source performance standard under the Clean Water Act was inadequate because the agency "based its cost figures on 1971 prices, even though the Development Document and the regulations were published in March of 1974").

[14] National Emission Standards for Hazardous Air Pollutants From Coal- and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units, 77 Fed. Reg. 9304, 9310 (Feb. 16, 2012).

EPA wanted to evaluate HAP emissions from U.S. EGUs based on the most accurate information available."[15]

II. The 2020 Reconsideration's Approach to Making the "Appropriate and Necessary" Determination Was Inconsistent with *Michigan* and the Statutory Text

The Proposal is correct to reject the 2020 reconsideration's decision to focus on the comparison between monetized costs and monetized HAP-specific benefits. The 2020 reconsideration framed its analysis as a three-step process, first a comparison of "monetized costs of regulation against the subset of HAP benefits that could be monetized," second a consideration of unquantified HAP benefits, and third a consideration of co-benefits associated with controls of particulate matter.[16] We agree with EPA that this approach "fail[ed] to consider critical aspects of the inquiry posed to the EPA by Congress in CAA section 112(n)(1)," including "the important statutory objective of protecting the most at-risk subpopulations."[17] By effectively ignoring the vast majority of benefits by relegating them to the second and third steps of the analysis, and by considering only a very limited set of quantified benefits, the 2020 reconsideration assigned an outsized and determinative role to its estimate of the regulatory costs. In this section, we explain that this approach was inconsistent with the text of section 112(n) as interpreted by the Supreme Court in *Michigan v. EPA*.

To begin with, "appropriate and necessary" is a capacious phrase under which EPA must consider multiple factors—not only costs. In *Michigan*, Justice Scalia explicitly recognized that section 112(n)(1)'s "broad reference to appropriateness encompasses *multiple* relevant factors (which include but are not limited to cost)," and *Michigan* in no way suggested that cost should be the central, let alone determinative, factor in the finding.[18] Understood properly, the *Michigan* decision, by pointing out that "appropriate" is "the classic broad and all-encompassing term that naturally and traditionally includes consideration of all the relevant factors," simply reiterated that cost should be *one* of the factors that EPA considers when making the finding.[19] In other words, what *Michigan* requires is that cost play *some* role in the finding, not that cost considerations should dominate the finding. The 2020 reconsideration, by focusing primarily on the balance between the compliance costs and the quantified HAP benefits, was inconsistent with this direction from the Court.

Next, the text of section 112(n)(1) makes it clear that public health, not cost, should play the main role in the "appropriate and necessary" finding. Congress put health at the forefront of 112(n)(1) by requiring the Administrator to perform "a study of the hazards to public health reasonably anticipated to occur as a result of" power plant HAP emissions.[20] This is the only study that Congress explicitly instructed EPA to consider when making the appropriate and

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[15] *Id.* at 9337.

[16] 85 Fed. Reg. at 31,302.

[17] 87 Fed. Reg. at 7660.

[18] 576 U.S. at 755.

[19] *Id.* at 752.

[20] 42 U.S.C. § 7412(n)(1)(A).

necessary finding.[21] Moreover, Congress mandated three studies in section 112(n)(1) and while health impacts are part of all three studies, cost factors into only one of the three.[22] Although *Michigan* rejected the argument that this language foreclosed EPA from ignoring costs in the finding, the text does not go nearly so far as to make cost the central consideration.

The 2020 reconsideration's narrow focus on cost-effectiveness also thwarts the purpose of section 112 as a whole. Section 112 addresses HAPs that Congress determined to be "inherently harmful," and—as EPA now correctly recognizes—Congress expressly instructed the agency to "protect[] even the most exposed and most sensitive members of the population."[23] In this context, it was impermissible for the agency to allow an analysis that overstates costs and understates benefits to dictate the "appropriate and necessary" finding.

III. EPA Should Quantify and Monetize Additional Benefits of Reducing EGU Mercury Emissions, Which Will Provide Additional Support for the Appropriate and Necessary Finding

We commend EPA for conducting three screening-level risk assessments that consider the benefits of the MATS rule in reducing (1) the risk of acute myocardial infarctions (heart attacks) among subsistence fishers, (2) the same risk among all adults, and (3) IQ loss for children born to mothers in the general U.S. population resulting from the consumption of commercially-sourced fish. These assessments demonstrate that the total benefits of reducing EGU mercury emissions are much larger than the subset of those benefits quantified in the 2011 MATS RIA. Yet EPA can do more.

Even though we agree that EPA is correct to emphasize the unquantified benefits associated with reducing EGU HAP emissions, we present in this section several recommendations for ways that EPA can quantify and monetize a greater proportion of the benefits associated with reducing EGU mercury emissions. Such an analysis would illustrate that even quantifying only a subset of the direct benefits of the rule results in values that are comparable to the costs.[24] In particular, EPA can elucidate quantitatively the mercury exposure pathway based on available data and tools rather than conducting a simple screening analysis based on outdated estimates of emissions and deposition. We discuss the elements of such an analysis in the subsections below.

A. <u>EPA Should Use Best-Available Data on U.S. Mercury Emissions Sources and Speciation from the National Emissions Inventory (NEI)</u>

Prior to the MATS rule, coal-fired power plants were the largest source of mercury emissions in the United States (Figure 1). As a result of the large temporal changes in mercury emissions, the benefits associated with emissions controls for coal-fired EGUs are strongly affected by the baseline year chosen to index changes. Some states began to develop emissions control

[21] *Id.* ("The Administrator shall regulate electric utility steam generating units under this section, if the Administrator finds such regulation is appropriate and necessary *after considering the results of the study required by this subparagraph*.") (emphasis added).

[22] *Id.* § 7412(n)(1)(A)-(C).

[23] 87 Fed. Reg. at 7645.

[24] *See* Sunderland, *Template*, *supra* note 2 (providing a template for such calculations).

strategies prior to the MATS rule and industry trade journals indicate the utility sector began to plan for regulation in the late 1990s. Maximum benefits associated with reducing mercury emissions from coal-fired power plants would be estimated by comparing peak-emissions years (i.e., sometime between 1990 and 2005) to the most recent values. Regulatory benefits for the MATS rule would need to be related specifically to those actions taken under Section 112 of the Clean Air Act (i.e., comparing 2008 and 2020 emissions levels).

