

Global trade and inventory challenges of wild-dependent freshwater, brackish, and marine fish species: implications for “uncultivable or hard-to-cultivate” market taxa

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Abstract. Global trade in aquatic organisms relies on a complex interplay between aquaculture production and wild capture, yet a substantial proportion of commercially important fish species remains dependent on natural ecosystems. This review synthesizes current knowledge on freshwater, brackish, and marine fish species that are “uncultivable or hard to cultivate,” and whose market supply continues to rely partially or predominantly on wild capture. Drawing on literature from ornamental and food fish sectors, the study examines trade structure, domestication status, and the taxonomic composition of wild-dependent species across global markets. The ornamental fish trade, particularly in freshwater systems, is largely supported by aquaculture; however, a significant number of species - especially rare, endemic, or biologically specialized taxa - remain sourced from the wild. In contrast, marine ornamental fish trade continues to be overwhelmingly dependent on wild capture, reflecting persistent technological constraints in captive breeding. Inland food fisheries further illustrate the scale of wild dependency, with evidence of substantial underreporting and “hidden harvests” that exceed official statistics. Across systems, many fish species remain at early stages of domestication, requiring continued inputs from wild populations for broodstock, seed, or direct market supply. The review identifies key drivers limiting aquaculture expansion, including complex life histories, larval rearing challenges, economic barriers, and limited market incentives for domestication. It also highlights major gaps in species-level data, caused by inconsistent trade reporting, generic export categories, and fragmented monitoring systems, which complicate efforts to develop comprehensive inventories of wild-dependent taxa. Beyond production constraints, the continued reliance on wild capture has important ecological and socio-economic implications. These include pressures on vulnerable and endemic species, the role of trade in facilitating biological invasions, and the dependence of local communities on capture fisheries. At the same time, the trade can support conservation when linked to sustainable harvest practices and community-based management. Overall, this review underscores the need for improved traceability, standardized inventory frameworks, and targeted aquaculture innovation to reduce pressure on wild populations while maintaining the economic and social benefits of aquatic resource use.

Key Words: wild-caught fish, ornamental fish trade, freshwater fish, marine fish, brackish species, aquaculture limitations, domestication levels, capture fisheries, biodiversity trade, invasive species, data gaps, species inventory, conservation, aquarium trade, hidden harvest.

Introduction. Aquatic resources have consistently served humankind as a source of nourishment and as a medium of exchange since the earliest periods of human history (Balon 1995; Delgado-Ramírez et al 2023). More recently, they have become subjects of scientific inquiry aimed at advancing our understanding of nature (Petrescu-Mag 2005abc; Petrescu-Mag et al 2010; Szabó et al 2024; Gerlai et al 2025ab; Nowak & Păpuc 2026), as well as resources for enhancing human well-being—particularly mental health—and even as a form of educational recreation (Petrescu-Mag & Bud 2017; Collins et al 2020). Beyond these constructive and beneficial engagements, however, the

unchecked exploitation of aquatic resources by humans has taken an unfortunate and concerning turn (Yunanto et al 2018; Dao et al 2024; Leidonald et al 2025).

The present review aims to provide a comprehensive synthesis of the global trade in freshwater, brackish, and marine fish species that remain partially or entirely dependent on wild capture due to biological, technological, or economic constraints limiting their domestication in aquaculture. It examines the structure and dynamics of both ornamental and food fish markets, with particular emphasis on the relative contribution of wild capture versus captive production systems. The review identifies major taxonomic and ecological groups that can be considered “uncultivable or hard to cultivate,” highlighting patterns of continued reliance on natural populations across different geographic regions and trade segments. In addition, it evaluates the extent to which wild harvests remain underreported or poorly documented, especially in inland fisheries and ornamental trade chains characterized by low taxonomic resolution and inconsistent labeling practices. By addressing these data limitations, the study explores the challenges associated with compiling accurate species-level inventories of wild-dependent fish. Furthermore, it assesses the broader ecological and socio-economic implications of this reliance on wild capture, including risks related to overexploitation, biodiversity loss, invasive species introductions, and the dependence of local livelihoods on capture-based systems. Ultimately, the review seeks to contribute to the development of a conceptual and methodological framework for improving the identification, monitoring, and management of wild-dependent aquatic market species at a global scale.

