Marine Ornamental Fish SKI

Providing Data to Inform CITES Decisions and Recommendations to Manage the International Trade of Marine Ornamental Fish

The Marine Ornamental Fish Species Knowledge Index: Providing Data to Inform CITES Decisions and Recommendations to Manage the International Trade of Marine Ornamental Fish

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Acronyms

ATD	Aquarium Trade Database
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CITES TDB	CITES Trade Database
CMS	Convention on Migratory Species
CoP	Conference of the Parties
CPop	Interdisciplinary Centre on Population Dynamics
CR	Critically Endangered
DD	Data Deficient
EAZA	European Association of Zoos and Aquaria
EN	Endangered
EU TWIX	European Union Trade in Wildlife Information eXchange
EW	Extinct in the Wild
EX	Extinct
FAO	Food and Agriculture Organization of the United Nations
GBIF	Global Biodiversity Information Facility
GROMS	Global Register Of Migratory Species
IGO	Intergovernmental Organization
IUCN RL	International Union for Conservation of Nature Red List of Threatened Species™
IUCN SSC	International Union for Conservation of Nature Species Survival Commission
LC	Least Concern
LEMIS	Law Enforcement Management Information System
NGO	Non-Governmental Organization
NE	Not Evaluated
NT	Near Threatened
SKI	Species Knowledge Initiative
spp.	species
Species360 CSA	Species360 Conservation Science Alliance
TRACES	(European) Trade Control and Expert System
TAG	Taxon Advisory Group
TRAFFIC	Wildlife Trade Monitoring Network
UNODC	United Nations Office on Drugs and Crime
UNCLOS	United Nations Convention on the Law of the Sea
UNEP-WCMC	United Nations Environment Programme World Conservation Monitoring Centre
USFWS	United States Fish and Wildlife Service
VU	Vulnerable
World WISE	World Wildlife Seizures Database
WiTIS	Wildlife Trade Information System
ZIMS	Zoological Information Management System

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Executive Summary

The marine ornamental fish trade is a complex industry presenting both risks and opportunities for conservation efforts. Acknowledging the need for more attention on this species group, CoP18 Decision 18.296 called for a comprehensive review of the marine ornamental fish trade. In response, the Marine Ornamental Fish Species Knowledge Index (SKI) was established as part of the Species360 Conservation Science Alliance Species Knowledge Initiative, aiming to identify species requiring urgent research efforts for CITES considerations. Acknowledging the extensive work done by the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) in this regard, we present here an alternative research prioritization to support the discourse at the upcoming technical workshop, complementing the already existing efforts by UNEP-WCMC, IUCN Red List, and CITES.

Methods

Utilizing a diverse array of databases including WiTIS, LEMIS, UNODC, EU TWIX, Aquarium Trade Database, and the IUCN Red List, alongside pertinent literature, comprehensive data were gathered to facilitate informed decision-making. Expert workshops involving 28 participants from 10 countries and diverse sectors were conducted to refine the research prioritization, ensuring a robust and inclusive approach.

The SKI's research prioritization framework, comprising five categories (A-E), focuses on identifying species necessitating further research rather than recommending immediate CITES listing. The research prioritization is guided by four key factors: trade volumes, prior assessments of trade as threat, IUCN Red List status, and additional risks including endemism, habitat degradation, declining population trends, and alternative uses. Due to data limitations, only US import data from the Aquarium Trade Database was included in the first prioritization step involving trade volumes.

Prioritizing Species for Research

Our analysis found 2,667 species with records in the marine ornamental fish trade, with a vast majority (2,622 species, 98.3%) not listed under CITES. This trade encompassed species from 135 families, underlining its diversity and scope.

From the 2,622 non-CITES-listed species in trade, we used the criteria listed above assigning:

- **255** species to the highest research priority **A**,
- **186** species to research priority **B**,
- **161** species to research priority **C**,
- **704** species to research priority **D**,
- **1,316** species to research priority **E**.

Based on substantial trade volumes into the US, 255 species were designated as research priority A. This included species spanning various conservation statuses, emphasizing the potential threats posed by unsustainable trade practices. Categories B, C, D, and E delineate further prioritization, reflecting varying urgency for research efforts.

Notably, the inclusion of trade volume data significantly influenced prioritization outcomes, emphasizing the importance of considering both extinction risk and trade impacts. Excluding trade volumes resulted in fewer species categorized as high priority for research, highlighting the necessity of incorporating trade volume data in conservation assessments.

Captive breeding & aquarium holdings

We found 350 species with captive breeding records in the literature, including 112 commercially available species.

Public aquaria play a multifaceted role in the trade as consumers, but also by driving research on captive breeding, conservation initiatives, and education of the public. Therefore, identifying species for which public aquaria can contribute to breeding and biological research is essential. Our analysis showed that Species360's zoo and aquarium members hold 1,132 (43.2%) traded non-CITES listed species highlighting the potential for further research in these species.

Recommendations for CITES parties

Based on our results and expert inputs we recommend:

1) Improving reporting of trade volumes
2) Investigating mortality of animals in the supply chain
3) Conducting further threat analysis for species in research priorities A and B
4) Developing standardized assessment templates for the evaluation of trade sustainability for this specious group
5) Connecting and integrating data sources
6) Investigating the feasibility of captive breeding
7) Considering alternative conservation and fishery management measures

Background

The international trade of marine ornamental fishes is a multimillion-dollar market (Wabnitz et al., 2003), which presents both risks and opportunities for species conservation (Dee et al., 2014). On the one hand, international trade of marine ornamental fish can provide opportunities for conservation, economic growth, and financial security of livelihoods, by providing economic incentives for local communities to conserve ornamental fish populations and their ecosystems (Charles, 2021; Dee et al., 2014, 2019; King, 2019; Rhyne et al., 2014). While the marine aquarium industry is heavily reliant on wild-caught individuals to supply the trade (Biondo & Burki, 2019, 2020; King, 2019; Rhyne et al., 2012, 2017), more species have become available from captive breeding facilities over the last two decades, although supply is still limited (Pouil et al., 2020). Therefore, continuing advancements in aquaculture and captive breeding techniques present the potential for the marine ornamental fish trade to support conservation action. By reducing the need to rely on wild stock and supporting the establishment of assurance populations, these advancements can aid in protecting species within their natural habitats. However, the development of aquaculture can also displace livelihoods, if developed outside species' ranges, have negative impacts on the conservation of species and habitats, and could encourage the laundering of wild-caught fish (Rhyne et al., 2017; Tlusty, 2002).

The marine ornamental fish trade can pose serious threats to species and ecosystems, such as the introduction of invasive species, pests, and diseases. It may also have potential negative conservation impacts on rare and threatened species due to overharvesting and poor management practices (Conant, 2015; Lockwood et al., 2019; Molnar et al., 2008; Vagelli, 2011; WOAH, 2022). Moreover, high mortality rates within some supply chains also raise concerns about animal welfare (Militz et al., 2016; Stevens et al., 2017). Additionally, the marine ornamental fish trade primarily involves coral reef species from the world's tropical regions (Biondo & Burki, 2020; Rhyne et al., 2012, 2017), which are highly threatened ecosystems (Eddy et al., 2021; Hughes et al., 2017).

Currently, the international trade of a limited number of species is regulated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), a key international agreement that ensures legal and sustainable international wildlife trade. However, the lack of data on trade and life history of marine ornamental fishes poses a significant challenge in determining which species require consideration for a CITES listing or other regulations to ensure trade sustainability. Additionally, many species have vast geographical ranges, unknown dispersal ranges, and unknown natural mortality rates, complicating efforts to predict harvest rates that would have minimal impact. Differences in management practices and regulations across countries and regions further add to the complexity of this issue.

Recognizing the need to address the risks posed by the international trade of marine ornamental fish, the European Union (EU), Switzerland, and the United States of America (US), submitted a document at the CITES CoP18 (CoP18 Doc.94). This document highlighted the scope of the marine ornamental fish trade and potential conservation concerns, leading to CoP18 Decision 18.296 in 2019. This decision proposed a comprehensive review across four thematic areas and advocated for the organization of a technical workshop to address the conservation and management needs of non-CITES-listed ornamental marine fish (CITES Secretariat, 2021a). The United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) was entrusted with the task of preparing a report and conducting these workshops. The outcomes were subsequently submitted to the CITES Secretariat in 2022 (UNEP-WCMC, 2022).

The four themes covered by the UNEP-WCMC report are: 1) identification of species in international trade, 2) exploration of the conservation status and intrinsic vulnerability to extinction, 3) fisheries management of non-CITES listed live coral reef fishes, and 4) relevant legislation and enforcement. The report found 1,708 species in international trade with most of the trade in wild-caught individuals and only limited evidence of captive breeding. The report assessed 76% of these species as unlikely to be threatened by international trade. However, they also acknowledge the lack of global species-level data on the number of individuals in trade which hinders the assessment of trade sustainability.

Recognizing the extensive body of work carried out by UNEP-WCMC we do not seek to replicate their efforts but support the discourse by proposing an alternative prioritization focusing on high-quality trade volume data to assess trade sustainability. The aim of the Marine Ornamental Fish Species Knowledge Index (Marine Ornamental Fish SKI) is to develop a prioritization framework to support the identification of species in pressing need of research to inform CITES decisions based on evidence of international trade (Tlusty et al., 2023). This framework incorporates species' trade status, previous assessments of trade as a threat, global IUCN Red List status, and additional risks. We refined the prioritization framework based on stakeholder input and used trade volume data from imports in the US (one of the main destinations for marine aquarium fish; Dee et al., 2019; Rhyne et al., 2012; Wabnitz et al., 2003), as reliable data from other countries and regions were not available. Although these data only provide a limited snapshot of international trade volumes, we emphasize the importance and usefulness of incorporating trade volume data to inform CITES decisions wherever possible. We also propose a preliminary standardized sustainability assessment process utilizing existing assessment efforts as the next step following the prioritization presented here. Additionally, we have identified species for which information on the feasibility of captive breeding is available, both for CITES and non-CITES-listed species. Lastly, we provide recommendations for CITES Parties based on the results of this study.

Developing the Marine Ornamental Fish SKI

We used the methodologies previously developed for the Songbird SKI (Juergens et al., 2021; Species360 Conservation Science Alliance, 2021) and Shark SKI (Oegelund Nielsen et al., 2020) to integrate and map information, thereby constructing a decision framework for prioritizing species for further research. The CITES Secretariat has recognized the value of these methods, specifically for the sharks and rays and the songbird taxa (CITES Secretariat, 2021b, 2021a). Notably, the Songbird SKI informed listing decisions for two songbird species at CoP19 (WCS News Release*,* 2022).
In this study, the Marine Ornamental Fish SKI maps and integrates data on 15,965 extant species of marine bony fish (Actinopterygii and Sarcopterygii). The total number of species is based on the taxonomy used by the Global Biodiversity Information Facility (GBIF Secretariat, 2022; see methods for more detail).

Using the data collated in the Marine Ornamental Fish SKI (see Box 1 and Table 1), we identified marine ornamental fish species involved in international trade and prioritized species in need of further research on the sustainability of trade. Additionally, we identified CITES-listed and non-CITES-listed species that can be bred in captivity. This identification can support assessments aimed at detecting potential instances of laundering, where wild-caught species are falsely traded as captive-bred.

In the context of CITES, the Marine Ornamental Fish SKI can be used as a framework to:

- Prioritize species for conducting research to inform potential CITES listings,
- Identify data gaps for further studies,
- Refine the proposed prioritization framework to suit the particular needs of CITES Parties,
- Identify CITES-listed species that can be captive-bred[1],
- Develop Non-Detrimental Findings (NDFs)[2].

