1 Answers to the technical corrections and suggestions

Reviewer Comment

On line 18: Add reference for the threefold increase in environmental Hg and specify whether this data is a global average and the environmental medium that it comes from (ie. sediment and peat archives?)

Author Response

I will expand on this sentence and add the reference as below:

Suggested edit

Anthropogenic emissions have significantly raised environmental Hg levels, with 78%, 85%, and 50% of atmospheric, upper ocean, and deep ocean Hg, respectively, originating from anthropogenic emissions (Geyman et al., 2025).

Reviewer Comment

Line 30: Volume concentration factor (6.4E6) – specify units if applicable.

Suggested edit

The bioconcentration process can result in high concentrations in aquatic organisms. This process is commonly quantified using the Volume Concentration Factor (VCF), a unitless ratio between the Hg concentration in phytoplankton and that in the surrounding water:

$$\mathrm{VCF} = \frac{C_{\mathrm{phytoplankton}}}{C_{\mathrm{water}}} \tag{1}$$

where both $C_{\mathrm{phytoplankton}}$ and C_{water} have the same units, for example, ng Hg $\mu\mathrm{m}^{-3}$. For MeHg, very high volume concentration factors of up to 6.4×10^6 have been reported in the literature (Lee & Fisher, 2016; Schartup et al., 2018).

Reviewer Comment

Line 31: Sentence is overly casual – recommend removing or revising.

Author Response

I would make revise the sentence as below:

Suggested edit

MeHg concentrations that are elevated due to bioconcentration can be further increased by biomagnification along the aquatic food web.

Reviewer Comment

Line 34: Revise to: "Consumption of MeHg-contaminated seafood is the primary pathway of mercury exposure in humans, with elevated risk among coastal and seafood-reliant populations (Zhang et al. 2021)." This revised version better emphasizes exposure pathways while remaining sensitive to the context of seafood-dependent communities. If you

choose to expand on health effects, a brief mention of methylmercury's neurotoxicity could provide a natural transition to your discussion of Minamata Bay. If you do retain the sentences in lines 34 – 37, also consider briefly clarifying Minamata Bay's specific contamination source, to not create a false sense of fear that these pollution levels are common.
Reference: Zhang, et al. (2021) Global health effects of future atmospheric mercury emissions. Nat. Commun. https://doi.org/10.1038/s41467-021-23391-7

Suggested edit

Consumption of MeHg-contaminated seafood is the primary pathway of mercury exposure in humans, with elevated risk among coastal and seafood-reliant populations (Sheehan et al., 2014; Zhang et al., 2021). MeHg is a neurotoxin whose overconsumption can decrease IQ points (Trasande et al., 2006), and raise the risk of heart attacks (Genchi et al., 2017). The risk associated with consuming seafood contaminated with MeHg gained significant attention after over 1000 fatalities occurred in Japan in 1956 due to the consumption of contaminated seafood from Minamata Bay(Harada, 1995). Although this MeHg outbreak was a unique event linked to industrial waste disposal containing Hg, it highlighted the dangers of MeHg exposure. To mitigate the risk of acute MeHg contamination incidents, like those in Minamata, and to minimize long-term MeHg exposure, the Minamata Convention on Mercury was established (UNEP, 2013).

Reviewer Comment

Line 39: Rephrase to avoid starting with a number or acronym (e.g., "A total of 151 countries…").

Author Response

I will update that to:

Suggested edit

A total of 151 countries have pledged to reduce their Hg emissions in support of the Minamata Convention and 128 countries have signed and ratified the convention. The global state of Hg as a pollutant and the effect of the Minamata Convention is periodically reviewed in the Minamata Convention Effectiveness Evaluation (Outridge et al., 2018).

Reviewer Comment

Line 95: Add references for the coupled models (ie. GOTM, ECOSMO E2E and Mercy v2.0). Alternatively, the subheadings 2.3, 2.4, and 2.5 could be changed to 2.2.1, 2.2.2, and 2.2.3 respectively as they all fall under the "2.2 The models" subheading.