Wild-Sourced Freshwater and Brackish Fishes for Trade Worldwide. Freshwater and brackish-water fish traded on global markets come from both aquaculture and wild capture, but their relative importance differs strongly among segments of the trade. For many high value or biologically complex species, commercial supply still depends primarily, and in some cases almost entirely, on capture from rivers, lakes, wetlands, estuaries and deltas (Figure 1). The abstracts available focus mainly on ornamental (aquarium) markets, with limited quantitative species level detail for food markets, so the inventory below is necessarily partial and centered on ornamental fishes.



Figure 1. Wild-sourced fishes for trade worldwide.

Structure and Main Dynamics of the Freshwater Ornamental Trade. The global ornamental fish trade involves about 125 countries and is valued at roughly US\$ 15–30 billion annually, with around 90% of traded ornamental fishes being freshwater species (Evers et al 2019; King 2019; Novák et al 2025; Andrews 1990). Approximately 90% of freshwater ornamentals in international trade are captive bred, whereas 90–95% of marine ornamentals remain wild caught (King 2019; Evers et al 2019; Pouil et al 2020; Moorhead & Zeng 2010; Petrescu-Mag & Burny 2026). Despite this predominance of aquaculture for freshwater ornamentals, a substantial number of species - especially recently discovered, range restricted or biologically demanding taxa - are still supplied by capture from natural inland waters (Evers et al 2019; Novák et al 2025; Raghavan et al 2013; Andrews 1990).

From a very broad pool of more than 5300 freshwater species available in the ornamental trade, only about 1000 are widely available, and roughly 30 species dominate global volumes (Evers et al 2019). These leading taxa belong primarily to Cyprinodontiformes (including killifishes and livebearers), Perciformes (including cichlids and labyrinth fishes), Characiformes (tetras and allies), and Siluriformes (catfishes) (Evers et al 2019; Novák et al 2025). A historical review of European imports near the turn of the millennium shows that armored loricariid catfishes (Loricariidae), cory catfishes (Callichthyidae: Callichthyinae), African Great Lakes cichlids (Cichliformes), egg laying killifishes (Cyprinodontiformes), and characids (Characiformes) together represented about 74% of all freshwater and brackish ornamental fish species in trade (Novák et al 2025) (Figure 2). Species capable of atmospheric air breathing (e.g. gouramis and bettas, family Belontiidae) have long been important in the market, although their relative share has declined in recent decades (Novák et al 2025; Evers et al 2019).

Even where aquaculture dominates, reliable separation of captive bred and wild caught contributions is hampered by poor species level labeling, generic export categories such as “live aquarium fish,” and inconsistent customs data (Evers et al 2019; Raghavan et al 2013; Millington et al 2022). This opacity complicates any precise inventory of species whose trade depends exclusively or almost exclusively on wild capture.