[1] Following CITES terminology, we refer to individuals propagated in aquaculture as captive bred.
[2] Export permits for Appendix I and II species may only be issued if the Scientific Authority of the exporting state has found that such export will not be detrimental to the survival of the species (CITES, 2023).

Box 1. The Species Knowledge Initiative

The aim of the Species Knowledge Initiative (SKI) is to map gaps, challenges, and opportunities for research to support evidence-based decision-making by policymakers, management authorities, the zoo and aquarium community, and conservation practitioners.

The methodology for the SKI was first developed by Conde et al., (2019) to map demographic knowledge at the species level. The SKI works with key stakeholders and partners across disciplines to standardize, visualize, and consolidate data for every extant vertebrate species to support the development of prioritization frameworks to resolve data gaps and meet conservation challenges.

Taking a panoramic perspective akin to landscape ecology, the SKI methodology maps data from different knowledge areas using species as a mapping unit. Species information is retrieved from open-data repositories using data-processing algorithms. The results of the SKI are illustrated through data visualization to support decision-making at the species level.

The SKI integrates multiple data sources to quantify current knowledge for species across six knowledge areas.

The six knowledge areas mapped by the SKI are:

1. Human use (e.g., international trade, use as food or medicine).
2. Extinction risk (e.g., IUCN Red List, vulnerability to climate change).
3. Conventions and treaties (e.g., CITES, Convention of Migratory Species [CMS], United Nations Convention on the Law of the Sea [UNCLOS]).
4. Management opportunities (e.g., *in-situ* conservation programs, *ex-situ* interventions).
5. Biological information (e.g., clutch size, longevity, genomic sequences).
6. Species intrinsic values (e.g., evolutionary distinctiveness; but not available for Actinopterygii & Sarcopterygii including marine ornamental fish).

For the purpose of this document, and prioritization, three knowledge areas are presented here: 1. Human use; 2. Extinction risk, and 4. Management opportunities.

Methods

Taxonomic standardization

To integrate data across data repositories, we standardized fish taxonomies using the GBIF taxonomic backbone[3] (GBIF Secretariat, 2022). According to the CITES taxonomy, as of November 2021, 46 marine bony fish species are listed in the Convention (Appendix I: 3 species; Appendix II: 43 species, UNEP-WCMC (Comps.), 2022). These include species such as the totoaba (*Totoaba macdonaldi*) and the European eel (*Anguilla anguilla*), which are not usually traded for the aquarium trade. Only a few marine ornamental fish are currently protected under CITES, namely seahorses (*Hippocampus* spp.)[4], the humphead wrasse (*Cheilinus undulatus*)[5], and the Clarion angelfish (*Holacanthus clarionensis*; UNEP-WCMC (Comps.), 2022).

Due to discrepancies in the taxonomy used by GBIF and CITES, marine CITES-listed species referred throughout this report add to a total of 76 species, instead of the 46 species reported based on the CITES taxonomy (Appendix I: 3 species; Appendix II: 73 species). This is because GBIF accepts more *Hippocampus* species than the taxonomy used by CITES.

Data collection

Following the GBIF taxonomy, we assessed whether there was evidence of international live trade for each of the 15,965 extant species of marine bony fish. We used six trade data repositories and five publications to collect relevant data (Table 1). It is important to note that a species presence in these trade databases (Box 2) does not necessarily imply that its survival is "affected by trade", which is one of the fundamental principles in Article II 1 and 2 of the CITES Convention; (CITES, 1973). Moreover, some live traded species may also be primarily used for additional purposes aside from the aquarium trade, such as food or sport fishing, which may affect species sustainability. Therefore, we also include these species in this report.

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[3] When species could not be matched, we used Eschmeyer's Catalog of Fishes (ECoF) (Fricke et al., 2022) to find synonyms and identify the correct GBIF species. In cases where we could not find the correct synonyms with this resource, we searched the name on Google. We only included species level data.

[4] Note that the majority of the trade in seahorses, at least for some species, is for use in traditional medicines (Vincent et al., 2011).

[5] Note that the humphead wrasse trade is traded live as a luxury food item, which is likely a greater threat/use than the ornamental fish trade (Gillett, 2010).

Table 1. Data repositories and sources used in the Marine Ornamental Fish SKI across five knowledge areas. Note that only knowledge areas 1, 2, and 4 are presented in this report (see box 1). Some databases contain data used in more than one knowledge area (such as the IUCN Red List). For simplicity, we only list the database in its main knowledge area (see Methods for further details).

Knowledge Area	Reference
1. Taxonomy	
GBIF Backbone Taxonomy	GBIF Secretariat (2023). GBIF Backbone Taxonomy. Checklist dataset https://doi.org/10.15468/39omei accessed via GBIF.org
2. Global Extinction Risk	
IUCN Red List	IUCN (2023). IUCN Red List of Threatened Species. Version 2023-1.
Species likely to be threatened by international trade based on the IUCN Red List	Challender, D. W. S., Cremona, P. J., Malsch, K., Robinson, J. E., Pavitt, A. T., Scott, J., Hoffmann, R., Joolia, A., Oldfield, T. E. E., Jenkins, R. K. B., Conde, D. A., Hilton-Taylor, C., & Hoffmann, M. (2023). Identifying species likely threatened by international trade on the IUCN Red List can inform CITES trade measures. Nature Ecology & Evolution, 7(8), Article 8.
3. Management opportunities	
Species360 Zoological Information Management System (ZIMS)	Species 360 (2021). ZIMS Species Holdings, (April 2021). Species360 Zoological Information Management System.
CORAL Magazine's Annual Listing of captive-bred marine ornamental fish species	Sweet, T. & Pedersen, M. (2019) A Coral special report: The State of the Marine Breeder's Art, 2019. Coral Magazine.
CoP19 Inf. 99 captive breeding records	UNEP-WCMC (2022). International trade in non-CITES listed marine ornamental fish: International trade, conservation status, management and legislation for non-CITES marine ornamental fish in support of the implementation of Decision 18.296. UNEP-WCMC, Cambridge [draft].
Japan commercial breeding of Chaetodontidae and Pomacanthidae	Satoru Matsumura, Tokyo Sea Life Park, personal communication
Tokyo Sea Life Park in-house breeding of Chaetodontidae and Pomacanthidae	Satoru Matsumura, Tokyo Sea Life Park, personal communication
4. Human Use	
The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	UNEP-WCMC (2020), CITES trade statistics derived from the CITES Trade Database, Cambridge, UK.
Species recorded by the USFWS Law Enforcement Management Information System (LEMIS)	Eskew, E. A., White, A. M., Ross, N., Smith, K. M., Smith, K. F., Rodríguez, J. P., Zambrana-Torrelio, C., Karesh, W. B., & Daszak, P. (2020). United States wildlife and wildlife product imports from 2000 – 2014. Scientific Data, 7(1), 1–8.
TRAFFIC Wildlife Trade Information System (WiTIS)	TRAFFIC (2022), Fish seizures 2008-2021, Incident dataset.
World WISE Database	UNODC (2022), World WISE Database, List of Fish Records,
The Aquarium Trade Database	Rhyne, A. L., Tlusty, M. F., Holmberg, R. J., & Szczebak, J. T. (2015). AquariumTradeData—Marine Aquarium Biodiversity and Trade Flow. Aquariumtradedata.Org. https://aquariumtradedata.org/.
Food and Agriculture Organization of the United Nations (FAO) capture production statistics	FAO (2021) The Food and Agriculture Organization of the United Nations (FAO) Global capture production Quantity (1950 - 2020). Capture data 2021.1.2
European Trade in Wildlife Information Exchange (EU TWIX) database on seizures and offenses	EU TWIX (2022). Private communication. April 2022.
IUCN Red List species listed as threatened by the international trade	IUCN (2023) IUCN Red List of Threatened Species. Version 2023-1. https://www.iucnredlist.org. Threats data
IUCN Red List species assessed as used internationally	IUCN (2023) IUCN Red List of Threatened Species, Version 2023-1. https://www.iucnredlist.org. Usetrade data
FishBase	FishBase (2019). Data retrieved using: Boettiger, C., Chamberlain S., Lang D. T., Wainwrigh,. P. rFishBase: R Interface to 'FishBase', 3.0.4 (2019). R. Froese, D. Pauly (Eds), FishBase. 2019
4.1 Human Use: Literature sources	
Importation of marine ornamental fish to Switzerland	Biondo, M. V. (2017). Quantifying the trade in marine ornamental fish into Switzerland and an estimation of imports from the European Union. Global ecology and conservation, 11, 95-105
Monitoring the trade in marine ornamental fish through the European Trade Control and Expert System TRACES: Challenges and possibilities	Biondo, M. V. & Burki, R. P. (2019). Monitoring the trade in marine ornamental fishes through the European Trade Control and Expert System TRACES: Challenges and possibilities. Mar. Policy, 108, 103620.
Caught in the (inter)net: Online trade of ornamental fish in Brazil	Borges, A. K. M., Oliveira, T. P. R., Rosa, I. L., Braga-Pereira, F., Ramos, H. A. C., Rocha, L. A. & Alves, R. R. N. (2021). Caught in the (inter)net: Online trade of ornamental fish in Brazil. Biol. Conserv., 263.

Knowledge Area	Reference
Species composition and invasion risks of alien ornamental freshwater fish from pet stores in Klang Valley, Malaysia	Saba, A. O., Ismail, A., Zulkifli, S. Z., Halim, M. R. A., Wahid, N. A. A. & Amal, M. N. A. (2020). Species composition and invasion risks of alien ornamental freshwater fishes from pet stores in Klang Valley, Malaysia. Sci. Rep., 10, 1–13.
Assessing vulnerability of fish in the US marine aquarium trade	Dee, L. E., Karr, K. A., Landesberg, C. J. & Thornhill, D. J. (2019). Assessing vulnerability of fish in the US marine aquarium trade. Front. Mar. Sci., 5, 1–9.
Uncovering an obscure trade: Threatened freshwater fish and the aquarium pet markets	Raghavan, R., Dahanukar, N., Tlusty, M. F., Rhyne, A. L., Krishna Kumar, K., Molur, S. & Rosser, A. M. (2013). Uncovering an obscure trade: Threatened freshwater fishes and the aquarium pet markets. Biol. Conserv., 164, 158–169.
Understanding the United Kingdom marine aquarium trade – a mystery shopper study of species on sale.	Pinnegar, J. K. & Murray, J. M. (2019). Understanding the United Kingdom marine aquarium trade – a mystery shopper study of species on sale. J. Fish Biol., 94, 917–924.
Revealing the Appetite of the Marine Aquarium Fish Trade: The Volume and Biodiversity of Fish Imported into the United States	Rhyne, A. L., Tlusty, M. F., Schofield, P. J., Kaufman, L., Morris, J. A., & Bruckner, A. W. (2012). Revealing the appetite of the marine aquarium fish trade: The volume and biodiversity of fish imported into the United states. PLoS ONE, 7(5), e35808.
Early Culture Trials and an Overview on U.S. Marine Ornamental Species Trade	Rhyne, A. L., Tlusty, M. F., & Szczebak, J. T. (2017). Early Culture Trials and an Overview on U.S. Marine Ornamental Species Trade (R. Calado, I. Olivotto, M. P. Oliver, & G. J. Holt, Eds.). John Wiley & Sons Ltd. http://ebookcentral.proquest.com/lib/sdub/detail.action?docID=4815055
5. Conventions and treaties	
The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	UNEP-WCMC (2020), The Species + Website, Nairobi, Kenya. Compiled by UNEP-WCMC, Cambridge, UK.

