HEAVY METAL CERTIFIED · RESEARCH ANALYSIS

Why Mussels and Oysters Need a Different Cadmium Limit Than Fish

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Abstract

Cadmium concentrations in bivalve molluscs — mussels, clams, oysters, scallops — run one to two orders of magnitude higher than cadmium in fish muscle taken from the same waters. The cause is not contamination but biology: bivalves filter hundreds of litres of seawater a day and concentrate dissolved and particle-bound cadmium into soft tissue that has no route to excrete it. Because the bivalve and finfish distributions are separated by a factor of ten to a hundred, a single cadmium threshold applied across all seafood is not scientifically supportable — it would either exclude nearly every clean bivalve or wave through finfish that should be flagged. The honest instrument is a per-subcategory ceiling built on the bivalve-specific evidence, which is exactly how EU law and the Heavy Metal Certified shellfish standard are structured. The full anchor-source evidence base lives on the Heavy Metal Index, the independent literature reference this analysis cites one way.

An order-of-magnitude gap, not measurement noise

Across the seafood literature, the pattern is consistent enough to be treated as a biological constant. Fish muscle, wild or farmed, typically carries cadmium in the range of 0.005 to 0.05 mg/kg wet weight [5]. Bivalves — mussels, clams, oysters — typically run 0.1 to 1.0 mg/kg, with regional outliers approaching 1.0 mg/kg in specific sub-locations [2][3]. That is a ten-to-hundredfold separation, and it holds across geographies and seasons rather than varying with any single polluted site.

EU law already encodes the gap. Regulation (EU) 2023/915 sets a 1.0 mg/kg wet-weight cadmium maximum for bivalve molluscs and for cephalopods without viscera, against a 0.05 mg/kg default for most fish muscle [6] — a twenty-fold higher permitted ceiling that reflects the biological reality that bivalves accumulate cadmium at qualitatively different rates than fish do. The regulator did not relax its guard for shellfish; it recognised a different organism.

Why filter feeding concentrates cadmium

Bivalves feed by pumping seawater across their gills and trapping suspended particles and dissolved organic matter. An adult mussel can process 50 to 100 litres a day; an oyster substantially more. Both the dissolved cadmium ion and cadmium adsorbed to phytoplankton and detritus are extracted at the gill and moved into the digestive gland, gill and mantle tissue.

The decisive detail is what happens next. Cadmium uptake in bivalves is not physiologically regulated: metallothionein proteins bind the metal and sequester it in soft tissue with no active route of excretion. A bivalve therefore accumulates cadmium across its entire lifespan, and body burden climbs with size and age — older, larger animals carry more. Sediment-burrowing clams add a second pathway, taking up cadmium from sediment porewater as well as the water column, which suspended rope-grown mussels largely avoid [1]. None of this depends on a pollution source; it is the ordinary consequence of being a long-lived filter feeder in seawater that always carries trace cadmium.

Cephalopods, viscera, and the species tail

Cephalopods — squid, octopus, cuttlefish — are not filter feeders, but they concentrate dietary cadmium through prey and a high metabolic rate, with the digestive gland as the primary sink. Muscle (mantle) without viscera typically runs 0.1 to 0.5 mg/kg, while the digestive gland alone can exceed 5 mg/kg — which is precisely why the EU cap is written for cephalopods without viscera [6].

Within bivalves, the distribution has a tail. Scallops and certain oysters can approach or exceed the 1.0 mg/kg ceiling routinely, so characterising them reliably requires species-level evidence rather than a pooled shellfish average that hides the high-cadmium species inside a reassuring mean [4]. A certification benchmark that means to protect a buyer has to be built on the reference distribution for the species actually on the plate.

Lead runs the other way

The filter-feeding story does not generalise to every metal, and saying so is part of reading the evidence honestly. Lead in bivalves and cephalopods is generally lower than in fish and often sits below the EU 0.50 mg/kg cap for the category. Lead adsorbs less efficiently to phytoplankton than cadmium does and is excreted more readily through bivalve digestion, so it does not biomagnify through the filter-feeding pathway the way cadmium does [3]. The lesson is metal-specific: the analyte that drives the shellfish question is cadmium, and a standard should say so rather than treating heavy metals as one undifferentiated hazard.