Author Response

I will update the subheadings to a lower level as you suggest untill model development, so the structure is:
2.2 The models
2.2.1 The hydrodynamical model
2.2.2 The MERCY v2.0 model
2.2.3 ECOSMO E2E

2.3 Model Development
Additionally I will add the references in addition to their respective paragraph the the introductary sentence on line 95 as fellows:

Suggested edit

We used a fully coupled 1D water column model that is run in 2 setups that resemble typical hydrological regimes found in coastal oceans. We coupled the Generalized Ocean Turbulence Model (GOTM) (Burchard et al., 1999) with the ECOSMO E2E ecosystem model (Daewel et al., 2019) and the Mercy v2.0 Hg speciation and bioaccumulation model (Bieser et al., 2023).

Reviewer Comment

Figure 1: Uses URL links within the figure caption which is generally not recommended. One possibility for rewording the caption is: "Several sub-images were used to create this figure. Image sources (used under Creative Commons licenses or in the public domain) are as follows: Filter feeder: Sabella spallanzanii (image by Wikipedia contributors, CC BY-SA 3.0, via Wikipedia)."

Author Response

The images do not all have the same license, sometimes it is CC BY-SA 4.0, CC BY-SA 2.0 or public domain. I would reword it as below to remove the URLS but do specify the license, owner and source for all images.

Suggested edit

Filter feeder: *Sabella spallanzanii* (photo by Diego Delso, CC BY-SA 4.0, via Wikipedia), Suspension feeder: *Aplysina fistularis* (photo by Twilight Zone Expedition Team 2007, NOAA-OE, CC BY 2.0, via Flickr), Generalist feeder: *Crangon crangon* (photo by Etrusko25, Public Domain, via Wikipedia), Deposit feeder: *Buccinum undatum* (photo by Oscar Bos / Ecomare, CC BY 4.0, via Wikipedia), Benthic predator: *Hommarus gammarus* (photo by Bart Braun, Public Domain, via Wikipedia), Top predator: *Sepia officinalis* (photo by Nick Hobgood, CC BY-SA 3.0, via Wikipedia).

Reviewer Comment

Line 148: Provide justification or reference for the bprotected value used.

Suggested edit

The macrobenthos in the North Sea are estimated to have beween 1.1 and 35.5 gC m^{-2} (Daan & Mulder, 2001; Heip et al., 1992). The value for $B_{Protected}$ is chosen as 1 gC m^{-2} for all macrobenthos except for the benthic predator where $B_{Protected}$ is 0.5 gC m^{-2}. These values are chosen to protect macrobenthos functional groups from extinction due to predation when there values are below the expected range.

Reviewer Comment

Line 155: Maintain consistent MeHg/iHg order throughout the sentence for clarity.

Suggested edit

An assimilation efficiency of 0.31 for iHg and 0.95 for MeHg is chosen for everything except deposit feeding, which has a lower feeding efficiency of 0.07 for iHg and 0.12 for MeHg based on Dutton and Fisher (2012).

Reviewer Comment

Line 176: Unsure of what units d-1 refers to.

Author Response

I add d^{-1} (per day) the first time this abbreviation is uased. I also rewrote the sentence so that it does not start with a number.

Suggested edit

When organic carbon (detritus, labile DOM, and semi-labile DOM) is produced, 5% is allocated to semi-labile DOM. Additionally, detritus breaks down into semi-labile DOM at a rate of 0.001 d^{-1} (per day).

Reviewer Comment

Line 210: Include a reference for B10 value interpretation and the Jeffreys–Zellner–Siow prior assumption.

Author Response

I will this as below and add a refrence for the Monte Carlo analyses and add the reference for the Jeffrew Zellner Prior

Suggested edit

We first calculated the normalized bias as $(modeled - observed)/modeled$ for the average modeled and observed values. After this, we quantified the probability that the modeled mean is of the same distribution as the observations by performing a Bayes factor analysis. The Bayes factor value is estimated by first estimating the likelihood of the modeled mean under the H0 hypothesis, which assumes that the modeled and observed data share the same distribution, and the H1 hypothesis, which assumes that they do not share a distribution. The likelihood of the H1 hypothesis over the H0 hypotheses is the BF10 value. The BF10 factor is estimated using a Jeffreys–Zellner–Siow prior assumption so we assume no prior knowledge (Zellner & Siow, 1980).

Reviewer Comment

Line 216: Rephrase for clarity. For example: "A BF10 factor below 1 supports the H1 hypothesis, while BF10 values < 0.1 and < 0.01 are considered strong and very strong evidence, respectively, in favor of the H0 hypothesis."