Box 2. Main databases and publications used to characterize international trade in marine fish

1) **WiTIS:** The Wildlife Trade Information System (WiTIS) contains information on species confiscations. We included data reported for international trade between 2008 and 2021 (TRAFFIC, 2022).
2) **LEMIS:** United States Fish and Wildlife Service (USFWS) Law Enforcement Management Information System (LEMIS) on US imports of wildlife from 2000 to 2014 (Eskew et al., 2020).
3) **UNODC:** A list of species from the United Nations Office of Drugs and Crime World Wildlife Seizures (UNODC World WISE) on species confiscations reported by Member States (UNODC, 2022)
4) **EU-TWIX:** European Union Trade in Wildlife Information Exchange (EU-TWIX), which facilitates the exchange of information and intelligence among wildlife law enforcement officials across Europe, including data from all Member States that consented to share their data between 2010 and 2020 (EU TWIX, 2022).
5) **ATD:** The Aquarium Trade Database (ATD) with ornamental trade data from shipment declarations and associated commercial invoices (Rhyne et al., 2015; www.aquariumtradedata.org). This database reports trade volumes imported into the US between 2004 and 2011 based on shipment declarations and commercial invoices (we only included 2008, 2009, and 2011 as not all years have complete data coverage).
6) **IUCN RL:** International Union for the Conservation of Nature Red List Red List of Threatened Species™ (IUCN RL), including species used internationally as pets or display animals (IUCN, 2023).
7) **Selected peer-reviewed publications** (hereafter, 'publications') on live ornamental fish trade in

Europe (including EU TRACES data (Biondo & Burki, 2019), Switzerland (Biondo, 2018), Brazil (Borges et al., 2021), the UK (Pinnegar & Murray, 2019) and the US (Rhyne et al., 2012, 2017); see Table 2).

Literature

To reduce biases and fill gaps in the databases used, we also included data from peer-reviewed publications on ornamental trade to identify additional species in the international trade. Specifically, we focused on literature reporting on major importer and exporter regions potentially underreported in the trade databases, such as Europe and Brazil (Table 2). We only included publications containing species-level data published after 2010 to ensure the data are timely and relevant. As the aim was to elucidate internationally traded species, we only included species that are not native to the respective country they are traded in or that were reported as imports.

Table 2. Publications used to identify additional species traded as ornamentals, including data type, region, and time frame covered.

Publication	Data type/source	Region/Country	Timeframe
Biondo & Burki, 2019	EU TRACES	Europe	2014-2017
Biondo, 2018	Swiss customs	Switzerland	2009
Borges et al., 2021	Social media	Brazil	2018
Dee et al., 2019	US fish import records, literature review, informal surveys of US retailers	US	2000-2011
Pinnegar & Murray, 2019	Market survey of aquarium shops, government trade statistics	UK	2011, 1996-2017
Rhyne et al., 2012	Shipment declarations and commercial invoices	US	2004–2005
Rhyne et al., 2017	Shipment declarations and commercial invoices	US	2005-2011

Illegal trade

We further identified species seized in the illegal wildlife trade using three databases, namely TRAFFIC WiTIS (TRAFFIC, 2022), EU TWIX (EU TWIX, 2022), and the UNODC World Wise database (UNODC, 2022).

Species distribution

To analyze which countries can support research efforts for traded species within their territories, we used data on species extant range states listed in the IUCN Red List (IUCN, 2023) and GBIF (GBIF, 2022).

Captive breeding & aquarium holdings

We collated data on captive breeding, including captive-bred availability and successful *ex-situ* breeding in Japan for the families Chaetodontidae and Pomacanthidae (Satoru Matsumura, Tokyo Sea Life Park, personal communication), and in the US for all aquarium fish families (Sweet & Pedersen, 2019). Additionally, we included the captive breeding data published by UNEP-WCMC (UNEP-WCMC, 2022). We followed CITES terminology and referred to aqua-cultured specimens as captive-bred. All data on captive breeding are available in the spreadsheet accompanying this report (Annex I).

We also gathered data on the presence of internationally traded species in the Species360 Zoological Information Management System (ZIMS) holdings (Species360, 2021). ZIMS is the world's largest database on animals in zoos and aquariums, with data from over 1,300 members from more than 100 countries. The extract of ZIMS holding used for this document includes the number of individuals held by Species360 members per species and alive at the date of data extraction (i.e., February 11th, 2021) as well as the number of birth records for the year of extraction (2021).

Expert online workshops & stakeholder engagement

We conducted two online expert workshops, as part of the Species360 Experts Workshop Series, to further develop and refine the decision framework presented in this study, and to gather additional data (Pittman et al., 2021; Selig et al., 2017). Experts were identified with the help of the Species360 Board of Trustees and the CITES Secretariat. We contacted 65 experts, of which 28 participated in the workshops. Participating experts represented 10 countries, all continents (except Antarctica), and varied sectors (Fig. 1).

These workshops led to two key additions to the framework. First, we incorporated trade volumes into the species prioritization process for species requiring further research to inform CITES listing amendments (see Research prioritization framework below). The importance of including these data was highlighted by several experts during the online workshop. However, due to the limited availability of high-quality global trade data, we only incorporated high-quality US import data in the prioritization at this time. In the future, it will be crucial to add additional trade volume data from other regions. Second, experts identified additional risks that render certain species vulnerable to overexploitation. As a result, we included four additional risk factors in the prioritization

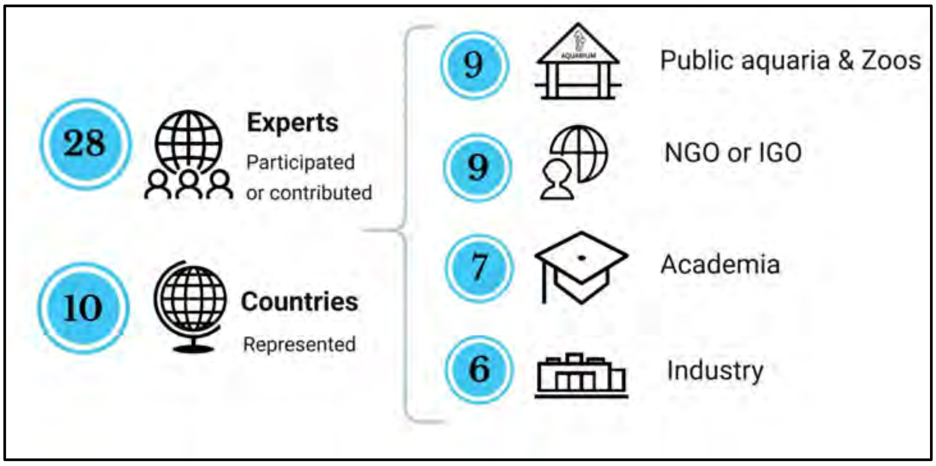

Figure 1. Number of experts from different sectors participating in the Species360 Experts Workshops - Marine Ornamental Fish SKI. Note that some experts are affiliated with multiple sectors. NGO = Non-Governmental Organization, IGO = Intergovernmental Organization.

based on available data. A summary of experts' comments can be found in Annex II (Supplementary Material S1, Fig. S1)

Research prioritization framework

Including a species under CITES Appendices requires assessments of trade and species biology, as well as evidence that the trade is detrimental or may harm species survival. The SKI proposes a basic framework to identify species in international trade that are not currently listed by CITES and for which further research on the impact of international trade is needed. The SKI does not aim to recommend species for CITES listing; rather, it highlights species for which additional research is needed to inform CITES listing decisions. The framework resulted in five prioritization categories that are described in detail in Table 3. The research prioritization is based on four main factors - trade volumes, previous assessment of trade as threat, IUCN Red List status, and additional risks - further explained below.

Trade volumes

Data on quantities in the ornamental trade are limited, and available data are often misleading (Biondo & Calado, 2021; Rhyne et al., 2012). While it was not possible to acquire global trade quantities, import data from three major importers were available for limited periods (i.e., the US (2004-2011), Switzerland (2009), and the EU (2014-2017)). For the prioritization below, we used only US import volumes based on the Aquarium Trade Data which includes trade volumes from shipment declarations and commercial invoices providing detailed volume data. Around 50% of marine aquarium fish volumes collected globally are imported into the US (Tissot et al., 2010; Wabnitz et al., 2003), hence this dataset may provide some indication of general global trade volumes and patterns. We used an evidentiary approach to classify significant trade (i.e., species with over 10,000 individuals traded over 4 years). We did not include the EU data based on EU TRACES in the first step of the prioritization as the database is not designed to track wildlife trade and about a third of trade is reported on a higher taxonomy level, although the data can still be useful to infer imports to the EU (Biondo & Burki, 2020). Additionally, in a preliminary analysis including the EU data, we found similar results for the prioritization as when only incorporating the US data. We excluded the Swiss data due to its limited scope in terms of location and duration (Biondo, 2018). Both Swiss and EU data were still used to identify species in the trade and establish evidence of trade (see Table 2 & Fig. 2). Trade quantities from all datasets are listed in the accompanying prioritization spreadsheet for comparison (Annex I).

International trade as a threat

We included two previous assessments of international trade posing a threat to species sustainability in our prioritization. The first is the "international trade as a threat" category listed in species IUCN Red List assessments. However, it is important to note that this category is a voluntary addition to the assessment, and therefore may not be completed for every species (Challender et al., 2023). The second is derived from threat codes and assessment text within IUCN Red List assessments, following a recent publication by Challender et al. (2023).

IUCN Red List Status

We derived species threat status from their global IUCN Red List assessment (IUCN, 2023) as a measure of extinction risk for traded species.

Additional risk factors

We established four additional risk factors based on expert feedback (see Annex II - Fig S1):

- Endemism as a proxy for restricted species distribution range,
- Habitat degradation, fragmentation, or conversion, which reduce population resilience to overcollection (Nañola et al., 2011; Symes et al., 2018),
- Decreasing population trends based on the IUCN Red List,
- Alternative uses (e.g., use as food, animal feed, sports fishing, or traditional medicine).

Data on additional risk factors were obtained from FishBase, GBIF, and the IUCN Red List. All four additional risks were considered equal for the prioritization, and the number of risks a species faces was not taken into account for the prioritization.

Overview of international trade

Of the 15,965 extant species of marine bony fish (Actinopterygii and Sarcopterygii), 2,667 (17%) had records in the ornamental fish trade across all databases. Of these 2,667 species, 2,622 (98.3%) are not CITES listed (based on the GBIF taxonomy). For these 2,622 non-CITES species in trade, we present a detailed analysis per data source, taxonomic and spatial distribution, trade volumes, and evidence of illegal trade.

Species in international trade per data source

The Aquarium Trade Database (Rhyne et al., 2015) contained the highest number of non-CITES species in trade, representing 82.7% of traded species (2,169 spp. including 691 spp. [31.9%] only recorded in this database; Fig. 2). We found an additional 1,423 spp. species with evidence of trade in the IUCN Red List (i.e., in the use trade section: including 268 spp. [18.8%] with trade data only available from this source). Moreover, further species were identified from selected peer-reviewed publications (1,338 spp. including 101 spp. [7.5%] only recorded from this source). Finally, only one species not listed in CITES was recorded in the CITES Trade Database and EU-TWIX confiscations, the Banggai cardinalfish (*Pterapogon kauderni*), which is listed in the EU Wildlife Trade Regulations Annex D.