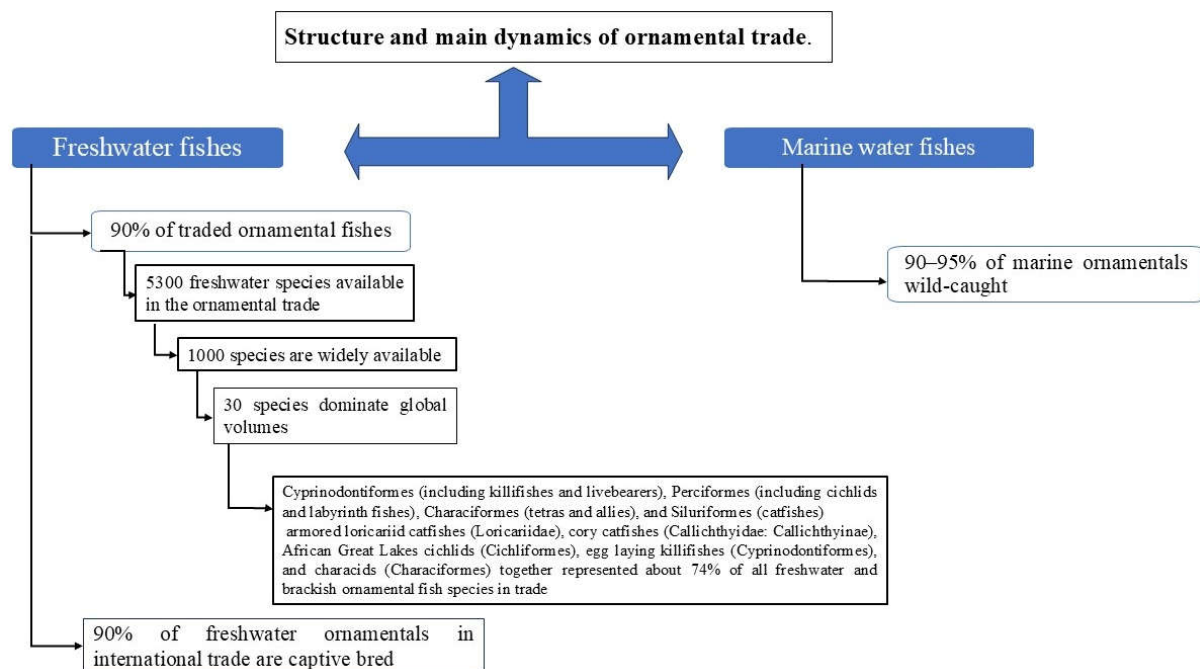


Figure 2. Structure and main dynamics of the freshwater ornamental trade.

Freshwater and Brackish Species Groups Heavily Reliant on Wild Capture. Within the ornamental segment, several freshwater and brackish water groups stand out as being dominated by wild capture because they are either not yet domesticated, only partly domesticated, or difficult and costly to reproduce in captivity at scale (Evers et al 2019; Novák et al 2025; Raghavan et al 2013; Andrews 1990). Available abstracts do not always state “uncultivable” explicitly, but collectively they indicate the following taxonomic foci for capture based supply from rivers, floodplains and lakes in tropical regions (Table 1).

Table 1

Main freshwater ornamental groups still strongly reliant on wild capture

<i>Taxonomic / ecological group</i>	<i>Typical habitat and trade context</i>	<i>Likely cultivation status for ornamental supply</i>	<i>References from literature</i>
Armored catfishes (Loricariidae: “plecos”)	Neotropical rivers; many localized endemics, strong demand for rare color/pattern morphs	Many species still predominantly wild-caught; captive breeding developed only for a subset of high-volume forms	(Novák et al 2025; Evers et al 2019; Raghavan et al 2013; Andrews 1990)
Cory catfishes (Callichthyidae: Callichthyinae)	South American rivers, streams and floodplains	Mix of farmed and wild-caught; numerous geographically restricted species collected from the wild	(Novák et al 2025; Evers et al 2019)
Characids (Characiformes; including tetras)	Amazon, Orinoco and other tropical basins; large-volume schooling species	Some major species (e.g. neon/cardinal-type tetras) have captive-breeding lines, but important export fisheries remain based on wild populations in blackwater rivers and tributaries	(Novák et al 2025; Evers et al 2019; Raghavan et al 2013)
African Great Lakes cichlids (Cichliformes)	Lakes Malawi, Tanganyika, Victoria and associated systems	Captive breeding is widespread in Europe and Asia, yet export fisheries for wild-caught ornamental cichlids persist, especially for novel morphs and new species	(Novák et al 2025; Evers et al 2019)
Egg-laying killifishes (Cyprinodontiformes)	Seasonal pools, savannas, small streams in South America, Africa, Mediterranean region	Many species remain primarily wild-collected owing to short lifespans, complex diapause egg biology and very small, specialized markets	(Novák et al 2025; Evers et al 2019)
Air-breathing labyrinth fishes (gouramis, bettas, Belontiidae)	Low-oxygen wetlands, rice fields, small streams in Asia	Major commercial strains are captive-bred; however, localized wild forms and newly discovered species are still collected from natural habitats	(Novák et al 2025; Evers et al 2019; Borges et al 2022)
Threatened and endemic Indian freshwater ornamentals	Western Ghats and Northeast India rivers; biodiversity hotspots	Trade in multiple endemic, threatened barbs, puffers and loaches (e.g. <i>Puntius denisonii</i> and <i>P. chalakkudiensis</i> complex, <i>Botia striata</i> , <i>Carinotetraodon travancoricus</i>) is based on wild capture in rivers and streams, with little evidence of commercial-scale aquaculture	(Raghavan et al 2013).

