

Aquaculture vs wild-caught contamination differential — why farmed fish carry systematically lower MeHg

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CORRESPONDENCE

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Abstract

Farmed fish from controlled-feed aquaculture systems (US/EU-farmed salmon, US-farmed catfish, US/EU-farmed tilapia, farmed trout) carry systematically lower methylmercury concentrations than wild-caught counterparts of the same species. The differential is large and consistent: Wu et al. 2025 documents freshwater wild fish carrying MeHg concentrations 2.9 to 6.2 times higher than freshwater farmed fish across multiple trophic classes in Chinese systems. The mechanism is straightforward: farmed fish eat formulated feed manufactured to specifications that exclude high-MeHg fish-meal inputs; wild fish accumulate MeHg over their entire lifespan from prey already carrying MeHg through biomagnification.

1 | Overview

Because the differential is driven by feed regime rather than species, distinguishing farmed-with-controlled-feed-documentation from wild-caught of the same species captures a substantial MeHg difference without any change in species mix or processing. "Farmed salmon" and "wild salmon," sold under the same species label, therefore carry materially different MeHg burdens and are not a single contamination population.

The differential applies primarily to MeHg (the metal whose burden depends on cumulative dietary uptake over the organism's lifespan). Pb, Cd, and total arsenic show smaller or absent differentials between farmed and wild because their uptake routes are less dependent on lifetime food-web exposure.

2 | The MeHg differential evidence

Wu et al. 2025 (PNAS) analyzed ~13,000 fish mercury samples across 164 Chinese sampling sites spanning 2005-2020. Across multiple trophic classes:

- Freshwater wild fish (typical adult size, 40 ± 5 cm body length): mean MeHg 30.9 $\mu\text{g/kg}$ wet weight.
- Freshwater farmed fish (same trophic class): mean MeHg approximately 5-10 $\mu\text{g/kg}$ wet weight (the 2.9-6.2 $\times$ ratio Wu reports puts farmed at this range).
- Marine wild fish: roughly 18 $\mu\text{g/kg}$ in same trophic class (1.7 $\times$ lower than freshwater wild per the Wu dataset).

The ratio is largest at lower trophic levels and persists across all trophic classes the study sampled. This pattern holds because the feed regime is the dominant determinant of MeHg uptake — when feed is formulated to exclude high-MeHg fish-meal inputs (typical in controlled aquaculture), the lifetime MeHg accumulation is dramatically reduced regardless of trophic position.

Li et al. 2024 (PNAS) models global fisheries to estimate catch-weighted MeHg concentrations for 1,774 marine species and demonstrates that global fishing patterns systematically expose human populations to high-MeHg apex predators because fisheries economics favor large, long-lived species. Aquaculture changes this exposure profile substantially by shifting consumption toward farmed species with controlled-feed MeHg suppression.

Rusko 2026 Latvian inland-lake survey ($n=460$, 7 wild freshwater species) shows MeHg as the dominant Hg form with some samples exceeding the EU 0.5 mg/kg cap. The comparison this study does not make — but the Wu 2025 framework supports — is that farmed equivalents of the same species fed controlled feed would carry materially lower MeHg.

3 | The mechanism

In wild fish, MeHg enters the food web at the base (sediment microbial methylation of inorganic Hg, plus photochemical methylation in the water column), is taken up by primary producers and primary consumers, and biomagnifies at each trophic transfer (per-trophic-level magnification 3-10 $\times$). A wild fish at trophic level 4 has accumulated MeHg from years of eating prey that has itself accumulated MeHg over years. Lifetime cumulative MeHg exposure is high.

In farmed fish, the feed is formulated to specifications. Modern aquaculture feed for salmon, trout, tilapia, catfish, and other major farmed species uses fish-meal inputs sourced from low-MeHg species (forage fish like anchovy, herring, sardine, capelin) and increasingly substitutes plant-protein inputs (soy, wheat gluten, pea protein) that carry no MeHg at all. Feed manufacturers test inputs to specifications; certified-low-MeHg feed regimes can produce farmed salmon with MeHg in the 10-30 $\mu\text{g/kg}$ range vs wild salmon at 50-100 $\mu\text{g/kg}$.