Taxonomic patterns of international trade

We found 135 families represented in the trade (37.8% of all Actinopterygii and Sarcopterygii families), with several families showing larger proportions of traded species (Fig. 3). Families with the highest numbers of traded species were Labridae (321 spp., 57.8% of family diversity), Pomacentridae (237 spp., 57.6% of family diversity), and Gobiidae (231 spp., 18.4% of family diversity). Among families with more than 10 species, the families with the highest percentage of traded species were Chaetodontidae (125 spp., 94.7%), Pomacanthidae (86 spp., 94.5%), and Acanthuridae (68 spp., 81.9%). These findings suggest that these families possess attributes attractive to the aquarium trade.

Distribution of internationally traded species

Range states with the largest number of marine species identified in international trade include Indonesia (1,260 species), Australia (1,162 species), and the Philippines (1,128 species), followed by Papua New Guinea (1,045 species), Japan (1,031 species), and Malaysia (972 species; Fig. 4; Annex II - Table S1). We only indicate range states here; this does not necessarily mean that traded species are harvested and traded from all range states. Our findings align with previous studies on the main origins of aquarium fish (Biondo & Burki, 2020; Dey, 2016; Rhyne et al., 2012, 2017). For 121 species (4.6%), data on range states were not available.

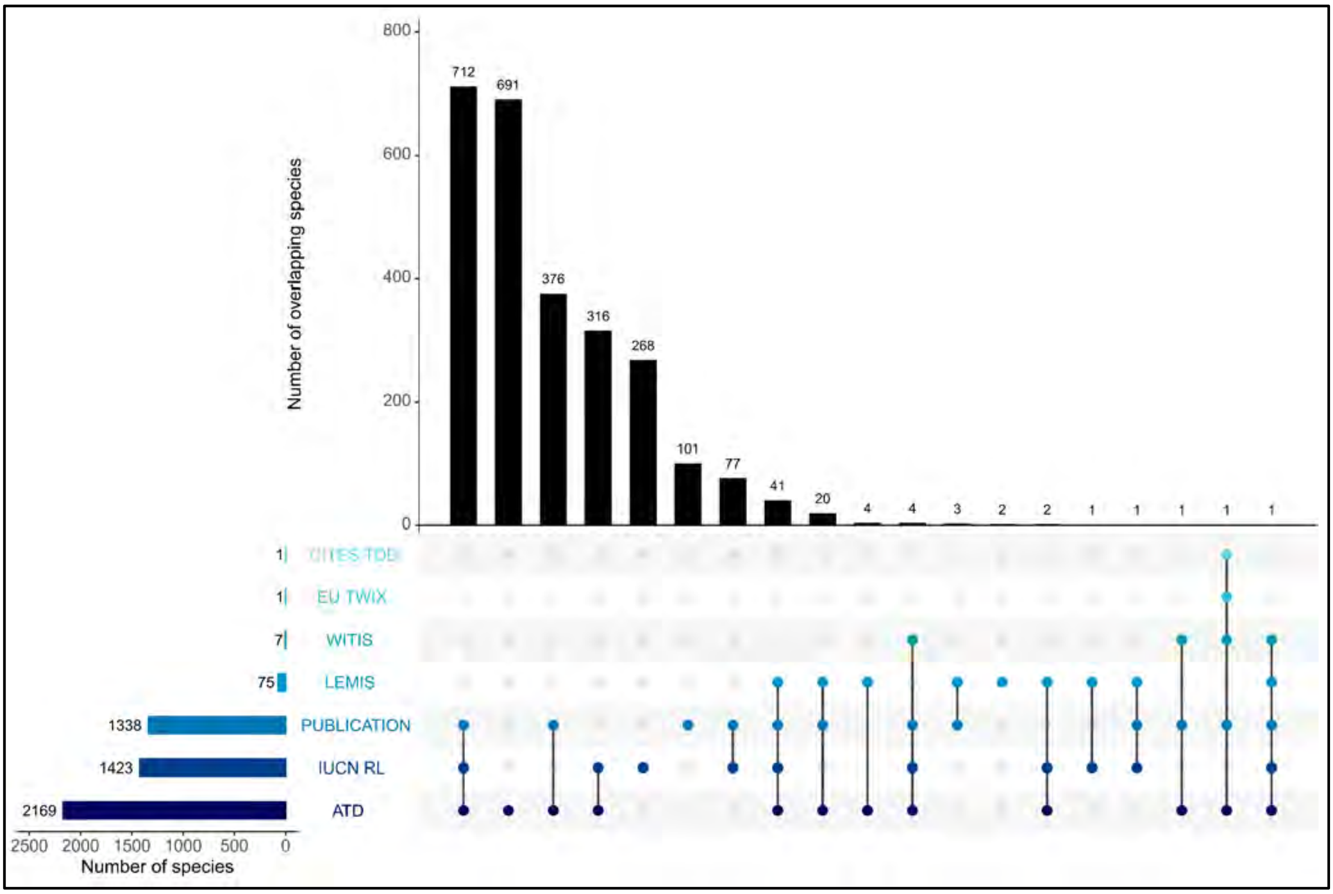

Figure 2. Number of species recorded as internationally traded per database (lower colored bar plots) and overlaps among databases (connected dots) for marine bony fish (classes Actinopterygii and Sarcopterygii). The upper black bar plots show the number of species in overlapping datasets. Note that the UNODC World Wise database is not shown as it did not include any non-CITES listed species. **CITES TDB** = CITES Trade Database, **EU TWIX** = Official European Confiscation Database, **WITIS** = TRAFFIC Wildlife Trade Information System, **LEMIS** = United States Fish and Wildlife Service Law Enforcement Management Information System, **Publication** = Six publications used to identify species in trade (Table 1), **IUCN RL** = IUCN Red List of Threatened Species (international trade as pet records), **ATD** = Aquarium Trade Database.

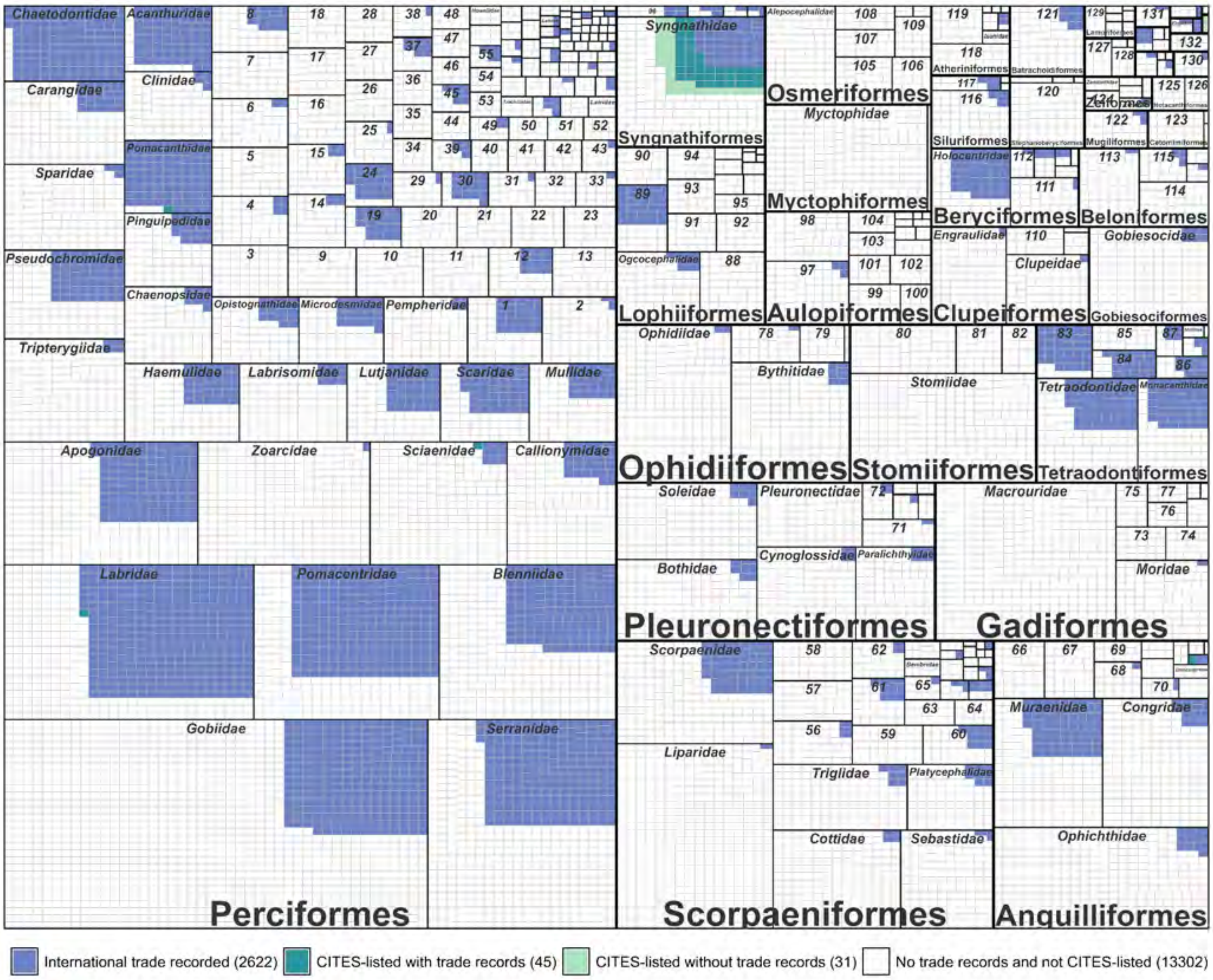

Figure 3. Treemap of bony fish internationally traded live, highlighted among 15,964 extant marine bony fish (classes Actinopterygii and Sarcopterygii). Each small square represents one species, grouped by taxonomic family (larger squares), nested in taxonomic order (thick black squares). Dark blue = species with international trade records not listed in CITES. Dark green = CITES-listed species with trade recorded in one of the databases. Light green = CITES-listed species with no records of trade. Families with more than 80 species are labeled on the graph. Families with fewer than 80 species and more than 10 were assigned a number (1-132) and listed below. Families with fewer than 10 species were not labeled.