In India, export records for “live aquarium fish” conceal a substantial trade in at least 30 endemic species listed as threatened on the IUCN Red List (Raghavan et al 2013). Of approximately 1.5 million individuals of threatened Indian freshwater fishes exported during the study period, three species or species complexes accounted for the majority of volume: the endangered loach *Botia striata*, the vulnerable dwarf puffer *Carinotetraodon travancoricus*, and the endangered “Red Lined Torpedo Barbs,” a complex mainly comprising *Puntius denisonii* and *Puntius chalakkudiensis* (Raghavan et al 2013). For

these taxa, commercial supply at the time of study was effectively based on capture from rivers and streams, with documented overharvesting and poor enforcement of local collection regulations (Raghavan et al 2013).

Comparable patterns emerge in other regions, although with less species resolved information. Surveys of pet stores in Klang Valley, Malaysia, documented 251 alien freshwater ornamental fish species belonging to 18 orders and 53 families, with non native species comprising about 85.7% of the trade (Saba et al 2020). The study focused on invasion risk rather than culture status, yet the diversity and continuous arrival of novel taxa - many from tropical rivers - suggest an important ongoing role for wild capture of ornamental fishes that are either not yet bred in captivity or only rarely cultured (Saba et al 2020; Evers et al 2019; Millington et al 2022).

A review of the history of ornamental aquaculture in Europe highlights that the cumulative number of imported freshwater and brackish species now exceeds 7900, including many undescribed morphotypes (Novák et al 2025). The very rapid expansion of species lists, especially for loricariid catfishes, African rift lake cichlids and killifishes, has far outpaced the development of domesticated aquaculture protocols for the majority of these species (Novák et al 2025; Evers et al 2019). Consequently, although some high volume species are now fully supplied by aquaculture, many rarer or newly discovered forms enter trade solely through targeted collecting expeditions on rivers and floodplains in South America, Africa and Asia (Evers et al 2019; Novák et al 2025; Raghavan et al 2013).

Inland Capture Fisheries and “Hidden” Wild Harvests of Freshwater Fish. While most of the detailed species level information in the abstracts pertains to ornamentals, several studies emphasize that wild freshwater fish capture from continental waters remains extremely important for both food and income in low and middle income countries (Fluet-Chouinard et al 2018; Em et al 2025; Kang et al 2022). Many of these fisheries target species that are only partially domesticated, or not yet domesticated at all, so that markets for these fish—although often local or regional rather than global—depend almost entirely on wild stocks in rivers, lakes and wetlands (Fluet-Chouinard et al 2018; Em et al 2025; Teletchea & Fontaine 2014).

Household consumption data from 42 low and middle income countries indicate that official inland fisheries statistics substantially underestimate wild freshwater fish catches (Fluet-Chouinard et al 2018). After accounting for trade and aquaculture, these countries consumed an estimated 3.6 million tonnes more wild caught freshwater fish than officially reported, corresponding to a net underreporting of about 65% (Fluet-Chouinard et al 2018). Extrapolation suggests that a global inland catch officially reported as 10.3 million tonnes in 2008 was more likely around 16.6 million tonnes (Fluet-Chouinard et al 2018). This “hidden harvest” almost entirely involves wild caught fish from rivers, lakes, reservoirs and floodplains, reinforcing the importance of capture based supply chains for many freshwater species that either are not yet cultured or are only marginally cultivated (Fluet-Chouinard et al 2018; Em et al 2025).

Market level surveys in Butuan City, the largest urban center in the Caraga Region of the Philippines, identified 15 freshwater fish species traded across public markets and small artisanal stalls (talipapa) (Libot et al 2024). Two of these species were listed as endangered or vulnerable, and approximately two thirds of all recorded species were native, with the remainder being introduced (Libot et al 2024). Most fish sold in these markets were wild caught, and only four species were sourced from local farms (Libot et al 2024). Several species were described as “rare,” appearing in markets for only 10–30% of the year but consistently facing moderate to high demand (Libot et al 2024). This case study exemplifies how regional markets can depend heavily on wild capture from inland waters for both common and rare species, including taxa of conservation concern, in contexts where aquaculture either does not yet exist for the species or cannot meet local demand (Libot et al 2024; Fluet-Chouinard et al 2018).