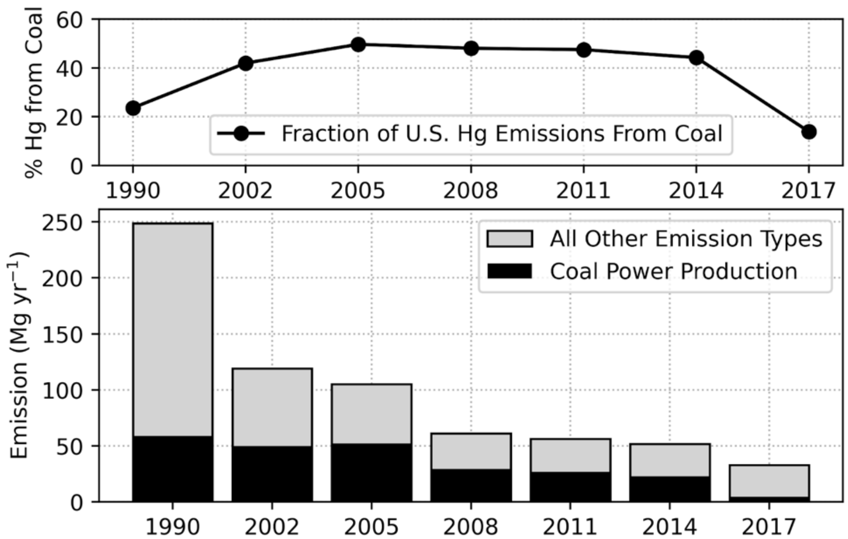

Figure 1 | United States mercury emissions (1990 - 2017). Bottom: Annual mercury emissions from coal-fired power plants (*black*) and total U.S. emissions (*black + gray*). Top: the fraction of total domestic emissions from coal combustion. Data are from the US EPA *National Emissions Inventory* (NEI).

The 2011 RIA used 2005 as the baseline year for the analysis and projected what EGU mercury emissions would be in 2016 after the implementation of other CAA regulations, but in the absence of MATS (Figure 2). The Proposal's broader bounding analyses of benefits continue to rely on this projection.[25] This analysis can be improved by using actual data on domestic mercury emissions, including emissions attributable to coal-fired EGUs, from the NEI. Further, Zhang et al. (2016) corrected an error in reporting by EPA of the speciation of mercury released by EGUs that resulted in an underestimate of declines in deposition of oxidized mercury following addition of pollution controls.[26]

[25] EPA, supra note 7, at 1 (explaining that the analyses were "based on the previous projection that U.S. EGU Hg emissions would total 29 tons in 2016 prior to implementation of MATS but after implementation of all other relevant Clean Air Act (CAA) regulations, as described in the 2011 MATS Risk Assessment").

[26] Yanxu Zhang et al., *Observed Decrease in Atmospheric Mercury Explained by Global Decline in Anthropogenic Emissions*, 113 Proc. Nat'l Acad. Sci. 526 (2016).

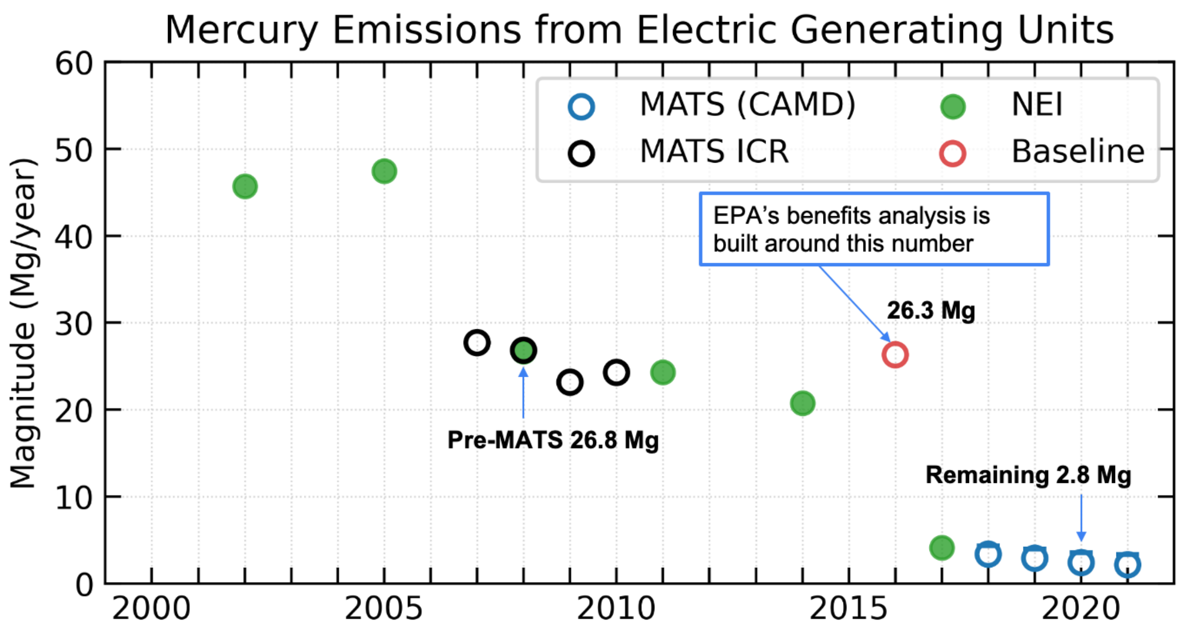

Figure 2 | Comparison of different data sources on mercury releases from coal-fired power plants. Blue circles are total emissions reported by EGUs regulated under MATS. The center of the open circle represents the sum total of reported emissions. Under MATS, EGUs which emit <29 lbs Hg/yr are considered low emitting EGUs (LEEs) and are exempted from reporting. The **horizontal bars on the blue circles** represent the sum total of reported and maximum emissions (29 lbs) from all LEEs. The data have been compiled in EPA Clean Air Markets Division (CAMD) quarterly reports. **Black circles** are emissions from the final four years of the MATS information collection request (ICR). **Green circles** are the "Utility Coal Boiler" emission estimates from the National Emissions Inventories (NEI). The **red circle** is the emission value (29 US tons, 26.3 Mg) used by the Proposal for all analyses characterizing the public health burden (risk) associated with Hg release from U.S. EGUs.

EPA's analysis can be improved by using best-available data on U.S. mercury emissions sources and speciation that are incorporated in the NEI. Such an analysis would bolster the conclusion that it is appropriate and necessary to regulate EGU mercury emissions because it would be based on actual changes in mercury emissions from EGUs.

B. EPA Should Update its Assessment of Utility-Attributable Mercury Deposition in the United States

The 2011 MATS RIA underestimated the locally deposited fraction of EGU mercury emissions, which contributed to its underestimation of the benefits associated with reducing those emissions. Mercury deposition in U.S. ecosystems is derived from both domestic and global anthropogenic sources, as well as natural and reemitted historical mercury. (Mercury that was previously emitted into the environment can be reemitted to the atmosphere from land or water.[27] Past mercury emissions from coal-fired power plants continue to cycle in the global environment as part of this reemitted mercury and contribute to general U.S. population exposures through the consumption of seafood from global commercial fisheries.)