1: Nemipteridae, 2: Stichaeidae, 3: Nototheniidae, 4: Kyphosidae, 5: Scombridae, 6: Uranoscopidae, 7: Percophidae, 8: Plesiopidae, 9: Dactyloscopidae, 10: Leiognathidae, 11: Epigonidae, 12: Malacanthidae, 13: Trichiuridae, 14: Cepolidae, 15: Lethrinidae, 16: Gerreidae, 17: Acropomatidae, 18: Artedidraconidae, 19: Cirrhitidae, 20: Sillaginidae, 21: Chiasmodontidae, 22: Ammodytidae, 23: Centrolophidae, 24: Siganidae, 25: Sphyraenidae, 26: Polynemidae, 27: Gempylidae, 28: Channichthyidae, 29: Cheilodactylidae, 30: Caesionidae, 31: Embiotocidae, 32: Bramidae, 33: Eleotridae, 34: Caproidae, 35: Caristiidae, 36: Creediidae, 37: Priacanthidae, 38: Callanthiidae, 39: Grammatidae, 40: Bathydraconidae, 41: Emmelichthyidae, 42: Stromateidae, 43: Nomeidae, 44: Draconettidae, 45: Ephippidae, 46: Pholidae, 47: Xenisthmidae, 48: Champsodontidae, 49: Pentacerotidae, 50: Symphysanodontidae, 51: Odacidae, 52: Bovichtidae, 53: Harpagiferidae, 54: Istiophoridae, 55: Trichonotidae, 56: Aploactinidae, 57: Agonidae, 58: Peristediidae, 59: Psychrolutidae, 60: Tetrarogidae, 61: Synanceiidae, 62: Cyclopteridae, 63: Neosebastidae, 64: Hoplichthyidae, 65: Hexagrammidae, 66: Nettastomatidae, 67: Synaphobranchidae, 68: Chlopsidae, 69: Muraenesocidae, 70: Moringuidae, 71: Samaridae, 72: Achiridae, 73: Merlucciidae, 74: Lotidae, 75: Gadidae, 76: Bregmacerotidae, 77: Phycidae, 78: Carapidae, 79: Aphyonidae, 80: Sternoptychidae, 81: Gonostomatidae, 82: Phosichthyidae, 83: Balistidae, 84: Ostraciidae, 85: Triacanthodidae, 86: Diodontidae, 87: Aracanidae, 88: Oneirodidae, 89: Antennariidae, 90: Lophiidae, 91: Chaunacidae, 92: Linophrynidae, 93: Gigantactinidae, 94: Himantolophidae, 95: Brachionichthyidae, 96: Centriscidae, 97: Synodontidae, 98: Paralepididae, 99: Ipnopidae, 100: Scopelarchidae, 101: Chlorophthalmidae, 102: Notosudidae, 103: Aulopidae, 104: Paraulopidae, 105: Platytroctidae, 106: Argentinidae, 107: Bathylagidae, 108: Microstomatidae, 109: Opisthoproctidae, 110: Pristigasteridae, 111: Trachichthyidae, 112: Berycidae, 113: Exocoetidae, 114: Hemiramphidae, 115: Belonidae, 116: Ariidae, 117: Plotosidae, 118: Atherinidae, 119: Atherinopsidae, 120: Melamphaidae, 121: Batrachoididae, 122: Mugilidae, 123: Cetomimidae, 124: Oreosomatidae, 125: Halosauridae, 126: Notacanthidae, 127: Monognathidae, 128: Saccopharyngidae, 129: Trachipteridae, 130: Ateleopodidae, 131: Albulidae, 132: Polymixiida.

Trade volumes

While it was not possible to acquire global trade quantities, we obtained import data for limited periods from three major importers: the US (2004-2011), Switzerland (2013), and the EU (2014-2017). These trade data covered 2,357 species (89.9% of internationally traded species) with 2,179 species (83.1%) present in US records, 1,295 (49.4 %) in EU records, and 432 (16.5%) in Swiss records. This leaves 265 species in our study without known trade volumes. Additionally, we are missing comprehensive import quantities from other major importers and exporting countries.

Illegal trade

The TRAFFIC WiTIS database only records seven seized species with four incidents from 2008-2021, accounting for 18,852 seized individuals. Only one species, the Banggai cardinalfish (*Pterapogon kauderni)* was reported in EU TWIX as it is listed under Annex D in the EU Wildlife Trade Regulations. The UNODC World Wise database did not record any confiscations of non-CITES-listed marine species. The lack of confiscation records across these databases highlights a lack of either confiscation reporting or enforcement efforts for marine ornamental fish as well as the limited legal regulations in place for this trade.

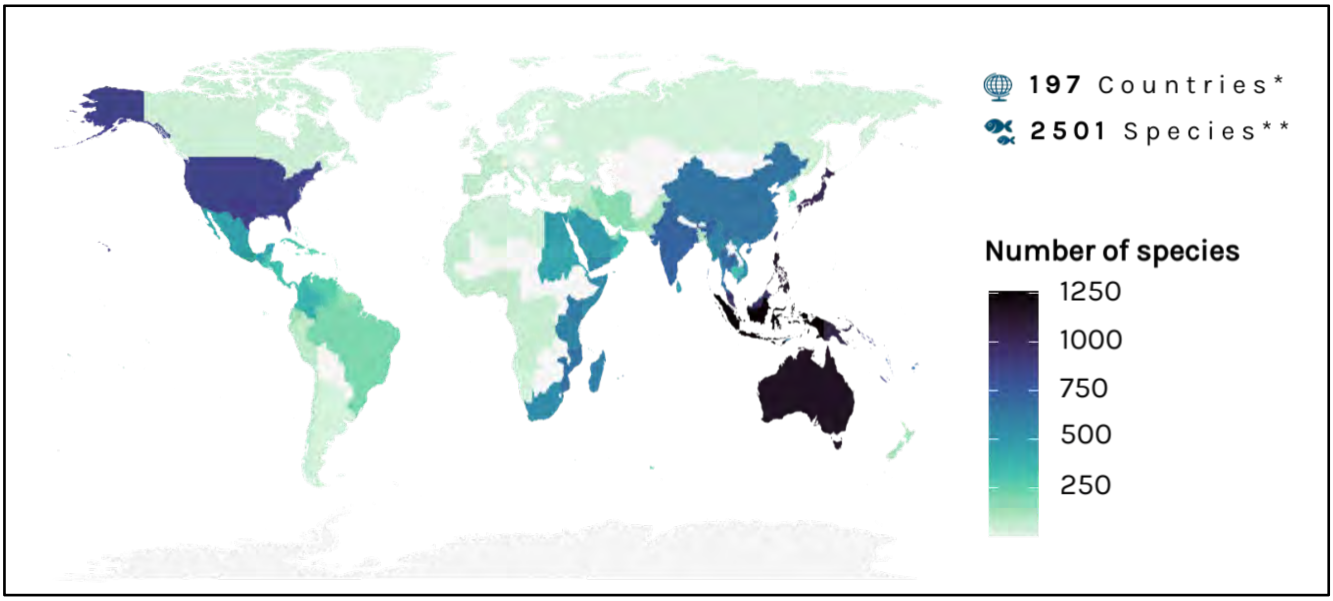

Figure 4. Number of traded marine species per range state based on the IUCN Red List and GBIF distribution data. The data presented here do not indicate trade routes. Made with the R package *ggmap* (Kahle & Wickham, 2013). *The figure shows 197 countries and territories. **For 121 of the 2,622 species in international trade distribution, data were not available at the country level in the IUCN Red List or GBIF.

Prioritizing species for research to inform CITES listing amendments

Research prioritization results

We assigned species to five research priority categories A-E, with A being the highest and E the lowest research priority (see Table 3). An overview of the steps and summary of the results of the research prioritization can be found in Figure 5 while the assignment of each species to a research priority category can be found in Annex I.

Based on significant trade volumes into the US (more than 10,000 individuals imported over 4 years), we included 255 species in research priority category **A**. This includes one species (0.4% of priority **A** species) listed as Endangered (**EN**) on the IUCN Red List, 4 Vulnerable (**VU**) species (1.5%), 235 Least Concern (**LC**) species (92.2%), 8 Not Evaluated (**NE**) species (3.1%), and 7 Data Deficient (**DD**) species (2.7%). It is important to stress that LC species could potentially become threatened by unsustainable international trade if trade were to rapidly deplete populations and lead to a deterioration in species conservation status. As such we believe these species are a priority for research in line with Article II (1 and 2) of the CITES Convention.

Category **B** includes 2 species (1.1%) listed as Critically Endangered (**CR**) on the IUCN Red List, 4 EN species (2.2%), 36 VU species (19.4%), 23 Near Threatened (**NT**) species (12.4%), 30 LC species (16.1%), 67 (36 %) DD, and 24 (12.9%) NE species. These species have either been identified by the IUCN Red List or by Challender et al., (2023) as threatened or likely to be threatened by international trade; or face at least one of the four additional risk factors that may predispose species to threats, such as overexploitation. Of the species categorized as globally threatened by the IUCN Red List (CR, EN, or VU) in Category **B,** 26 species were not assessed as threatened by international trade in the above assessments.

Category **C** contains all DD (53 spp.) and NE (108 spp.) species for which we did not identify other risk factors. Following the recommendation of the IUCN Red List, we considered DD and NE species to be of higher priority compared to their LC counterparts (IUCN, 2012). No NT species were assigned to this category as all NT species were assigned to category **B** based on other risk factors.

We assigned 704 LC species based on the presence of at least one additional risk factor to Category **D** (Annex II - Table S2). The remaining LC species (1,316 spp.) not assigned to categories **A**, **B,** or **D** were assigned the lowest research priority category **E**. Species assigned in categories **C**, **D**, and **E** may still merit further research, however, given limited research funding, we consider this research of lower priority.

Table 3. Overview of the criteria used to assign research priority categories to 2,622 marine ornamental fish not listed by CITES but with evidence of international trade. Additional risk factors are based on data extracted from the IUCN Red List, FishBase, and GBIF: 1) endemism, 2) habitat degradation, fragmentation, or conversion, 3) decreasing population trend, and 4) alternative uses (e.g., for food, animal feed, sports fishing, or medicine). Species can only be assigned to one of five categories. All four additional risks were considered as equal for this project, and the number of risks a species faces was not taken into account for the prioritization.

<table>
<tr><th>Research Priorities</th><th>Criteria for assigning research priorities to marine ornamental fish species</th></tr>
<tr><td>A</td><td>Species that have significant import volumes recorded into the US (i.e., species with over 10,000 individuals imported between 2004-2011).</td></tr>
<tr><td>B</td><td>Species that
● are identified as threatened by international trade by the IUCN Red List or
● identified as likely to be threatened by international trade by Challender et al., (2023)
OR
● are NOT identified in the category above, BUT
● are globally threatened (Critically Endangered, Endangered or Vulnerable) on the IUCN Red List
OR
● are assessed as Near Threatened (NT) or Data Deficient (DD) or have not been evaluated (NE) by the IUCN Red List and are assigned at least one additional risk factor (see table caption)</td></tr>
<tr><td>C</td><td>Species that
● are NOT identified in the two categories above
● are assessed as NT or DD or NE by the IUCN Red List and are NOT assigned one additional risk factor (see table caption)</td></tr>
<tr><td>D</td><td>Species that
● are NOT identified in the three categories above
● assessed as LC by the IUCN Red List and are assigned at least one additional risk factor (see table caption).</td></tr>
<tr><td>E</td><td>Species that
● are NOT identified in the four categories above
● assessed as LC and are NOT assigned an additional risk factor (see table caption)</td></tr>
</table>