Analyses of domestication levels across 250 farmed finfish species reveal that 70% fall into lower domestication categories (Levels 1–3), meaning that their production is still dependent, to varying degrees, on the availability of wild resource—whether for

broodstock, seed, or continuous input of wild individuals (Teletchea & Fontaine 2014). Truly domesticated fish populations, comparable to major livestock breeds, remain rare in aquaculture (Teletchea & Fontaine 2014; Lorenzen et al 2012). Thus, for a large proportion of inland fish taxa that are used locally or regionally as food, aquaculture has not yet replaced wild capture as the primary mode of supply (Teletchea & Fontaine 2014; Em et al 2025; Fluet-Chouinard et al 2018) (Figure 3).

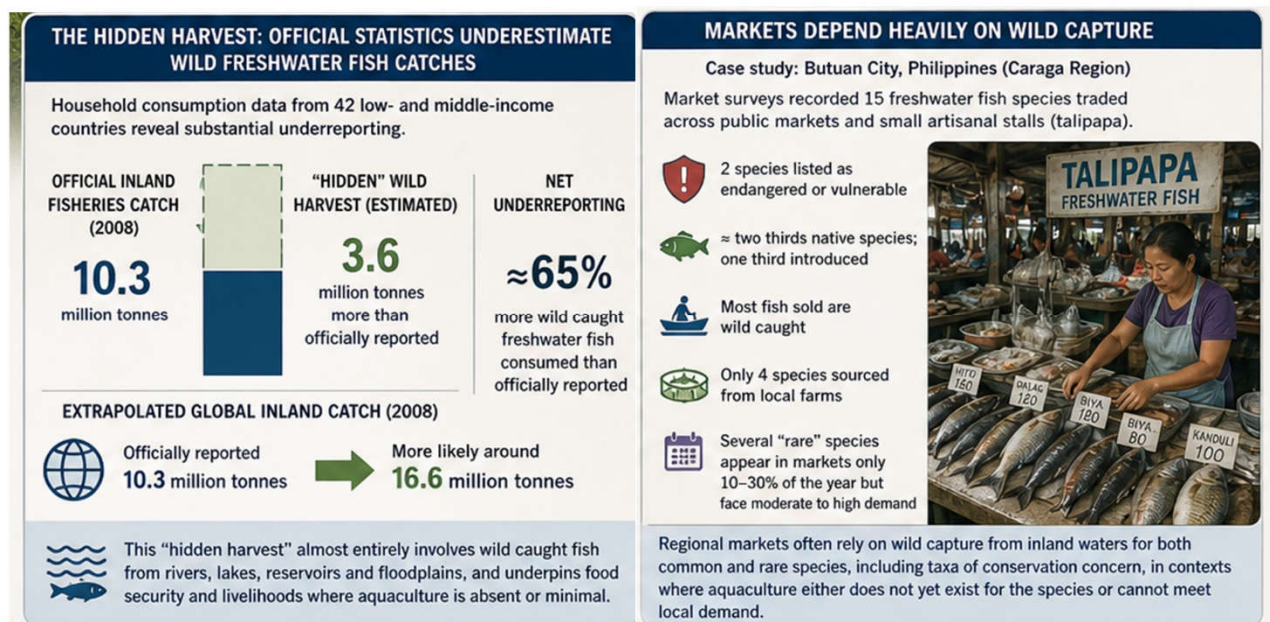


Figure 3. Hidden wild harvests and market dependency of freshwater fishes.

Ornamental Freshwater Fish Trade, Non-Native Introductions and Management Considerations. A global analysis of non native freshwater fish introductions underscores that ornamental trade is a major pathway for transboundary movement of species (Bernery et al 2024; Kang et al 2022; Millington et al 2022; Saba et al 2020; Borges et al 2022; Kotovska et al 2024; Petrescu-Mag et al 2013). Species introduced via ornamental pathways often originate from tropical regions and belong to diverse taxonomic orders, in contrast to aquaculture introductions that tend to concentrate in groups such as Cypriniformes (Bernery et al 2024; Kang et al 2022). Ornamental species with broad diets and high parental care tend to be widely introduced and established when released, emphasizing the invasion risks associated with continued wild capture, international transport and subsequent escape or release (Bernery et al 2024; Millington et al 2022; Saba et al 2020; Borges et al 2022; Mousavi-Sabet 2018; Mousavi-Sabet 2023; Mousavi-Sabet et al 2021ab; Petrescu & Mag 2006, 2007).