[27] *Mercury Emissions: The Global Context*, EPA, https://www.epa.gov/international-cooperation/mercury-emissions-global-context (last visited Apr. 10, 2022).

Information on changes in global and domestic emissions over time is readily available in the scientific literature and should be used, in combination with updated models simulating atmospheric chemistry and transport, to understand and attribute changes in mercury inputs to U.S. ecosystems. Typically, such an analysis is conducted by running a 3-D atmospheric chemical transport model ("CTM") and calculating wet and dry deposition of mercury to U.S. ecosystems with and without emissions from U.S. coal-fired power plants. Temporal changes in mercury deposition are computed by forcing the model analysis with emissions values for different years. Differences among model simulations result from variability in emissions information used as an input for the analysis and the simulated atmospheric chemistry of mercury. Importantly, mercury undergoes reactions (oxidation-reduction (redox) chemistry) in the atmosphere that convert mercury from the stable, long-lived form (gaseous elemental mercury) to the rapidly deposited form (oxidized mercury).

Extensive research on mercury emissions and atmospheric mercury chemistry has occurred since the MATS RIA was developed in 2011. Several emissions inventories have been produced that are useful for analyzing changes in U.S. mercury deposition. Streets et al. (2019) developed the most temporally and spatially consistent estimate of global mercury emissions that we recommend for specifying global boundary conditions for this analysis.[28] The GEOS-Chem model was used in the original MATS RIA to simulate the boundary conditions for a regional atmospheric chemical transport model (Community Multiscale Air Quality; CMAQ). Updated versions of these models could be used in a revised analysis.[29]

Shah et al. (2021) developed a state-of-the-science simulation of atmospheric mercury redox chemistry within the GEOS-Chem model (Figure 3). The new simulation framework considers chemical reactions discovered after the MATS RIA based on measured photolysis rates and quantum chemistry calculations.

[28] David G. Streets, et al., *Global and Regional Trends in Mercury Emissions and Concentrations, 2010-2015*, 201 Atmospheric Env't 417 (2019).

[29] Viral Shah, et al., *Improved Mechanistic Model of the Atmospheric Redox Chemistry of Mercury*, 55 Envtl. Sci. & Tech. 14,445 (2021); Zhuyun Ye et al., *Evaluation of CMAQ Coupled with a State-of-the-art Mercury Chemical Mechanism (CMAQ-newHg-Br),* 10 J. Advances Modeling Earth Sys. 668 (2018).

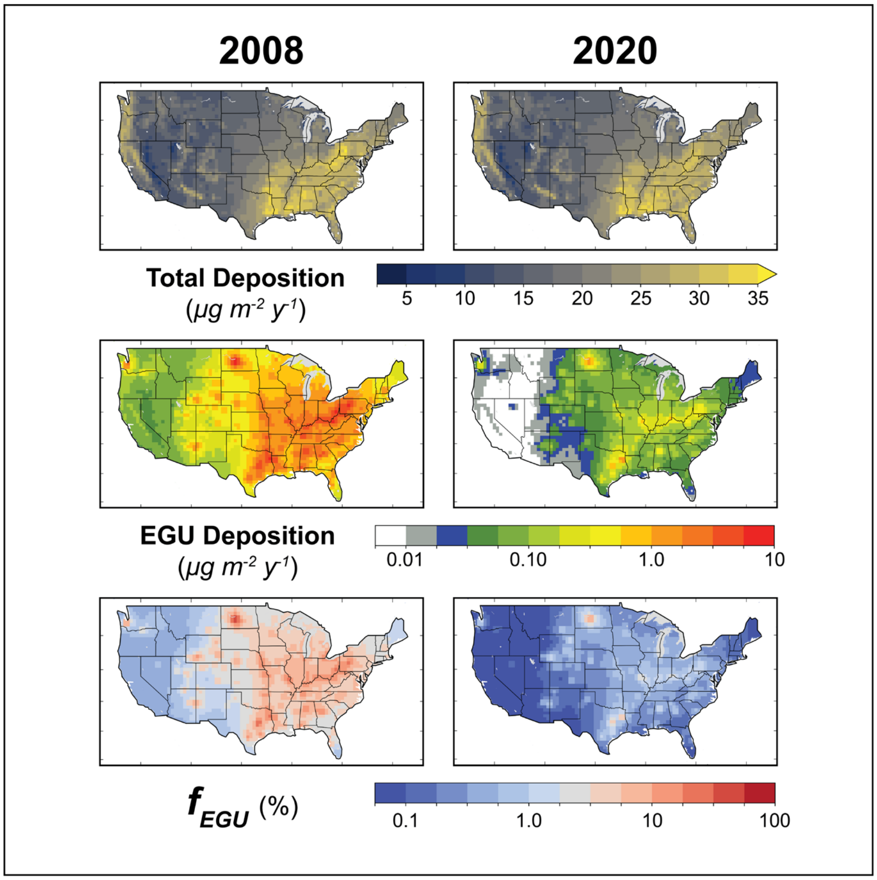

Figure 3 | Modeled atmospheric mercury deposition for before (2008) and after (2020) implementation of the Mercury and Air Toxics Standards (MATS). Results are based on a nested simulation (0.5°x0.625° horizontal resolution) using the GEOS-Chem global chemical transport model described in Shah et al. (2021). Total deposition (top panels) shows mercury deposited from all sources. The middle panels show deposition originating from only U.S. coal-fired electricity generating units (EGU deposition). The fraction of total mercury deposition from EGUs (f_{EGU}) is shown on the bottom panels. (Sunderland et al. 2022)

Incorporating NEI data, the speciation correction from Zhang et al., and the updated modeling from Shah et al. (2021), Sunderland et al. (2022) find that *average EGU-attributable mercury deposition in the United States is approximately twice as large as the Proposal's estimate*.[30]

In addition, the Proposal did not consider the impacts of reemitted mercury originally derived from historical U.S. EGU emissions. After mercury from EGUs is deposited to ecosystems, some is reemitted and continues to cycle in the global environment where it can accumulate in the commercial seafood consumed by the general U.S. population. Sunderland et al. (2022) estimate the contribution to global deposition from cumulative U.S. EGU emissions as 1.0% in 2010 and 0.89% in 2020.[31] This analysis demonstrates that reemitted mercury is an important contributor to mercury exposures from global ocean seafood harvests (Figure 4).