Author Response

I will this as below, and include a reference:

Suggested edit

A BF10 factor below 1 indicates that the modeled distribution is more likely the same as the observed distribution, and a BF10 <0.1 can be considered strong evidence and a BF10 <0.01 as very strong evidence in favor of the H0 hypotheses (Doll & Jacquemin, 2019).

Reviewer Comment

Figure 2 caption: Final sentence seems to have been cut down short. Recommend: “This contrasts the iHg concentration (<100 ng g-1 d.w.) for all animals, except starfish, eel, and sponges.” The caption should also clarify that the data shown came from a literature review. If each point comes from a separate study, consider citing sources directly in the figure legend.

Author Response

I will move this figure to the supplement information. And update the legend. As it has all the data from the dataset I will clearly specify that.

Suggested edit

The effect of different feeding strategies on the measured MeHg and iHg in several benthic functional groups and groups of animals feeding on the benthos. The figure is the combination of all literature data presented in Table 5. The seabird is the common eider which feeds on benthos. Bioaccumulated MeHg is below 50 ng g^{-1} d.w. for all functional groups that are not predatorial (predators, benthic fish, and seabirds), but can reach up to 171, 565, and 895 ng g^{-1} d.w. for predators, seabirds, and benthic fish respectively. This contrasts the iHg concentration below 100 ng g^{-1} d.w. for every animal. Except for starfish, Eel, and sponges. The tHg shows that the Hg can even be higher in suspension feeders (in this case sponges) than in fish.

Reviewer Comment

Line 256: Typo. Should read: “. . . followed by deposit feeders with up to 5 g C m-2.”

Author Response

I will correct that as follows:

Suggested edit

Filter feeders have the highest biomass, which is up to 10 g C m^{-2} followed by deposit feeders with up to 5 g C m^{-2}, generalist feeders with up to 3 g C m^{-2}, and suspension feeders with up to 1 g C m^{-2}.

Reviewer Comment

Figure 7: Recommend removing plot titles and reformatting to look more like Figure 3. The Hg species should be identified in the y-axis label, and the order of the Hg species should match Figure 3 (MeHg, iHg, tHg). Will also need to be repeated for figure 8.

Author Response

I will redo the plots with the updated layout script as shown in Fig. 1. I will also combine Fig. 7 and Fig. 8 so that the differences between the base model and allometric scaling model are easier to evaluate.