Systematic reviews of national ornamental industries show that the scientific literature generally lags behind trade practice in documenting species in circulation (Millington et al 2022). In Australia, an attempt to reconstruct species lists from academic and veterinary reports revealed a fragmented, incomplete picture of the freshwater ornamental trade, with many traded species remaining unassessed in terms of invasion risk (Millington et al 2022). E commerce and informal channels (e.g. postal shipments) further obscure the real composition and volume of wild derived freshwater ornamentals in trade (Millington et al 2022; King 2019; Saba et al 2020).

Historical and contemporary evaluations of the aquarium trade emphasize a dual role for the industry: on the one hand, as a driver of overexploitation and species introductions; on the other, as a potential ally in conservation through ex situ breeding programs, awareness campaigns and support to low impact community based fisheries (Evers et al 2019; Novák et al 2025; King 2019; Andrews 1990; Borges et al 2022). The trade has been implicated in direct depletion of certain endemic species, especially where regulations are absent or weakly enforced, as documented for Indian threatened barb, *Mystus* spp.

loaches and puffers (Raghavan et al 2013). Nevertheless, projects such as community based sustainable harvest of cardinal tetras in the Rio Negro ("Project Piaba") and organized conservation breeding initiatives for killifishes and other taxa (e.g. *Parosphromenus*, Goodeids, Brazilian killifishes, Mediterranean *Aphanius*) illustrate how market demand, if properly managed, can be linked to habitat protection and in situ conservation incentives (Novák et al 2025; Evers et al 2019; King 2019).

Legislative frameworks are evolving unevenly across countries. In the European Union, only a small number of freshwater ornamental species are currently listed as invasive alien species of Union concern, but future expansion of blacklists is anticipated (Novák et al 2025; King 2019; Saba et al 2020; Papuc 2020; Papuc et al 2018). Industry organizations argue for risk based and regionally differentiated restrictions that replace high risk species with lower risk alternatives, coupled with stronger attention to disease vectors and pathogen transfer (Novák et al 2025; King 2019; Saba et al 2020). At the same time, non compliance and illegal trade - including unauthorized imports of gars and other prohibited fishes - highlight the difficulty of controlling species flows once lucrative markets exist for rare or charismatic wild caught freshwater fishes (King 2019; Millington et al 2022; Saba et al 2020; Borges et al 2022).

Taken together, the available literature shows that across ornamental and food markets, a significant share of freshwater and brackish fish supply remains grounded in capture from inland waters, particularly for species that are difficult to breed, at early stages of domestication, geographically restricted, or newly discovered. For many such taxa, especially in the ornamental sector, trade still depends exclusively or almost exclusively on wild populations, with important implications for conservation, livelihoods and invasive species management (Evers et al 2019; Novák et al 2025; King 2019; Bernery et al 2024; Raghavan et al 2013; Millington et al 2022; Teletchea & Fontaine 2014; Andrews 1990; Saba et al 2020; Borges et al 2022; Libot et al 2024; Fluet-Chouinard et al 2018).

Wild-Caught Marine Fish with Limited Aquaculture Feasibility. Global demand for marine finfish is rising, yet many high value species remain uncultured or only partially domesticated, so their markets still depend predominantly on wild capture (Akbar et al 2024; Hendri et al 2024; Hendrayana et al 2025; Alamsah et al 2025; Kiak et al 2025). This dependence is particularly evident in coral reef ornamentals and several marine food fish taxa whose biology or economics constrain aquaculture development (Pouil et al 2020; Lin et al 2025; Moorhead & Zeng 2010; King 2019).

Wild Dependent versus Cultured Marine Finfish. Marine finfish production can be classified along a gradient from capture fisheries, through capture based aquaculture (wild seed, farmed grow out), to fully domesticated aquaculture using closed breeding cycles (Froehlich et al 2023; Froehlich et al 2018; Clavelle et al 2019). Many commercially important marine species remain in the first or second category because of complex life histories, larval rearing difficulties, or limited market incentives for domestication (Froehlich et al 2023; Lee & Ostrowski 2001; Stieglitz et al 2021; Albasri et al 2020). For such taxa, effective market demand is currently met almost entirely by wild capture, even in regions actively pursuing marine finfish aquaculture expansion (Engle et al 2022; Rexroad et al 2021; Riche 2021; Samarajeewa 2023).