What this means for certification

The consequence for a certification standard follows directly. A single cadmium ceiling stretched across all seafood cannot be right: set near the finfish distribution, it would exclude nearly every bivalve regardless of how clean the source water is; set near the bivalve distribution, it would sit far above the finfish distribution and discriminate poorly among fish. The only defensible instrument is a per-subcategory ceiling, with bivalves benchmarked against bivalve-specific evidence.

That is how the Heavy Metal Certified standards are structured. The default limit for any product and analyte is the strictest maximum level set by a credible government regulator, converted to the product's own basis — for shellfish cadmium that anchor is the EU bivalve cap, not the finfish default. Because cadmium is one of the four Tier-1 toxics the program treats most strictly, the shellfish ceiling is set to the stricter of that government maximum and the cleaner end of the bivalve-specific occurrence evidence. Cephalopods, finfish and predatory species each carry their own subcategory standard for the same reason. The finding is not that shellfish are dangerous; it is that they are a different distribution, and the number that certifies them has to come from that distribution.

Frequently asked questions

Do mussels and oysters really contain more cadmium than fish?

Yes. Bivalve molluscs typically carry cadmium at ten to a hundred times the level found in fish muscle from the same waters — roughly 0.1 to 1.0 mg/kg wet weight in bivalves versus 0.005 to 0.05 mg/kg in most fish. The difference is consistent across regions and seasons and reflects biology, not a specific polluted location.

Why do shellfish accumulate so much cadmium?

Bivalves are filter feeders that process 50 to 100 or more litres of seawater a day, concentrating dissolved and particle-bound cadmium into soft tissue. They cannot excrete it — metallothionein proteins bind and store it for life — so cadmium builds up with the animal's size and age. Sediment-dwelling clams take up additional cadmium from sediment porewater.

Why does EU law allow twenty times more cadmium in shellfish than in fish?

The EU sets a 1.0 mg/kg cadmium maximum for bivalves and for cephalopods without viscera against a 0.05 mg/kg default for fish muscle. The higher shellfish ceiling is not a relaxation of concern; it acknowledges that filter feeders accumulate cadmium at a fundamentally higher rate, so the same number applied to both categories would be meaningless.

Can a single cadmium limit cover all seafood?

No. Because bivalve and finfish cadmium distributions are separated by a factor of ten to a hundred, one threshold would either exclude nearly every clean bivalve or wave through finfish that should be flagged. Defensible certification uses a separate cadmium ceiling per seafood subcategory, with shellfish benchmarked against bivalve-specific evidence.

References

[1] Single-particle ICP-MS characterisation of cadmium nanoparticle forms in mussels. Bao et al., 2024. Distinguishes nanoparticle-bound from dissolved cadmium in mussel tissue; a load-bearing distinction because bioavailability differs by form.

[2] Trace metals in mussels and clams of Faro Lake, Sicily. Bruno et al., 2024. Lagoon mussel and clam cadmium values approaching the EU bivalve cap in specific sub-locations.

[3] Heavy metals in Mediterranean mussels and consumer health risk. Dogruyol et al., 2024. Mediterranean mussel survey reporting cadmium at consumer-relevant concentrations for weekly-intake risk modelling.

[4] Cadmium and mercury transfer in an Arctic marine food web. Rohonczy et al., 2024. Species-level accumulation showing why pooled shellfish means hide the high-cadmium tail.

[5] Mercury and trace metals in Portuguese coastal seafood. Cardoso et al., 2023. Coastal finfish cadmium typically below the EU 0.05 mg/kg fin-fish maximum, fixing the finfish reference distribution.

[6] Maximum levels for cadmium in bivalve molluscs and cephalopods. European Union. Commission Regulation (EU) 2023/915. 1.0 mg/kg for bivalves and cephalopods without viscera; 0.05 mg/kg default for fish muscle.

[7] Heavy Metal Index — bivalve cadmium amplification (synthesis with full anchor-source records). The independent literature synthesis this analysis reframes, with every anchor source and its per-record page. · heavymetalindex.com

Cite this analysis