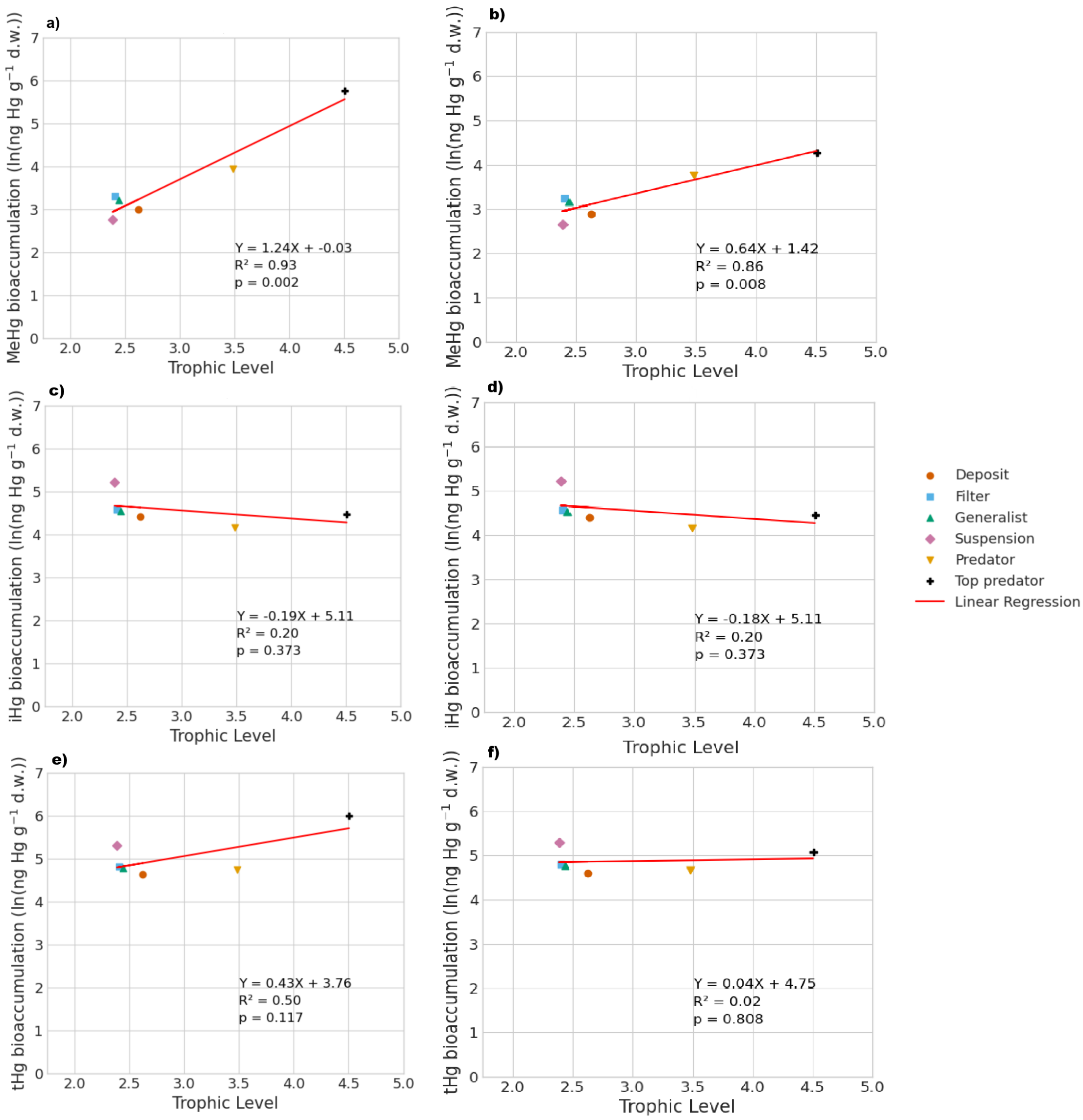

Figure 1: The inluence of trophic level on the bioaccumulation of MeHg, iHg, and tHg in both the AS (panels a, c, e) and the base model (panels b, d, f). In the AS model, the relationship with trophic level is stronger, where ln(MeHg)=1.24TL-0.03, compared to the base model, which is ln(MeHg)=0.64TL+1.42. TL represents trophic level, and MeHg is expressed in ng Hg g^{-1} d.w. For iHg, the bioaccumulation patterns are nearly identical, with ln(MeHg)=-0.19TL+5.11 for the AS model and ln(MeHg)=-0.18TL+5.11 for the base model, both showing a weak inverse correlation with trophic level, largely due to higher iHg levels in low trophic level feeders. In terms of tHg, there is a higher increase in bioaccumulation in the AS model (ln(MeHg)=0.43TL+3.76) compared to the base model (ln(MeHg)=0.04TL+4.175), driven by the stronger association between MeHg and trophic level in the AS model.

Reviewer Comment

Table 2 and 3 captions: Define AS as allometric scaling in the caption only

Author Response

Updated caption Table 2

Suggested edit

Comparison of modeled and observed Hg and MeHg bioaccumulation in different feeding strategies for the Southern North Sea (SNS), Northern North Sea (NNS), and field observations. Values are presented as ranges with means in parentheses. Units are ng Hg g d.w. for iHg and MeHg, and% for MeHg percentage. The bottom two rows are the predator and top predator frm the allometric scaling model (AS).

Author Response

Updated caption Table 3

Suggested edit

Statistical analysis of model performance for iHg and MeHg levels by feeding strategy for Southern North Sea (SNS) and Northern North Sea (NNS). The predator and top predator of both the default setup and Allometric Scaling (AS) model is shown.

References

Bieser, J., Amptmeijer, D., Daewel, U., Kuss, J., Soerenson, A. L., & Schrum, C. (2023). The 3D biogeochemical marine mercury cycling model MERCY v2.0; linking atmospheric Hg to methyl mercury in fish. *Geoscientific Model Development Discussions*, 1–59.

Burchard, H., Bolding, K., & Villarreal, M. R. (1999). *GOTM, a General Ocean Turbulence Model. Theory, implementation and test cases* (tech. rep.).