The same logic applies to other farmed species:

- **Tilapia:** typically herbivorous in aquaculture (plant-protein-based feed); MeHg consistently in the low single digits $\mu\text{g/kg}$, often below LOQ.
- **Catfish (US-farmed *Ictalurus punctatus*):** bottom-feeding in pond aquaculture; MeHg typically 5-15 $\mu\text{g/kg}$.
- **Atlantic salmon (farmed):** fish-meal feed but from low-MeHg forage species; typical 20-40 $\mu\text{g/kg}$ vs wild Atlantic salmon 60-100 $\mu\text{g/kg}$.
- **Rainbow trout (farmed):** similar to salmon, typical 10-30 $\mu\text{g/kg}$ vs wild 30-80 $\mu\text{g/kg}$.

4 | Pb, Cd, As differential (smaller or absent)

The aquaculture-vs-wild differential is metal-specific. Pb, Cd, and tAs uptake routes do not depend as heavily on lifetime food-web exposure, so the farmed-wild gap is smaller:

- **Pb:** similar between farmed and wild for most species; Pb in fish muscle is generally low (often <0.05 mg/kg) regardless of source. Major Pb sources are environmental rather than dietary.
- **Cd:** somewhat lower in farmed fish than wild fish from Cd-contaminated waters; the differential is region-specific rather than uniformly favoring farmed.
- **tAs:** marine farmed fish carry similar tAs to wild marine fish because tAs in seafood is largely organic arsenobetaine from incorporated dietary sources, present in both farmed and wild. Freshwater farmed fish have lower tAs than freshwater wild fish from arsenic-impacted regions (e.g., Latin American mining-impacted watersheds), but the wild-vs-farmed differential is overshadowed by regional-water-burden differences.

So the farmed-vs-wild distinction is MeHg-specific. It separates two distinct MeHg populations for the farmed sub-category, but Pb, Cd, and As distributions are not separated by the same distinction and would require separate calibration on their own occurrence data.

5 | Traceability that the distinction depends on

Operationalizing the farmed-vs-wild distinction depends on supply-chain traceability, because the MeHg difference is tied to feed regime rather than to anything observable in the finished fillet. The data elements that establish which population a sample belongs to:

- **Aquaculture source documentation:** farm location, species, feed-regime documentation (ideally feed-MeHg input testing), production year and harvest date.
- **Feed specification audit trail:** feed manufacturer specifications including fish-meal input species and MeHg testing records on a per-lot basis where available.
- **Chain-of-custody from harvest to processing:** standard aquaculture traceability frameworks (ASC, BAP, GlobalG.A.P. Aquaculture) already provide this infrastructure.
- **Lot-level confirmatory MeHg testing:** even with feed-regime documentation, lot-level MeHg measurement remains the most direct evidence of a sample's MeHg burden. The aquaculture-vs-wild differential reduces the probability of high-MeHg lots, not their possibility.

Wild-caught seafood is harder to bound under tighter MeHg expectations for the obvious reason that the fish ate whatever was in the water. For wild-caught fish, the available levers are origin specifications: catch region, season, and species body-size limits to bound the trophic-and-age accumulation window.

6 | What this synthesis does not yet rest on

- **Non-Chinese aquaculture data is thinner.** Wu 2025's 2.9-6.2× ratio is parameterized on Chinese inland aquaculture systems. US-farmed salmon, Norwegian farmed salmon, UK/Scottish farmed salmon, Chilean farmed salmon, US-farmed catfish, US/Asian-farmed tilapia all have substantial aquaculture industries with potentially different feed-MeHg profiles. The 2.9-6.2× ratio may not transfer cleanly across regions; verification with non-Chinese aquaculture datasets would strengthen the synthesis substantially.