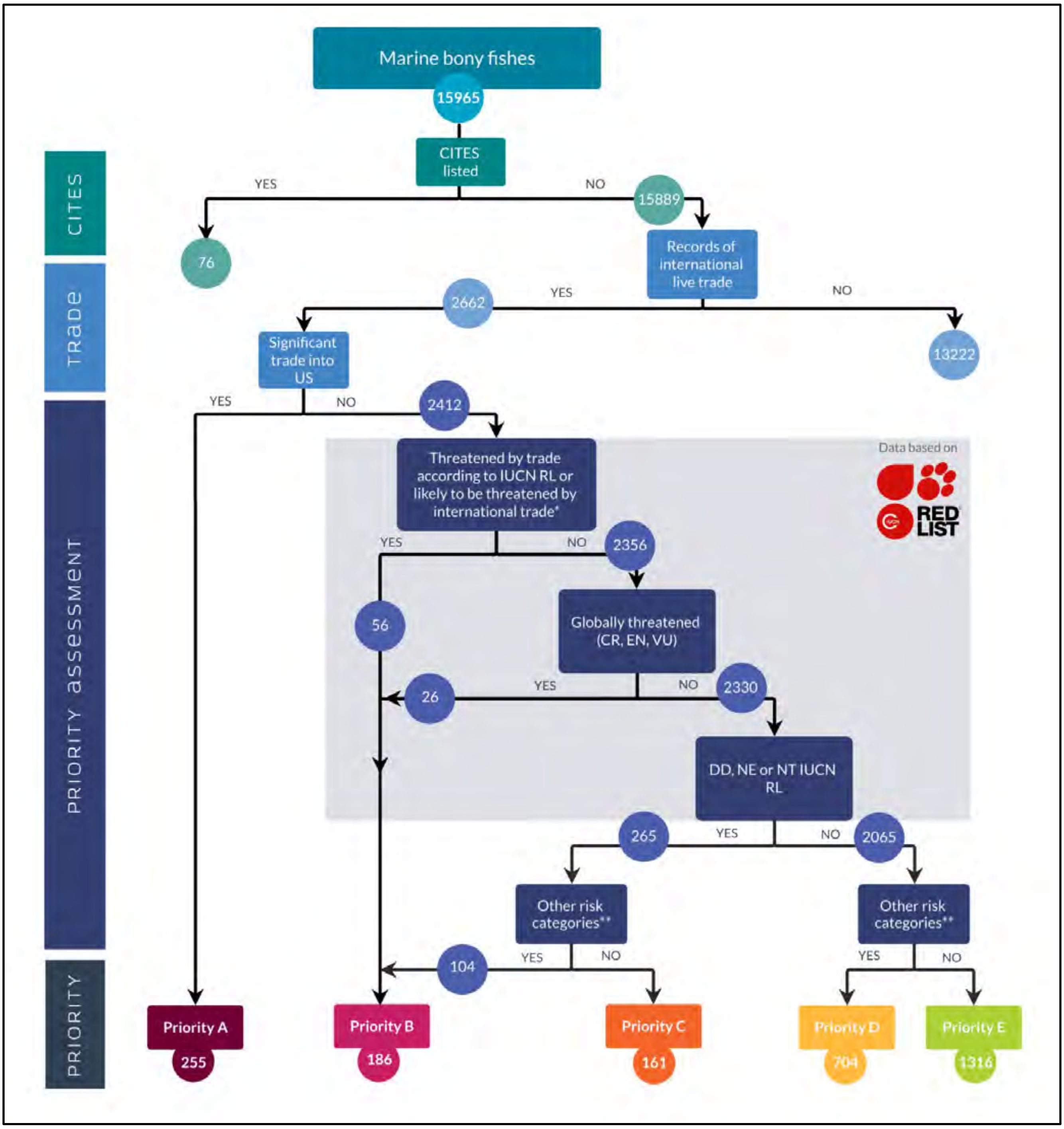

Figure 5. Research prioritization framework for 15,964 marine bony fish species in the international aquarium trade that require further research to inform potential amendments to CITES listings (based on the GBIF taxonomy). Significant trade into the US based on Rhyne et al., (2015) Aquariumtradedata.org. CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, DD = Data Deficient, NE = Not Evaluated. *Challender et al., (2023). **Based on four additional risk factors: 1) endemism (IUCN Red List and GBIF), 2) habitat degradation, fragmentation, or conversion (IUCN Red List), 3) decreasing population trend (IUCN Red List), and 4) alternative uses as human food, sport fishing or traditional medicine (FAO, IUCN Red List, and FishBase). Category listing of these species can be found in the accompanying spreadsheet in Annex I.

Research priority by family

Considering only families with more than 10 traded species, the families with the highest relative number of species in research priority A are Cirrhitidae (6 spp., 50.00%), Pomacanthidae (24 spp., 28%), and Pomacentridae (61 spp., 25.7%; Fig. 6). This indicates the high trade volumes in these families to the US (Fig.6). Labridae was the most species-rich family in trade overall. However, only 9.4% (30 spp.) of Labridae species were categorized as research priority A, while the majority was assigned to research priority E (165 spp., 51.4%). Similarly, for the Pomacentridae and Gobiidae, 43.8% (104 spp.) and 64.5% (151 spp.) of traded species were assigned to the lowest research priority E, respectively.

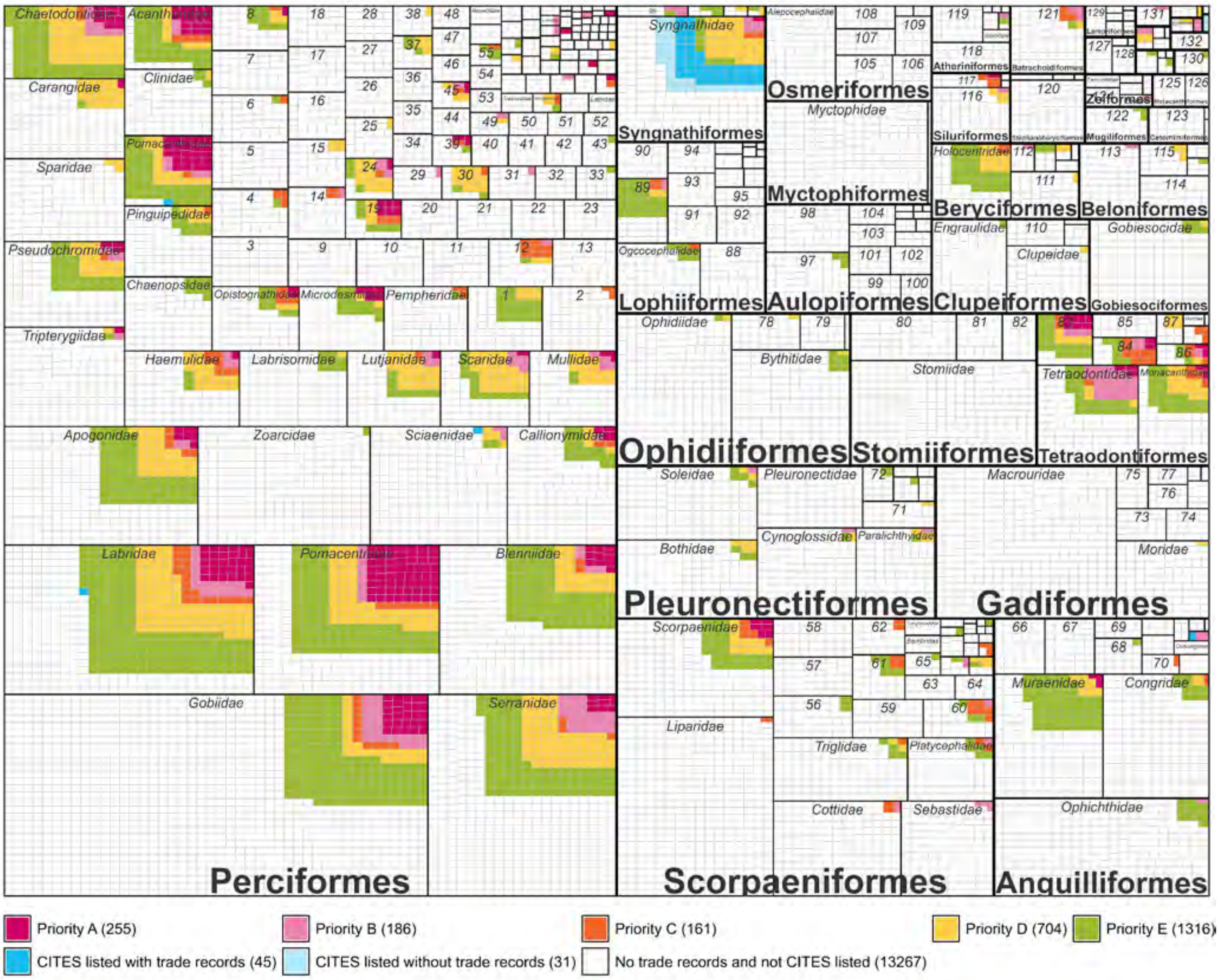

Figure 6. Treemap of research priority categories for internationally traded marine aquarium fish among 15,965 extant marine bony fish. Each small square represents one species, grouped by taxonomic family (larger squares), nested in taxonomic order (thick black squares). Species are colored by their priority for research on the sustainability of trade based on the decision framework (Fig. 4). Dark red = Priority A, Pink = Priority B, Orange = Priority C, Yellow = Priority D, Green = Priority E, Blue = CITES-listed species with trade recorded in one of the databases. Light blue = CITES-listed species with no records of trade. Families with more than 80 species were labeled on the graph. Families with fewer than 80 species and more than 10 were assigned a number (1-132) and listed below. Families with fewer than 10 species were not labeled.

1: Nemipteridae, 2: Stichaeidae, 3: Nototheniidae, 4: Kyphosidae, 5: Scombridae, 6: Uranoscopidae, 7: Percophidae, 8: Plesiopidae, 9: Dactyloscopidae, 10: Leiognathidae, 11: Epigonidae, 12: Malacanthidae, 13: Trichiuridae, 14: Cepolidae, 15: Lethrinidae, 16: Gerreidae, 17: Acropomatidae, 18: Artedidraconidae, 19: Cirrhitidae, 20: Sillaginidae, 21: Chiasmodontidae, 22: Ammodytidae, 23: Centrolophidae, 24: Siganidae, 25: Sphyraenidae, 26: Polynemidae, 27: Gempylidae, 28: Channichthyidae, 29: Cheilodactylidae, 30: Caesionidae, 31: Embiotocidae, 32: Bramidae, 33: Eleotridae, 34: Caproidae, 35: Caristiidae, 36: Creediidae, 37: Priacanthidae, 38: Callanthiidae, 39: Grammatidae, 40: Bathydraconidae, 41: Emmelichthyidae, 42: Stromateidae, 43: Nomeidae, 44: Draconettidae, 45: Ephippidae, 46: Pholidae, 47: Xenisthmidae, 48: Champsodontidae, 49: Pentacerotidae, 50: Symphysanodontidae, 51: Odacidae, 52: Bovichtidae, 53: Harpagiferidae, 54: Istiophoridae, 55: Trichonotidae, 56: Aploactinidae, 57: Agonidae, 58: Peristediidae, 59: Psychrolutidae, 60: Tetrarogidae, 61: Synanceiidae, 62: Cyclopteridae, 63: Neosebastidae, 64: Hoplichthyidae, 65: Hexagrammidae, 66: Nettastomatidae, 67: Synaphobranchidae, 68: Chlopsidae, 69: Muraenesocidae, 70: Moringuidae, 71: Samaridae, 72: Achiridae, 73: Merlucciidae, 74: Lotidae, 75: Gadidae, 76: Bregmacerotidae, 77: Phycidae, 78: Carapidae, 79: Aphyonidae, 80: Sternoptychidae, 81: Gonostomatidae, 82: Phosichthyidae, 83: Balistidae, 84: Ostraciidae, 85: Triacanthodidae, 86: Diodontidae, 87: Aracanidae, 88: Oneirodidae, 89: Antennariidae, 90: Lophiidae, 91: Chaunacidae, 92: Linophrynidae, 93: Gigantactinidae, 94: Himantolophidae, 95: Brachionichthyidae, 96: Centriscidae, 97: Synodontidae, 98: Paralepididae, 99: Ipnopidae, 100: Scopelarchidae, 101: Chlorophthalmidae, 102: Notosudidae, 103: Aulopidae, 104: Paraulopidae, 105: Platytroctidae, 106: Argentinidae, 107: Bathylagidae, 108: Microstomatidae, 109: Opisthoproctidae, 110: Pristigasteridae, 111: Trachichthyidae, 112: Berycidae, 113: Exocoetidae, 114: Hemiramphidae, 115: Belonidae, 116: Ariidae, 117: Plotosidae, 118: Atherinidae, 119: Atherinopsidae, 120: Melamphaidae, 121: Batrachoididae, 122: Mugilidae, 123: Cetomimidae, 124: Oreosomatidae, 125: Halosauridae, 126: Notacanthidae, 127: Monognathidae, 128: Saccopharyngidae, 129: Trachipteridae, 130: Ateleopodidae, 131: Albulidae, 132: Polymixiida.