[30] Sunderland, *Template*, *supra* note 2, at 5.

[31] *Id.*

EPA should conduct an updated analysis of EGU-attributable deposition, the fraction of total U.S. deposition attributable to EGUs, and the proportion of deposition from global sources. This analysis should incorporate the chemical reaction scheme used in the model described in Shah et al. (2021) into an updated version of the CMAQ model used in the original MATS analysis. This update is important because the locally deposited fraction of mercury releases was underestimated in the modeling conducted for the 2011 MATS RIA. As a result, a revised analysis will show greater reductions in deposition to U.S. ecosystems resulting from regulating EGU mercury emissions and therefore provide additional support for the "appropriate and necessary" finding. Taking into account the increased fraction of U.S. deposition attributable to EGUs demonstrated by these simulations is especially important as EPA reviews the 2020 residual risk analysis and assesses the exposures of the most vulnerable populations.

C. EPA Should Improve its Quantification of the Methylmercury Exposure Pathways for the General U.S. Population

Most mercury exposure in the U.S. population is associated with seafood consumption. A major limitation of the analysis in the 2011 MATS RIA was that it quantified only benefits associated with reductions in the accumulation of EGU-derived mercury in freshwater fish caught by recreational anglers. Most people in the U.S. consume fish supplied by the commercial market, with more than 80% from estuarine and marine ecosystems.[32] Mercury emitted from U.S. EGUs is transported to domestic water bodies across the country, including both freshwater and coastal ecosystems. A substantial fraction of commercial market fish consumed in the U.S. is from domestic harvests of estuarine fish on North Atlantic and North Pacific coasts (Figure 4).

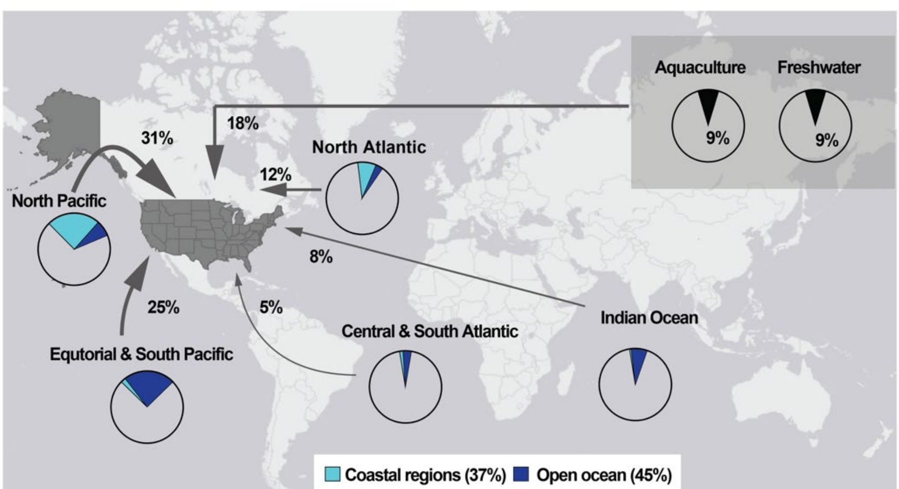

Figure 4 | Sources of U.S. population mercury intake from the commercial seafood market. Figure from Sunderland et al. (2018).

[32] Elsie M. Sunderland et al., *Decadal Changes in the Edible Supply of Seafood and Methylmercury Exposure in the United States*, 126 Envtl. Health Persp. 017006 (2018); Elsie M. Sunderland, *Mercury Exposure from Domestic and Imported Estuarine and Marine Fish in the U.S. Seafood Market*, 115 Envtl. Health Persp. 235 (2007).

The Proposal improves upon the 2011 MATS RIA by providing a bounding analysis for exposures of the general U.S. population to methylmercury from commercially-sourced fish.[33] Analyzing these exposures is essential because the commercial seafood market is the main exposure pathway for most Americans. However, this analysis is best characterized as a rough approximation that does not consider the best-available understanding of the mercury exposure pathway. Instead of simply relying on EGU emissions as a fraction of the global total for the lower bound, and average utility-derived deposition for the upper bound, we suggest that EPA more fully quantify the exposure pathway for general population exposures. EPA can do so by establishing a baseline mercury exposure level using NHANES data, using a probabilistic model to quantify exposure from fish consumption, and employing an updated approach to analyze the relationship between mercury emissions and deposition to U.S. ecosystems.

First, we recommend establishing a baseline mercury exposure level for all individuals aged 18 and over in the United States using National Health and Nutrition Examination Survey (NHANES) data for 1999/2000 or 2001-2018 based on their reported number of seafood meals (Figure 5). Exposure reflects the product of mercury concentrations in consumed fish and the amounts of fish consumed by people. Women of childbearing age and all individuals aged 18 and over can be separated in this analysis for later calculation of the relevant health endpoints (i.e., neurocognitive or cardiovascular health endpoints). The 2011 RIA incorporated a calculation of the number of individuals who are recreational anglers for each state based on survey data from the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation maintained by the Department of the Interior. This population should be subtracted from the rest of the U.S. population categorized as general seafood consumption to avoid double counting of exposure estimates. Additional data on seafood consumption rates and preferences of U.S. recreational fishers is available in von Stackelberg et al. (2017).[34]

Because NHANES is statistically representative of the U.S. population, these data can be used to estimate numbers of individuals and distributions of exposure that reflect different seafood consumption preferences that result in higher or lower mercury exposures. Dietary intake rates can be estimated by grouping individuals by their reported number of seafood meals (Figure 5).

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[33] 87 Fed. Reg. at 7643-44.

[34] Katherine von Stackelberg et al., *Results of a National Survey of High-frequency Fish Consumers in the United States*, 158 Envtl. Res. 126 (2017).