Major Groups of Wild-Dependent Marine Fish in Trade Worldwide. Within marine ornamentals, academic and industry reviews consistently emphasize that the trade "still largely relies on wild fish from tropical coral reef ecosystems" (Pouil et al 2020; Moorhead & Zeng 2010; King 2019). A recent web scraping analysis of U.S. e commerce platforms found that for 734 ornamental species on offer, nearly nine out of ten were sourced exclusively from the wild, and only a small subset were available both wild caught and captive bred (Lin et al 2025). Even where aquaculture exists, wild caught conspecifics often remain common on the market, and, in that study, were on average more expensive than captive bred variants (Lin et al 2025) (Table 2).

Main marine fish groups still dominated by wild capture

<i>Trade segment / group</i>	<i>Typical aquaculture status and reliance on wild capture</i>	<i>References from literature</i>
Marine ornamental reef fish (general)	90–95% of species wild-caught; aquaculture available for a small minority of traded taxa	(Pouil et al 2020; Lin et al 2025; Moorhead & Zeng 2010; King 2019)
Top 20 ornamental species (U.S. imports)	Only 13 of 20 have documented captive-breeding research; most volume still wild-sourced	(Pouil et al 2020; Baillargeon et al 2024)
Online U.S. marine aquarium trade (13 families, 734 spp.)	89.2% of species sold exclusively wild-caught; wild-only dominance across popular families	(Lin et al 2025)
Marine finfish candidate species for U.S. food aquaculture (e.g. groupers, flounders, snappers, basses)	Many at “technologically feasible” or “experimental” stages; commercial supply still dominated by capture fisheries and imports	(Engle et al 2022; Rexroad et al 2021; Lee & Ostrowski 2001; Riche 2021; Samarajeewa 2023; Stieglitz et al 2021; Albasri et al 2020)
High-value sashimi finfish in Korea (flounder, rockfish, sea bream, mullet)	Rapid aquaculture growth, but wild-caught product remains an important market component and price reference	(Park et al 2012).

For marine food fish, systematic surveys of species prioritized for U.S. aquaculture expansion (for example, olive flounder, southern flounder, groupers, striped mullet, milkfish, mahimahi, threadfin, sea basses) reveal that many remain at early stages of larviculture and commercialization, so domestic markets are supplied mainly by wild landings and imports (Engle et al 2022; Rexroad et al 2021; Lee & Ostrowski 2001; Riche 2021; Samarajeewa 2023; Stieglitz et al 2021; Albasri et al 2020). Biological constraints in early life history, feed requirements, and disease, together with economic uncertainty, have slowed full domestication for numerous high value marine predators and demersal species (Froehlich et al 2023; Lee & Ostrowski 2001; Samarajeewa 2023; Stieglitz et al 2021; Clavelle et al 2019; Braña et al 2021).

Implications for Inventorying “Uncultivable or Hard to Cultivate” Marine Market Species. A formal global inventory of the “most important” marine species whose trade relies almost exclusively on wild capture is not provided by the available papers in literature; instead, several partial inventories and prioritization exercises can serve as templates. For ornamentals, analyses of U.S. import volumes and species level vulnerability assessments cover hundreds of species and families, but indicate that the vast majority of traded taxa - especially among Labridae, Pomacanthidae, Gobiidae, Acanthuridae, and others - remain essentially wild dependent, with captive breeding documented for only a minority subset (Pouil et al 2020; Lin et al 2025; Moorhead & Zeng 2010; King 2019; Baillargeon et al 2024).

For food fish, national and regional prioritization frameworks (United States, Indonesia) identify 18–20 “first tier” marine finfish candidates for mariculture R&D, many of which currently have little or no commercial aquaculture, implying that existing

markets are sustained primarily by wild capture or imports from regions with more advanced farming of the same or closely related species (Engle et al 2022; Rexroad et al 2021; Riche 2021; Samarajeewa 2023; Stieglitz et al 2021; Albasri et al 2020) (Figure 4). Studies linking aquaculture development to declining prices of wild caught analogues in Korea further illustrate that, for several sashimi species, aquaculture has only recently begun to displace a historically dominant reliance on wild stocks (Park et al 2012).