Incorporating trade volumes

Our analysis heavily relies on the IUCN Red List data, the most comprehensive global database on species extinction risk. While both, CITES listings and Red List share similar biological criteria, the Red List's direct application to CITES decisions may be limited, as it primarily focuses on overall extinction risk, while trade only plays a minor role.

To address this limitation, we found that combining threat parameters (e.g., IUCN RL status, trade as threat, habitat degradation) with trade volume data in the research prioritization framework was crucial to highlight non-threatened species with high trade volumes, that may be susceptible to rapid population declines if trade is found to be unsustainable (Kamp et al., 2015; Nañola et al., 2011; Stanton, 2014).

To illustrate the influence of trade volume data on the research prioritization results, we assessed changes in prioritization results when trade volumes were removed, only including species' evidence of trade and extinction risk parameters (based on IUCN Red List assessments, GBIF, FishBase, and FAO). We then compared results with the prioritization framework including US trade volumes (Fig. 5). Excluding trade volumes generally resulted in species being categorized into lower research priorities (337 species; Fig. 7). In particular, the number of LC species in category **A** decreased from 253 to 39, highlighting that many of these species would be overlooked when trade volumes are not considered. The overall number of species in research priority **A** also decreased from 255 to 68 when trade quantities were not taken into account.

These results highlight the need to include trade quantities in research prioritization exercises to ensure highly traded species are identified and prioritized accordingly. We demonstrate the importance of integrating multiple databases in prioritization assessments to fill information gaps (e.g., those of the IUCN RL).

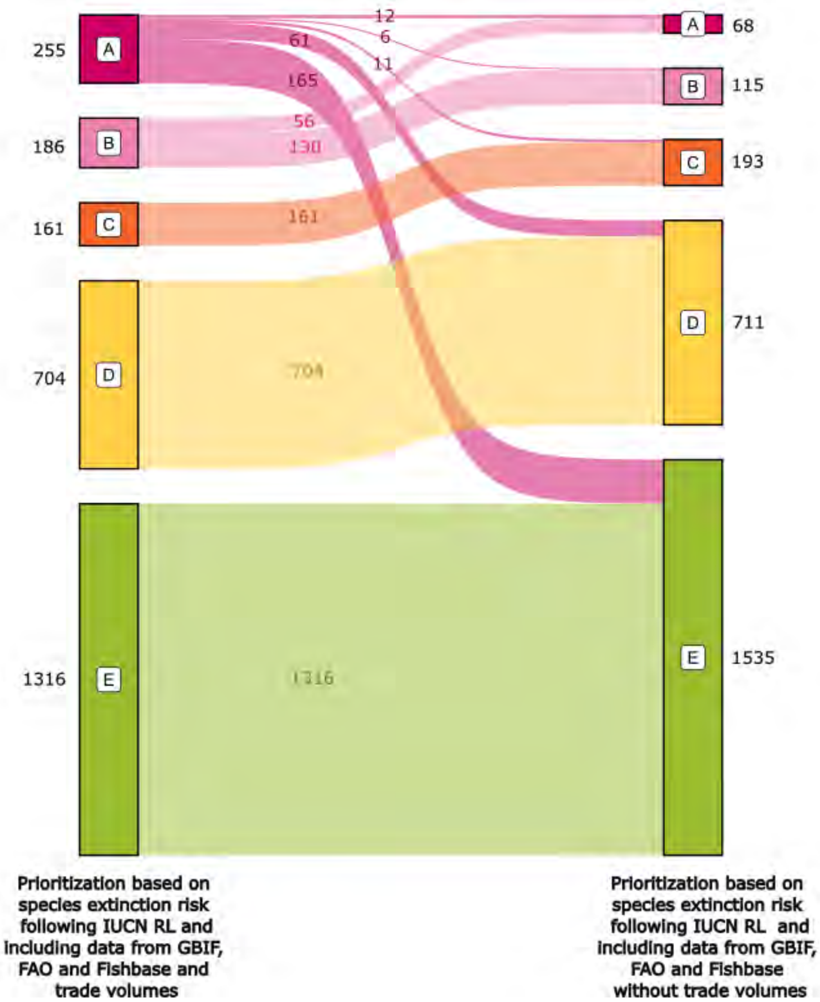

Figure 7. Movement of species between research priorities when trade volumes (US) are included. Note that all species in categories **D** and **E** are Least Concern.

Next steps in assessing research priority species

While an in-depth assessment of all research priority species was beyond the scope of this study, we propose a framework aimed at assessing the sustainability of international trade for prioritized species, beginning with those in research priority A (Fig. 8). The proposed framework can be a starting point to optimize resource allocation for assessing trade sustainability, thereby ensuring effective international regulations and maximizing species conservation outcomes and ensuring the success of CITES, as suggested by Cooney et al. (2021).

Many organizations and governmental bodies perform independent assessments of trade impacts on species of concern (e.g., the US Fish and Wildlife Service, previous CITES proposals, NDFs). Given limited funding resources and time, we suggest utilizing and integrating existing assessments in the next steps of assessing trade sustainability for priority species (e.g., category A-C), rather than initiating new evaluations. Our recommended process for assessing trade sustainability is detailed in Figure 8 and further explained in Box 3.

Box 3. Proposed framework to assess the sustainability of the international trade for research priority species

For any given species (Fig. 8):

1. Identify if a previous trade assessment on the impact of international trade on species survival or the survival of particular populations exists.

    1.1 If the assessment found a significant risk of population declines due to international trade, then:

    1.2 investigate if there is active management and/or monitoring of species populations in some or all range states.

        1.2.a If this is the case, then no new assessments are needed.

        1.2.b If species populations are not managed and monitored, then assessments of the impact of the trade and potential sustainable management will be urgent to assess the scope and consider whether CITES listing will be beneficial to species conservation.

    1.3 If a current assessment has identified that international trade does not pose a significant risk to species populations, then no additional studies are presently needed.

2. If no previous or current assessment exists on the impact of international trade on the sustainability of species populations, we recommend that Parties, stakeholders, and experts evaluate data availability:

    2.1. If there is data available (even if limited), some approaches (e.g., Productivity-Susceptibility Analysis) can be used. In this case, an assessment should be performed to indicate whether trade regulations and population management are likely to improve species conservation outcomes.

    2.2 If there is no data available, then Parties, experts, and stakeholders should prioritize data collection and perform a robust assessment.

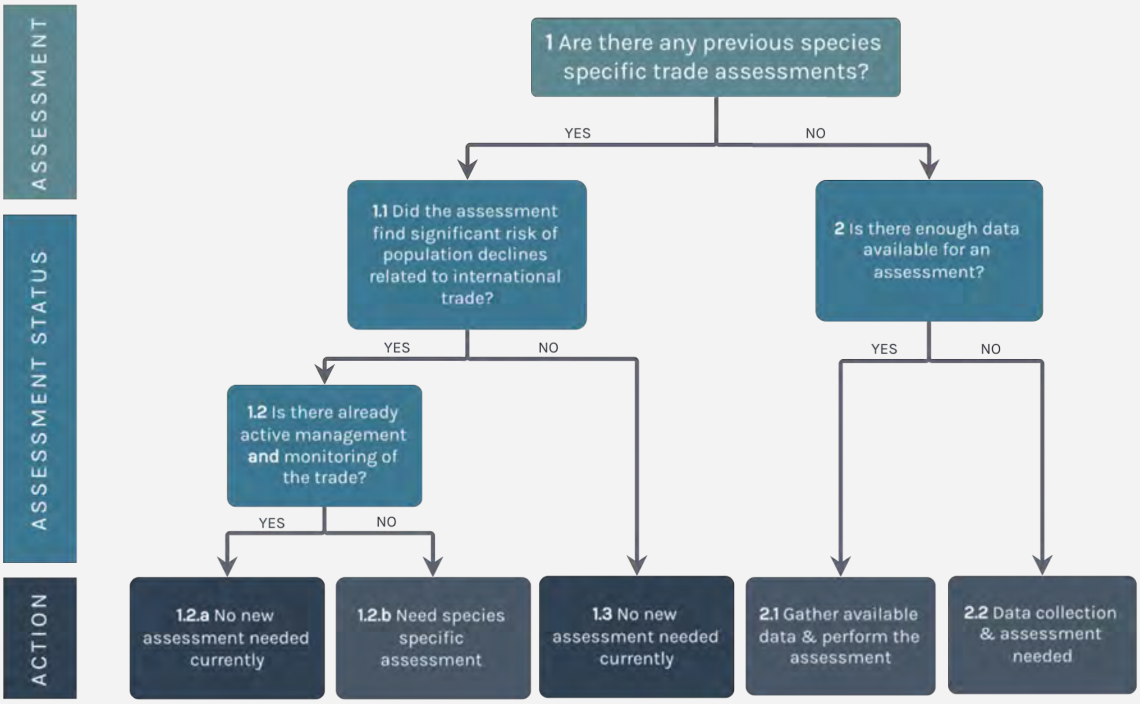

Figure 8. Potential steps for a standardized trade assessment procedure to prioritize research for marine aquarium fish species.

Species with potential for captive breeding

Several species in the research prioritization framework are available from commercial breeding enterprises, have successfully been bred in captivity, or are currently being bred (e.g., in aquaria and zoos, or by aquarium hobbyists). Captive breeding availability was suggested during the expert workshops as an opportunity to move a species to a lower-priority category. However, species may still be sold wild-caught even if commercially bred counterparts are available, as prices for wild-caught specimens are often lower and some hobbyists may prefer wild-caught individuals for different reasons (Ani Mardiastuti & Soehartono, 2020; Moorhead & Zeng, 2010; Pouil et al., 2020). Since this may be species- and site-specific, this area warrants further research. Therefore, we decided to not move species with captive-breeding availability to a lower research priority in our research prioritization framework and did not include captive-breeding in our prioritization.

Nevertheless, information on successful captive breeding is important to investigate trade sustainability. Here, we collated data on commercial captive breeding in the US across all families (Sweet & Pedersen, 2019). Additionally, we included successful and/or commercial captive breeding in Japan for the families Chaetodontidae and Pomacanthidae as of 2022 (Satoru Matsumura, Tokyo Sea Life Park, personal communication, Table 4). We also included the captive breeding data published by UNEP-WCMC (UNEP-WCMC, 2022) which includes Sweet & Pedersen's data as well as additional sources. Overall, we found that a total of 350 species, not currently listed in CITES, have been bred in captivity previously. Among these 110 species are commercially available as captive-bred in the US (Sweet & Pedersen, 2019). Additionally, a total of 12 species from the families Chaetodontidae and Pomacanthidae are commercially available in Japan, including two species (*Pomacanthus xanthometopon* and *Epinephelus fasciatus*) not reported as commercially captive bred in the US (Satoru Matsumura, Tokyo Sea Life Park, personal communication, Table 4).

For research priority **A,** 44 species are commercially available as captive-bred in the US. Of those, 22 species are commonly available, and 13 species are available at low to moderate levels (Table S3), while four are also commercially bred in Japan. For the remaining research priorities **B-E,** we found that 224 species have been successfully bred in captivity (Table 4). Species-specific captive breeding information can be found in Annex 2. While other species may also be captive bred, our study only had access to information from Japan and the US, omitting important consumer and supply markets, such as the EU.
We also provide captive breeding data on CITES-listed species in Annex II (Supplementary material S3).

Table 4. Number of species with reported captive breeding categorized by research priority (indicated by the same color scheme as in Figure 5) based on commercial captive breeding in the US across all families (Sweet & Pedersen, 2019), CoP19 Inf. 99 captive breeding records (UNEP-WCMC, 2022) and successful *ex-situ* and commercial breeding in Japan for the families Chaetodontidae and Pomacanthidae (Satoru Matsumura, Tokyo Sea Life Park, personal communication). Note that the total row does not sum to row-wise total as species can be present in more than one category and data availability is given for each category separately.