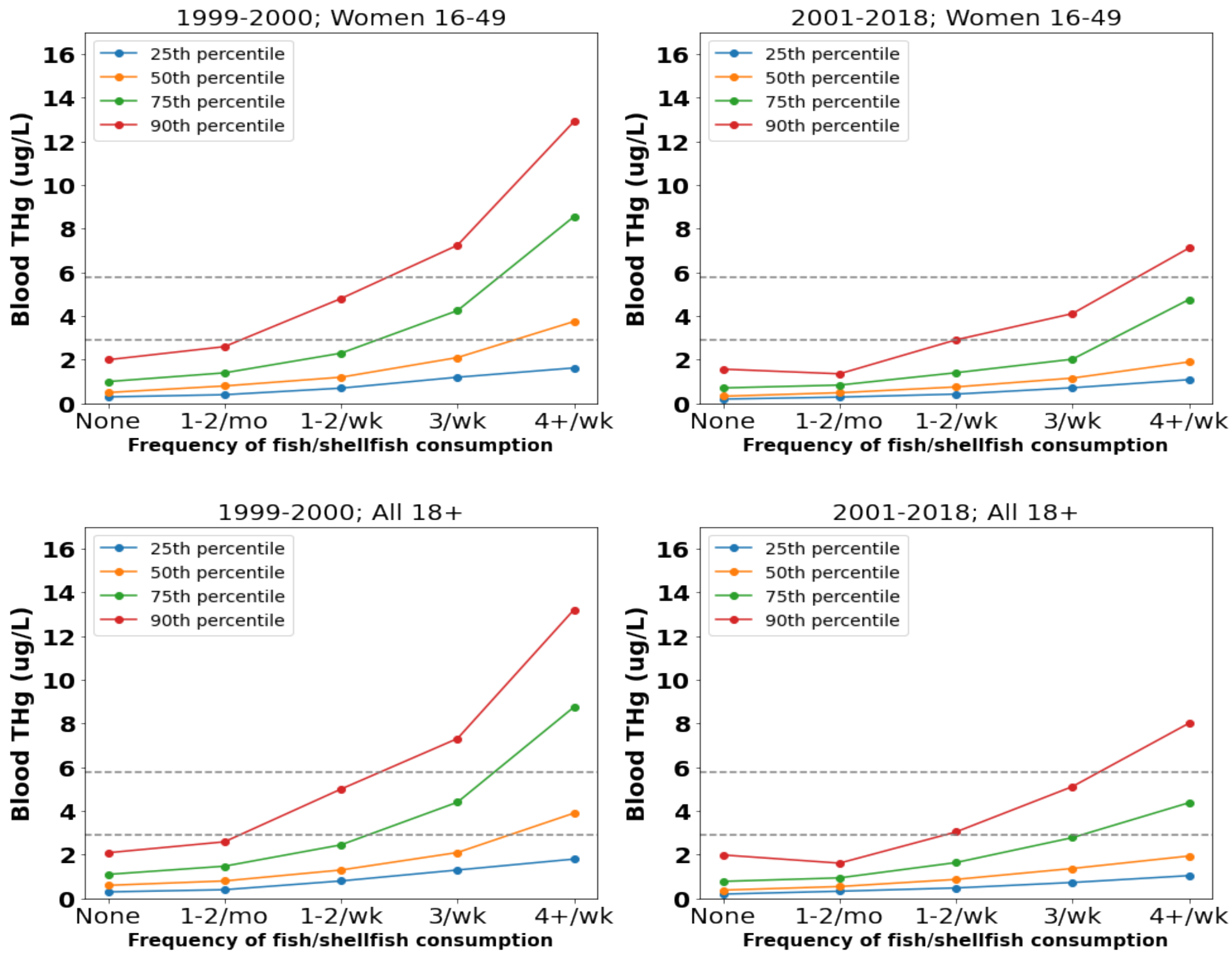

Figure 5 | Percentiles of exposure indicated by blood total mercury levels as a function of seafood consumption for all individuals aged 18+ in the U.S. Dashed lines correspond to EPA's reference dose (RfD) for methylmercury (upper dashed line) and proposed revised RfD after accounting for imprecision in exposure biomarkers (lower dashed line) based on the analysis by Grandjean and Budtz-Jorgensen (2007).[35] Data from CDC/NHANES.

Next, EPA could use a probabilistic version of its one-compartment toxicokinetic model based on best estimates of model parameters and their uncertainty to back-calculate the ingested dose of methylmercury that corresponds to observed blood mercury levels.[36] The fish meals corresponding to each dose can be simulated by assigning probabilities of consuming different types of seafood based on U.S. market preferences and their corresponding mercury concentrations, while optimizing these selections to match the ingested methylmercury dose (Figure 6). The fractions of each seafood category harvested from domestic ecosystems are available in Sunderland et al. (2018), providing an indication of methylmercury in ingested seafood from coastal and freshwater systems that are affected by changes in EGU emissions of

[35] Philippe Grandjean & Esben Budtz-Jørgensen, *Total Imprecision of Exposure Biomarkers: Implications for Calculating Exposure Limits*, 50 Am. J. Indus. Med. 712 (2007).

[36] Miling Li et al., *Insights from Mercury Stable Isotopes into Factors Affecting the Internal Body Burden of Methylmercury in Frequent Fish Consumers*, 4 Elementa: Sci. Anthropocene 000103 (2016).

mercury.[37] Sunderland et al. (2022) demonstrate a probabilistic modeling approach based on these data sources to quantify general U.S. population exposures.[38]

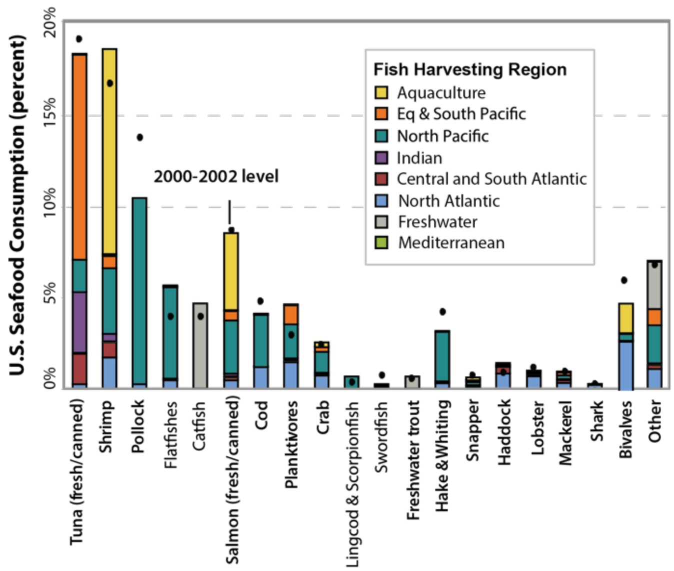

Figure 6 | Seafood consumption preferences of the U.S. general population and their harvesting origins based on the edible supply of fish sold domestically in the commercial market. Figure adapted from Sunderland et al. (2018). Bars show data for the years 2010-2012 and dots show the total for years 2000-2002.