Taken together, these strands of evidence support the existence of a broad class of economically important marine finfish - ornamental reef fishes, high value demersal and pelagic predators, and regionally prized sashimi or niche species - for which current global commerce is still based exclusively or predominantly on wild capture, due either to unresolved technical bottlenecks in culture or to insufficient economic incentives to close the life cycle in aquaculture (Pouil et al 2020; Engle et al 2022; Lin et al 2025; Froehlich et al 2023; Rexroad et al 2021; Lee & Ostrowski 2001; Samarajeewa 2023; Park et al 2012; Stieglitz et al 2021; Moorhead & Zeng 2010; Clavelle et al 2019; Albasri et al 2020; King 2019; Baillargeon et al 2024; Braña et al 2021).

Conclusions. This review highlights that, despite major advances in aquaculture, a substantial proportion of aquatic biodiversity traded globally—across freshwater, brackish, and marine systems—remains fundamentally dependent on wild capture. This dependency is especially pronounced among ornamental fishes and high-value marine taxa, but is also critically important for inland food fisheries in low- and middle-income countries.

A central finding is the asymmetry between freshwater and marine ornamental systems. While freshwater ornamental trade is now largely supported by captive breeding, a long tail of species—particularly rare, endemic, recently described, or biologically specialized taxa—continues to rely on wild populations. In contrast, marine ornamental fish trade remains overwhelmingly wild-based, with up to 90–95% of species sourced directly from coral reef ecosystems. This reflects persistent technical bottlenecks in closing life cycles under captive conditions.

Across both freshwater and marine domains, the review identifies a consistent set of drivers maintaining wild dependency: complex reproductive biology, larval rearing constraints, narrow ecological niches, limited market scale, and insufficient economic incentives for domestication. These factors are particularly evident in taxonomic groups such as loricariid catfishes, killifishes, coral reef fishes, and high-value marine predators. Another key insight is the systematic underestimation and poor documentation of wild harvests. Inland fisheries data are frequently incomplete, with evidence suggesting substantial “hidden harvests” that significantly exceed official statistics. Similarly, the ornamental fish trade is characterized by low taxonomic resolution, inconsistent labeling, and fragmented monitoring, which collectively hinder the development of accurate species inventories. The widespread use of generic trade categories (e.g., “live aquarium fish”) obscures the true scale of exploitation of individual taxa, including threatened and endemic species.

The review also underscores the dual role of the aquarium and fish trade sectors. On one hand, they contribute to overexploitation, biodiversity loss, and the global spread of invasive species through translocations and releases. On the other hand, when properly managed, these sectors can support conservation outcomes, including community-based sustainable fisheries, ex situ breeding programs, and habitat protection initiatives. This duality highlights the need for governance frameworks that balance trade with ecological sustainability.

From an inventorying perspective, the concept of “uncultivable or hard-to-cultivate species” emerges as both operationally useful and methodologically challenging. Current literature does not provide comprehensive global lists of such species; instead, knowledge is fragmented across regional studies, trade analyses, and aquaculture assessments. As a result, there is a critical need for standardized criteria, improved traceability systems, and integrated databases that link trade, biology, and production status at the species level.

Global Trade in Aquatic Organisms: Wild Dependence, Challenges and Pathways Forward

Many commercially important fish species remain uncultivable or hard to cultivate, and their supply continues to rely partially or predominantly on wild capture.



Figure 4. Global trade in ornamental and food fishes across freshwater, brackish, and marine environments.

Finally, the persistence of wild-dependent supply chains has important implications for conservation policy, fisheries management, and aquaculture development strategies. Without improved monitoring and targeted domestication efforts, continued demand for wild-caught fish—particularly rare and high-value species—may intensify pressure on vulnerable ecosystems. Conversely, strategic investment in aquaculture innovation, combined with transparent and traceable trade systems, could reduce reliance on wild stocks while maintaining economic benefits.

As final remark, this review demonstrates that global fish trade systems are still deeply interconnected with natural ecosystems. Recognizing, quantifying, and managing the category of wild-dependent species is therefore essential for achieving both biodiversity conservation and sustainable use of aquatic resources in the coming decades.

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