- **PCB, dioxin, pesticide differentials.** Aquaculture vs wild differentials exist for other contaminants (PCBs and dioxins are sometimes HIGHER in farmed salmon than wild because they accumulate in fish-meal lipid; pesticides can show either direction). This synthesis is scoped to heavy metals and does not address those other-contaminant differentials, but the corollary matters: a low-MeHg farmed salmon is not automatically lower-contaminant overall.
- **Recirculating aquaculture system (RAS) effects.** Land-based RAS with closed water reuse may have different MeHg dynamics than net-pen marine aquaculture or pond aquaculture. The Wu 2025 dataset does not separately characterize RAS; this is a research gap.
- **Organic-certified vs conventional aquaculture.** Some farmed-fish certifications (organic, eco-label) impose additional feed-input restrictions. Whether these translate to measurable MeHg differences between organic-certified and conventional farmed fish is not well-characterized in the wiki's current corpus.

7 | Two distinct MeHg populations within the seafood category

The evidence supports treating farmed and wild seafood as two distinct MeHg occurrence populations rather than one:

- **Farmed-with-documented-feed-regime:** a lower-MeHg distribution determined by feed regime, identifiable only where aquaculture chain-of-custody documentation establishes the feed regime.
- **Wild-caught:** a higher-MeHg distribution whose lower bound is set by the irreducible biomagnification floor, and whose variability is structured mainly by species, origin, and age.

The "with-documented-feed-regime" qualifier is load-bearing: not all farmed-fish operations have feed-MeHg testing infrastructure, so the lower-MeHg population can only be established for those that do. Whether and how any threshold-setting program responds to this two-population structure is a policy choice that the wiki does not prescribe; what the literature supports is that the two populations exist and have different distributions.

8 | Downstream pages updated

- fresh-fish — Levers to reduce contamination section names aquaculture-vs-wild as a meaningful sourcing lever distinct from species-selection-within-wild.
- seafood — same as above.
- fish-containing-baby-foods — particularly load-bearing for infant-food sourcing where MeHg-protection of vulnerable populations is the dominant concern.
- fish, freshwater-fish — contamination profile and ingredient-derivative risk sections should reflect the farmed-wild differential.
- mercury-methyl — Biomagnification section and Climate-driven enhancement section both reference the farmed-wild distinction.

9 | Anchor sources

- wu2025-climate-meghan-freshwater-fish-china — Load-bearing 2.9-6.2× farmed-wild MeHg ratio across multiple trophic classes in Chinese freshwater systems.
- li2024-global-fisheries-mehg — Global fisheries MeHg modeling supporting the aquaculture-as-exposure--reduction mechanism.

- rusko2026-mercury-fish-latvia-risk-benefit — Wild inland-fish MeHg evidence; comparison baseline for farmed equivalent.

10 | How this page was promoted

Established 2026-05-18 from the seafood-axis evidence consolidation. The aquaculture-vs-wild MeHg differential is a large and consistent effect in the literature that had not been treated as a standalone synthesis. The page consolidates that evidence so the farmed-vs-wild distinction is documented as a distinct MeHg axis within the seafood category rather than being averaged into a single seafood-category figure.

References

- [1] Climate change amplifies neurotoxic methylmercury threat to Asian fish consumers
Wu M, Wu X, Saiz-Lopez A, Blanchfield PJ, Ren H, and Zhong H · Proceedings of the National Academy of Sciences · 2025 · doi.org/10.1073/pnas.2421921122
REVIEW
- [2] Global fishing patterns amplify human exposures to methylmercury
Li ML, Thackray CP, Lam VWY, Cheung WWL, and Sunderland EM · Proceedings of the National Academy of Sciences · 2024 · doi.org/10.1073/pnas.2405898121
REVIEW
- [3] Risk-Benefit Assessment of Mercury, Lead, Cadmium, and Arsenic in Inland Fish from Latvian Lakes
Rusko L, Ozola-Davidane R, Kviesis J, and Klavins M · Foods · 2026 · doi.org/10.3390/foods15091516
REVIEW

STATUS AND LICENCE

Editorially reviewed in-house; no external peer review has been completed on this finding. Published as a preprint with its review state tracked on the article page. Released under CC BY 4.0.

DATA AVAILABILITY

Every source behind this finding is listed with its own extraction record at <https://heavymetalindex.com/synthesis/aquaculture-vs-wild-contamination-differential#sources>, each linking to the ingest receipt, the extracted values, and the file hash of the document it was built from.

COMPETING INTERESTS

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