As described in the previous section, we also recommend that EPA adopt an updated approach for characterizing the relationship between changes in mercury emissions from EGUs and deposition to U.S. ecosystems. EPA can use the same approach for both coastal and freshwater fish for the revised analysis. This approach is reasonable because scientific research now shows that most methylmercury accumulated in coastal fish is derived from the water column rather than a sediment source, and therefore will respond more rapidly to shifts in atmospheric inputs than previously expected.[39] The potential lag times of both freshwater and estuarine ecosystems could be explored using sensitivity scenarios for response times characterized in prior work.[40] This approach will result in a more accurate assessment of the population that is affected by

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[37] Sunderland et al., *Decadal Changes in the Edible Supply of Seafood and Methylmercury Exposure in the United States*, *supra* note 32.

[38] Sunderland, *Template*, *supra* note 2.

[39] Amina T. Schartup et al., *Freshwater Discharges Drive High Levels of Methylmercury in Arctic Marine Biota*, 112 Proc. Nat'l Acad. Sci. 11,789 (2015); Celia Y. Chen et al., *Benthic and Pelagic Pathways of Methylmercury Bioaccumulation in Estuarine Food Webs of the Northeast United States*, 9 PLos ONE e89305 (2014); Elsie M. Sunderland et al., *Response of a Macrotidal Estuary to Changes in Anthropogenic Mercury Loading Between 1850 and 2000*, 44 Envtl. Sci. & Tech. 1698 (2010).

[40] Ryan F. Lepak et al., *Mercury Source Changes and Food Web Shifts Alter Contamination Signatures of Predatory Fish from Lake Michigan*, 116 Proc. Nat'l Acad. Sci. 23,600 (2019); Christopher D. Knightes et al., *Application of Ecosystem-scale Fate and Bioaccumulation Models to Predict Fish Mercury Response Times to Changes in Atmospheric Deposition*, 28 Envtl. Toxicology & Chemistry 881 (2009); Reed C. Harris et al., *Whole Ecosystem Study Shows Rapid Fish-mercury Response to Changes in Mercury Deposition*, 104 Proc. Nat'l Acad. Sci. 16,586 (2007).

changes in methylmercury exposure that result from controlling mercury emissions from U.S. EGUs. Such an analysis would also support estimates of changes in methylmercury exposure by population subgroups.

D. EPA Should Consider how EGU-derived Mercury Emissions Contribute to Individuals' Cumulative Exposure to Methylmercury

Both the 2011 RIA and the Proposal consider only the health effects associated with utility-attributable mercury exposure without accounting for additional sources of mercury exposure. Health effects from methylmercury exposure reflect the accumulated body burden and concentrations of this toxicant at active sites within the body. The human body is unable to distinguish EGU-derived mercury from other sources and therefore such an abstraction is difficult to justify from a health perspective. For other risk-based decisions, a "relative-source contribution" ("RSC") is commonly used to account for pollutant exposures that originate outside of the pathway being considered for regulation. For example, recreational fish consumption advisories for methylmercury commonly assume a default RSC of the recreational fishing activity of 20%, with 80% of exposures assumed to originate from other sources.[41]

Given the ubiquity of mercury in the environment, EPA should account for exposures from all sources when considering potential health effects, especially if a threshold such as the reference dose (RfD) is used for such assessments. Inputs of EGU-derived mercury together with mercury from other sources may result in an individual exposure above the RfD and regulation of EGU emissions may prevent an individual from exceeding the RfD. Such a methodology would confer a higher monetized value than an estimate of benefits that does not account for cumulative exposure.

Not accounting for cumulative exposure may also perpetuate the disproportionate burden borne by some communities. Sunderland et al. (2022) estimate that reductions in EGU emissions between a 2008-2010 baseline and 2020 resulted in 60,000-100,000 women of childbearing age (16-49) shifting from above to below the RfD for methylmercury and 3700-5600 fewer babies born per year above the RfD.[42]

EPA should account for cumulative exposure to mercury when estimating the benefits of reducing mercury emissions from EGUs. This could be accomplished by developing an EGU-attributable RSC. Such an approach would better capture the full health benefits of emission regulation.

E. EPA Should Consider Other Cardiovascular Impacts in Addition to Acute Myocardial Infarctions

We commend EPA for including two screening-level assessments of the benefits of the MATS rule in reducing the risk of acute myocardial infarctions (heart attacks).[43] It is important that the

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[41] EPA, *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories: Volume 2: Risk Assessment and Fish Consumption Limits* (2000), https://www.epa.gov/sites/default/files/2015-06/documents/volume2.pdf.

[42] Sunderland, *Template*, *supra* note 2.

[43] 87 Fed. Reg. at 7641-44.

"appropriate and necessary" finding take into account cardiovascular risks, given the strong scientific evidence that methylmercury exposure can seriously harm cardiovascular health.[44]

We urge EPA to further strengthen this analysis. Myocardial infarction is only one type of cardiovascular harm associated with methylmercury exposure, and is only associated with approximately one-seventh of total cardiovascular mortality.[45] Others include oxidative stress, atherosclerosis, heart rate variability, and to a certain degree, blood pressure and hypertension—all of which are intermediary impacts that contribute to myocardial infarction risk.[46] Two systematic reviews of the association between methylmercury exposure and heart disease showed that methylmercury enhances production of free radicals resulting in a long-lasting range of effects on cardiac parasympathetic activity, such as myocardial infarction, hypertension, blood pressure, and death.[47] Additionally, the effect of prenatal methylmercury exposure on blood pressure is more pronounced among children with lower birth weights. Comparing boys who had a mercury cord blood concentration of 10 µg/L to those who had 1 µg/L, heart rate variability was found to decrease by 47%.[48]

Including an expanded set of cardiovascular health risks associated with methylmercury exposure will provide a more comprehensive benefits analysis. More than 100,000 children are born per year in the United States with blood mercury levels exceeding EPA's RfD, but this is less than the number of affected adults 18+ in the U.S. population with hair mercury levels (1-2 µg/g) exceeding the threshold for increased risk of multiple adverse cardiovascular endpoints, based on a recent systematic review of the literature.[49] Blood mercury exposure levels measured in NHANES suggest millions of U.S. adults are at risk of fatal heart attacks, and more than 10 million individuals are at risk of non-fatal ischemic heart disease (Figure 7). Modeling by Sunderland et al. (2022) suggests that reductions in EGU mercury emissions between a 2008-2010 baseline and 2020 decreased by 380,000 the number of individuals in the United States exposed to levels above those associated with increased risk of ischemic heart disease, and decreased by 160,000 the number of individuals in the United States exposed to levels above those associated with increased risk of cardiovascular mortality.[50]

[44] *See, e.g.*, Xue Feng Hu et al, *Mercury Exposure, Cardiovascular Disease, and Mortality: A Systematic Review and Dose-response Meta-analysis*, 193 Envtl. Res. 110538 (2021).