Daan, R., & Mulder, M. (2001). The macrobenthic fauna in the Dutch sector of the North Sea in 2003 and a comparison with previous data. *NIOZ-RAPPORT*, *2001-2*, 97.

Daewel, U., Schrum, C., & MacDonald, J. I. (2019). Towards end-to-end (E2E) modelling in a consistent NPZD-F modelling framework (ECOSMO E2E-v1.0): Application to the North Sea and Baltic Sea. *Geoscientific Model Development*, *12*(5), 1765–1789.

Doll, J. C., & Jacquemin, S. J. (2019). Bayesian Model Selection in Fisheries Management and Ecology. *Journal of Fish and Wildlife Management*, *10*(2), 691–707.

Dutton, J., & Fisher, N. S. (2012). Bioavailability of sediment-bound and algal metalsto killifish Fundulus heteroclitus. *Aquatic biology*, *16*, 85–96.

Genchi, G., Sinicropi, M. S., Carocci, A., Lauria, G., & Catalano, A. (2017). Mercury Exposure and Heart Diseases. *International Journal of Environmental Research and Public Health*, *14*(1), 74.

Geyman, B. M., Streets, D. G., Olson, C. I., Thackray, C. P., Olson, C. L., Schaefer, K., Krabbenhoft, D. P., & Sunderland, E. M. (2025). Cumulative Anthropogenic Impacts of Past and Future Emissions and Releases on the Global Mercury Cycle. *Environmental Science and Technology*, *59*(17), 8578–8590.

Harada, M. (1995). Minamata Disease: Methylmercury Poisoning in Japan Caused by Environmental Pollution. *Critical Reviews in Toxicology*, *25*(1), 1–24.

Heip, C., Basford, D., Craeymeersch, J. A., Dewarumez, J.-m., Dorjes, J., de Wilde, P., Duineveld, G., Eleftheriou, A., J Herman, P. M., Niermann, U., Kingston, P., Kiinitzer, A., Rachor, E., Rumohr, H., Soetaert, K., Soltwedel Heip, T., Wilde, d., Heip A Craeymeersch, C. J., Soetaert, a., … Kiinitzer, S. A. (1992). Trends in biomass, density and diversity of North Sea macrofauna. *ICESJ. mar. Sci*, *49*, 13–22.

Lee, C. S., & Fisher, N. S. (2016). Methylmercury uptake by diverse marine phytoplankton. *Limnology and Oceanography*, *61*(5), 1626–1639.

Outridge, P. M., Mason, R. P., Wang, F., Guerrero, S., & Heimbürger-Boavida, L. E. (2018, October). Updated Global and Oceanic Mercury Budgets for the United Nations Global Mercury Assessment 2018.

Schartup, A. T., Qureshi, A., Dassuncao, C., Thackray, C. P., Harding, G., Sunderland, E. M., Harvard, †., & Paulson, J. A. (2018). A Model for Methylmercury Uptake and Trophic Transfer by Marine Plankton. *Environ. Sci. Technol*, *52*, 18.

Sheehan, M. C., Burke, T. A., Navas-Acien, A., Breysse, P. N., Mcgready, J., & Fox, M. A. (2014). Systematic reviews Global methylmercury exposure from seafood consumption and risk of developmental neurotoxicity: a systematic review. *Bull World Health Organ*, *92*, 254–269.

Trasande, L., Schechter, C., Haynes, K. A., Landrigan, P. J., & Acad Sci, A. N. (2006). Applying Cost Analyses to Drive Policy That Protects Children Mercury as a Case Study.

UNEP. (2013). Global Mercury Assessment 2013: Sources, Emissions, Releases and Environmental Transport. *UNEP Chemicals Branch, Geneva, Switzerland.*

Zellner, A., & Siow, A. (1980). Posterior Odds Ratios for Selected Regression Hypotheses.

Zhang, Y., Song, Z., Huang, S., Zhang, P., Peng, Y., Wu, P., Gu, J., Dutkiewicz, S., Zhang, H., Wu, S., Wang, F., Chen, L., Wang, S., & Li, P. (2021). Global health effects of future atmospheric mercury emissions. *Nature Communications 2021 12:1*, *12*(1), 1–10.