[45] Sunderland, *Template*, *supra* note 2 (citing CDC data derived from https://wonder.cdc.gov/ucd-icd10.html).

[46] Henry A. Roman et al., *Evaluation of the Cardiovascular Effects of Methylmercury Exposures: Current Evidence Supports Development of a Dose–Response Function for Regulatory Benefits Analysis*, 119 Envtl. Health Persp. 607, 607 (2011).

[47] Giuseppe Genchi et al., *Mercury Exposure and Heart Diseases*, 14 Int'l J. Envtl. Res. & Pub. Health 74 (2017); Xue Feng Hu, Kavita Singh & Hing Man Chan, *Mercury Exposure, Blood Pressure, and Hypertension: A Systematic Review and Dose–response Meta-analysis*, 126 Envtl. Health Persp. 076002 (2018).

[48] Nicolina Sørensen et al., *Prenatal Methylmercury Exposure as a Cardiovascular Risk Factor at Seven Years of Age*, 10 Epidemiology 370 (1999).

[49] Hu et al., *supra* note 44.

[50] Sunderland, *Template*, *supra* note 2 (citing Hu et al., *supra* note 44).

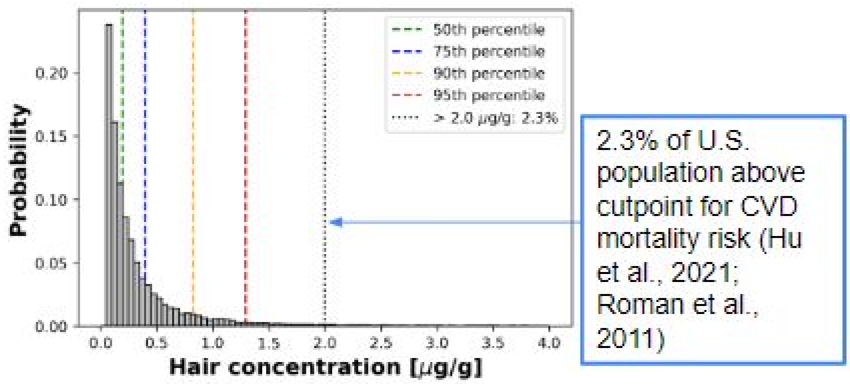

Figure 7 | Number of U.S. individuals at risk for adverse health effects due to methylmercury exposure. Data are from CDC/NHANES blood Hg measurements, extrapolated to the entire U.S. population. See Sunderland et al. (2022).

F. <u>EPA Should Quantify Neurocognitive Outcomes Other than IQ Loss, Update the Dose-Response Relationship between IQ and Methylmercury, and Consider Broader Societal Impacts of IQ Loss</u>

In both the 2011 RIA and the Proposal, the only neurocognitive endpoint monetized was reductions in IQ for children born to mothers who consumed fish containing methylmercury. In the RIA, this analysis was limited to recreational anglers consuming freshwater fish. The Proposal expands the analysis to provide estimates for the general U.S. population consuming commercially-sourced fish. While we commend EPA for expanding the analysis, we recommend that it further update and expand the analysis to include other neurocognitive outcomes, revise the dose-response relationship between IQ and methylmercury, and to capture not only the direct earning benefits to individuals from higher IQ but also benefits to society as a whole.

The only health endpoint taken into account in the quantification of benefits for the 2011 MATS RIA was IQ losses from exposures above EPA's current RfD for methylmercury. That RfD was published in 2001[51] and based on a 2000 assessment conducted by the National Academy of Science's National Research Council.[52] Neonatal studies conducted in the United States, Europe, China, and Japan have consistently found low-level exposure to methylmercury below the RfD established by EPA to be associated with adverse neurobehavioral development.[53] EPA

[51] National Center for Environmental Assessment, EPA, *CASRN 22967-92-6, Methylmercury Chemical Assessment Summary* (2001).

[52] Nat'l Research Council, *Toxicological Effects of Methylmercury* (2000), https://www.nap.edu/catalog/9899/toxicological-effects-of-methylmercury.

[53] Sally Ann Lederman et al., *Relation between Cord Blood Mercury Levels and Early Child Development in a World Trade Center Cohort*, 116 Envtl. Health Persp. 1085, 1090 (2008); Emily Oken et al., *Maternal Fish Intake during Pregnancy, Blood Mercury Levels, and Child Cognition at Age 3 Years in a US Cohort*, 167 Am. J. Epidemiology 1171, 1177–79 (2008); Kristine Vejrup et al., *Prenatal Mercury Exposure, Maternal Seafood Consumption and Associations with Child Language at Five Years*, 110 Env't Int'l 71 (2018); Wieslaw Jedrychowski et al., *Effects of Prenatal Exposure to Mercury on Cognitive and Psychomotor Function in One-Year-Old Infants: Epidemiologic Cohort Study in Poland*, 16 Annals Epidemiology 439 (2006); Jinhua Wu et al., *Effect of*

acknowledged in its 2019 proposal to update the Integrated Risk Information System (IRIS) assessment of the health effects for methylmercury that the 2001 RfD is now outdated.[54]

Neurocognitive effects of adult exposures have also been documented, with a key concern being that it may accelerate age-related declines.[55] Fine-motor function and verbal memory are compromised among adults who are exposed to elevated amounts of methylmercury, which is consistent with outcomes observed in children with prenatal exposures.[56] EPA should expand the suite of health endpoints considered in its analysis to include neurocognitive outcomes such as memory, delayed learning, and behavioral impacts, in addition to IQ, for both children and adults. The effects on these endpoints below the RfD should also be analyzed and included in the benefits estimate.

In addition, EPA should update the dose-response relationship between IQ and methylmercury to reflect the latest scientific understanding. Human exposure to methylmercury occurs primarily through consuming fish in which methylmercury has bioaccumulated. These fish also contain nutrients, such as fatty acids, that have neurodevelopmental benefits for offspring. Studies have shown that correcting for the negative confounding of these benefits results in a steeper dose-response relationship between methylmercury exposure and IQ.[57]

Finally, EPA should expand the consequences of IQ loss that it quantifies in the analysis, which are currently limited to reductions in future earnings. Reduced IQ can result in a variety of broader societal impacts, including costs associated with increased need for special education, reductions in the number of innovators in society, and increases in the number of individuals that rely on the state for care.

G. EPA Should More Fully Consider the Environmental Justice Implications of EGU Mercury Emissions

We commend EPA for characterizing the environmental justice implications of variations in fish consumption practices in different communities in the United States.[58] However, EPA should

Low-Level Prenatal Mercury Exposure on Neonate Neurobehavioral Development in China, 51 Pediatric Neurology 93 (2014); Yu Gao et al., *Prenatal Exposure to Mercury and Neurobehavioral Development of Neonates in Zhoushan City*, China, 105 Envtl. Res. 390 (2007); Keita Suzuki et al. *Neurobehavioral Effects of Prenatal Exposure to Methylmercury and PCBs, and Seafood Intake: Neonatal Behavioral Assessment Scale Results of Tohoku Study of Child Development*, 110 Envtl. Res. 699 (2010).

[54] EPA, *Integrated Risk Information System (IRIS) Assessment Plan for Methylmercury (Scoping and Problem Formulation Materials)* 6 (Apr. 4, 2019) (stating that a reassessment is "justified by recent epidemiological studies that analyzed effects at lower methylmercury exposure levels than those in studies used to derive the existing RfD").

[55] Deborah Rice & Stan Barone Jr., *Critical Periods of Vulnerability for the Developing Nervous System: Evidence from Humans and Animal Models*, 108 Envtl. Health Persp. Supp. 511 (2000).

[56] Edna M Yokoo et al., *Low Level Methylmercury Exposure Affects Neuropsychological Function in Adults*, 2 Envtl. Health 8 (2003).

[57] Anna L. Choi et al., *Selenium as a Potential Protective Factor Against Mercury Developmental Neurotoxicity*, 107 Envtl. Res. 45, 51 (2008).

[58] 87 Fed. Reg. at 7646-47.

take into account new data on high-quantity fish consumers and their socioeconomic attributes, and address disproportionate exposures of indigenous people, Pacific Islanders, and others.

Data on high-frequency seafood consumers are limited in NHANES to a few hundred individuals per survey cycle. To address this data gap, von Stackelberg et al. (2017) conducted a nationally representative survey of high-frequency fish consumers.[59] The inclusion criterion for this study was consumption of more than three fish meals per week, which corresponds to the 95th percentile consumer in the NHANES survey. These data provide more appropriate seafood consumption rates for a residual risk analysis and suggest that values used in the 2011 RIA underestimate methylmercury exposure and associated health risks, especially for lower incomes households and those with less than a high school education.

Table 1 | Consumption rates for high frequency fish consumers (>3 meals/week).

Description	**Mean (95% CI) (g/kg-day)**	**Mean (95% CI) (g/day)**
All participants	1.5 (1.4-1.6)	111 (106-116)
Recreational/self-caught anglers	1.7 (1.5-2.0)	130 (116-145)
Exclusively self-caught anglers	1.5 (1.2-1.9)	115 (392-138)
Less than high school education	2.1 (1.5-2.6)	149 (111-185)
Less than 20K household income	1.9 (1.6-2.2)	136 (112-156)

Data from von Stackelberg et al. (2017).

There is also evidence that disparities in methylmercury exposure exist in the U.S. population. For example, U.S. individuals who identified their ethnicity as "other" (i.e., Asian, Pacific and Caribbean Islander, Native American, Alaska Native, multi-racial and unknown race) consistently have blood mercury levels that are higher than other demographic groups between 2001-2018 based on NHANES/CDC data (Figure 8).

[59] von Stackelberg et al., *supra* note 34.

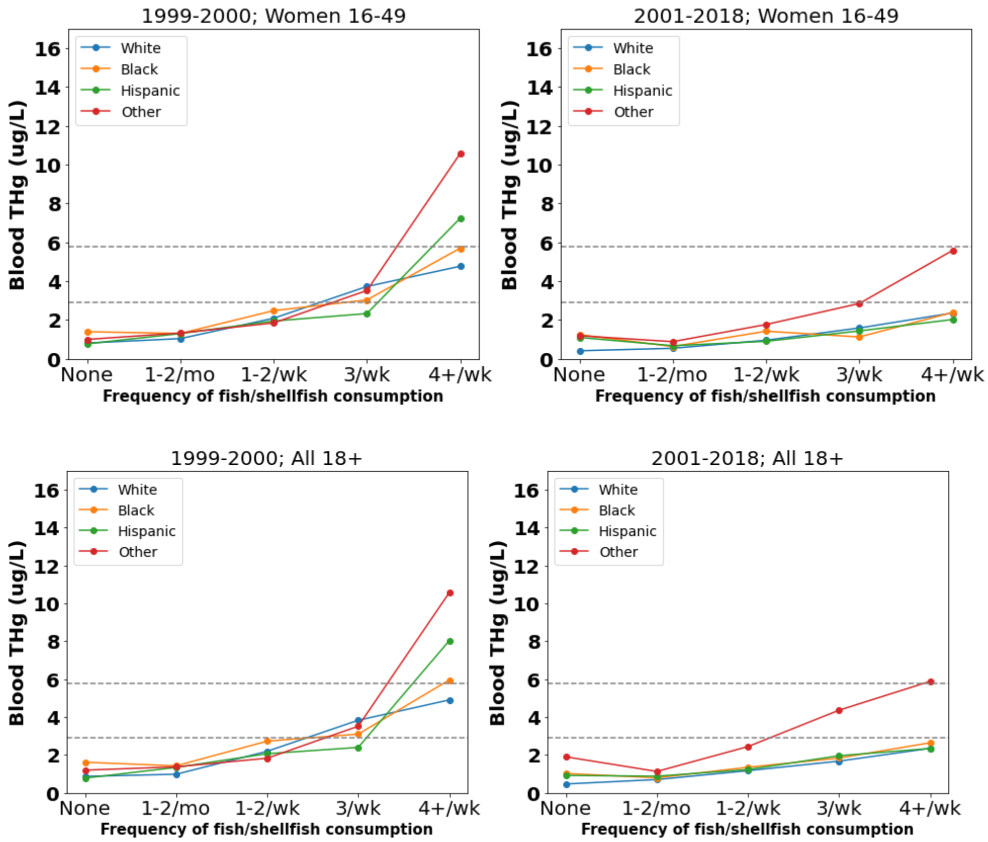

Figure 8 | Blood mercury concentrations in U.S. individuals identifying with different ethnic groups. Data are from CDC/NHANES blood Hg measurements.

We therefore recommend that EPA leverage the consumption data provided here to estimate exposures of vulnerable groups more accurately. A more comprehensive consideration of environmental justice of methylmercury exposure is warranted.

* * *

Thank you for your consideration of these comments. We welcome the opportunity to discuss this important matter with you at any time. Please direct follow up communications to Elsie Sunderland, 617-496-0858 (ems@seas.harvard.edu), Charles Driscoll, 315-443-3434 (ctdrisco@syr.edu), or Shaun Goho, 617-496-5692 (sgoho@law.harvard.edu).

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