Research Priority	Total	Has been bred in captivity*		US commercial captive-breeding		Japan commercial breeding	
		Yes	No	Yes	No	Yes	No data
A	255	126	129	44	211	4	251
B	186	18	168	4	182	1	185
C	161	3	158	2	159	0	161
D	704	80	624	25	679	2	702
E	1316	123	1193	35	1281	5	1311
Total	2622	350	2272	110	2512	12	2610

*based on CORAL Magazine's Captive-Bred Marine Fish Species List, Tokyo Sea Life Park in-house breeding of Chaetodontidae and Pomacanthidae and UNEP-WCMC 2022

Zoo & aquarium holdings

Public aquaria play a crucial and multifaceted role in the trade of aquatic organisms. They actively engage in the trade as discerning consumers, but also serve as instrumental agents in advancing research and promoting public education about the myriad of anthropogenic stressors that threaten coral reef ecosystems (Cassiano et al., 2015; Tlusty et al., 2013). Therefore, we gathered data on the presence of traded species in the Species360 Zoological Information Management System (ZIMS) holdings of Species360's aquarium members (Species360, 2021). The presence of a species in global zoo and aquarium records (e.g., ZIMS) does not necessarily mean that the species is being successfully bred in captivity or that the species can be commercially bred. However, this assessment can help identify species for which public aquaria can contribute to breeding and biological research, in addition to helping prioritize collection planning to support species conservation.

To date, Species360 members hold 1,132 (43.2%) of the 2,622 traded non-CITES listed species (Fig. 9). This includes 242 Priority **A** (94.9% of the category), 68 Priority **B** (36.6%), 44 Priority **C** (27.3%), 306 Priority **D** (43.5%), and 472 Priority **E** species (35.9%). Holding sizes varied from 1 individual to thousands, with the green chromis (*Chromis viridis*) having the biggest holding size of 10,072 individuals alive in 2022 in Species360's member institutions (Fig. 9). The species held by most institutions were *Amphiprion* *ocellaris* (163 institutions), *Paracanthurus hepatus* (134 institutions), and *Zebrasoma flavescens* (129 institutions), followed by *Chromis viridis* (104 institutions) and *P. kauderni* (99 institutions). Additionally, ZIMS data records births of 19 species in 2021 with 4 of these not recorded in any of the other captive breeding sources above, namely *Ocyurus chrysurus* (25 births), *Lutjanus kasmira* (21 births), *Parapriacanthus ransonneti* (3 births) and *Haemulon aurolineatum* (3 births). It should be noted that the recording of successful breeding of marine ornamental fish can be difficult due to multiple factors including technical requirements for fish culture systems, specialized food requirements, the nature of reproduction, challenges associated with multiple developmental stages, the small size of juveniles, and collection of gametes in big exhibits with multispecies holdings.

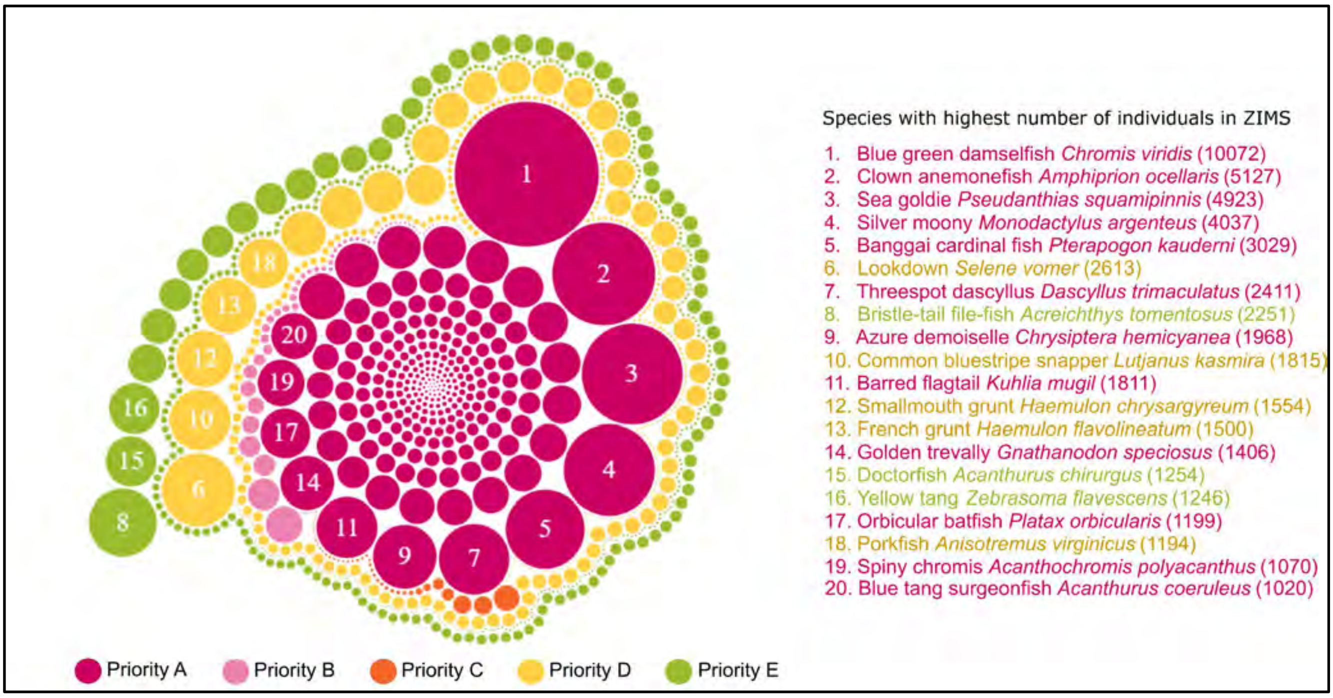

Figure 9. Population size of ZIMS holdings for traded species. Colors correspond to the assigned research priority; dark pink= Priority A, light pink = Priority B, orange = Priority C, yellow = Priority D, green = Priority E. The size of the circle corresponds to the number of individuals recorded in ZIMS. The 20 species with the largest holdings are listed with the number of individuals in ZIMS and colored based on their assigned priority. The full list of species and holding sizes is available in the supporting research prioritization spreadsheet (Annex I).

Data on Species360 holdings for CITES-listed species can be found in Annex II (Supplementary Material S3).

Data limitations of the Marine Ornamental Fish SKI

This document has several limitations, mainly resulting from the lack of comprehensive data sources. Therefore, we have identified several data gaps, biases, and assumptions, including:

- Taxonomic issues to integrate species across databases, for example, the taxonomic system adopted by the GBIF recognizes more species in the genus *Hippocampus* than the CITES taxonomy. Likewise, the IUCN Red List uses a different taxonomy. Additionally, we did not consider subspecies.
- There is no centralized trade monitoring system for aquarium fish, so species may have been overlooked if they were not present in the data sources used in this study.
- Data are biased towards two major marine aquarium fish importers (US and EU), as we did not have access to comprehensive data from other importer or exporter regions.
- Information on trade volumes was lacking for most regions and species.
- Due to the lack of reliable global trade volumes, we used US trade data in our analysis. In the future, it will be necessary to expand this to other major import and export regions to assess global trade volumes reliably.
- As the prioritization framework presented here relies heavily on IUCN Red List data, species not yet evaluated by the IUCN Red List or with outdated assessments (see Annex II - Supplementary Material S2) may not be accurately classified in the research prioritization. Additionally, global IUCN Red List data may not always be the most suitable assessment of fish species' extinction risk (FAO, 2022)
- As most traded species are not protected or regulated internationally, seizure data from confiscations were limited. Additionally, seizures were often not identified at the species level but only at higher taxonomic levels.
- Other species than those presented here may be captive-bred or housed by aquaria that are not members of Species360.
- English-language sources dominated the data record, but more information might be available in other languages (Amano et al., 2021).
- The Marine Ornamental Fish SKI is currently static, meaning that computational routines must be re-run to extract, standardize, and map the data to obtain updated results. To support policymakers and conservation practitioners, we suggest regularly updating this data.

Recommendations for CITES Parties

Improve reporting of trade volumes

We recommend that both importer and exporter countries improve reporting and data collection for all traded species, as trade data are severely lacking, hindering assessments of the sustainability of global trade.

Investigate mortality of animals in the supply chain

We recommend investigating mortality rates across supply chains as these may be substantial for some species and supply chains (Militz et al., 2016; Stevens et al., 2017) leading to increased harvesting rates for the affected species.

Action for species in research priorities A and B

For the 255 species in research priority **A** and the 186 species in priority **B** we suggest further analysis of species at risk, e.g. using Productivity Susceptibility Analysis (Baillargeon et al., 2020) to identify those needing the most attention. Parties with adequate resources should also include the 161 species categorized as research priority **C** in these efforts.

Develop standardized assessment templates

We recommend developing a standardized assessment template to expedite the evaluation of trade sustainability for this species-rich group.

Connect data sources

We highlight the need to improve connectedness between information sources. We acknowledge the challenge of integration given taxonomic differences. However, liaising with the Catalogue of Life Governance Working Group is recommended, as they develop strategies to set standards to support database integration at the species level.

Investigating the feasibility of captive breeding

We recommend continuing and supporting efforts of developing and improving captive breeding and husbandry practices for marine ornamental fish species and investigating the feasibility of expanding these activities while preserving local livelihoods in species' range states.

Consider alternative management measures

A CITES listing may not be the most effective conservation tool for many species to achieve successful conservation outcomes. Range states could consider whether management tools other than (or in addition to) CITES listing (e.g., monitoring, restricted fishing, or catch quotas) may be effective in ensuring long-term sustainable trade and securing local livelihoods.

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Annex I - Research Prioritization Spreadsheet

All data used for the prioritizations as well as prioritization assignments for all 2,622 non-CITES listed species identified in the trade are available in the research prioritization spreadsheet (Annex I). A detailed description of the data available in the spreadsheet can be found in Table A1.

Table A1. Description and data sources for each column in the research prioritization spreadsheet.

Column	Description	Data Source
ResearchPriority	Research priority category assigned based on the presented research priority framework	Research prioritization framework
Subcategory	Indicates through which step in the framework the species was assigned to the respective category	Research prioritization framework
Species	Species scientific name	GBIF backbone taxonomy (GBIF Secretariat, 2023)
Common name	Common name in Englis	GBIF backbone taxonomy (GBIF Secretariat, 2023)
Order	Order	GBIF backbone taxonomy (GBIF Secretariat, 2023)
Family	Family	GBIF backbone taxonomy (GBIF Secretariat, 2023)
Genus	Genus	GBIF backbone taxonomy (GBIF Secretariat, 2023)
other Risks	Indicates which other risk category was assigned to the species. decreasingPop = Decreasing population trend; other uses = species is used for other purposes e.g. food, sports fishing; endemic = species is endemic; habitatfactors = species is threatened by habitat conversion, degradation, or fragmentation	IUCN Red List (IUCN, 2023), GBIF (GBIF, 2023), FAO (FAO, 2021), FishBase (FishBase, 2019)
Number of other Risks	Number of other risks identified	IUCN Red List (IUCN, 2023), GBIF (GBIF, 2023), FAO (FAO, 2021), FishBase (FishBase, 2019)
IUCN Red List Status	IUCN Red List status	IUCN Red List (IUCN, 2023)
IUCN Red List Status number of threats	Number of threats according to the IUCN Red List	IUCN Red List (IUCN, 2023)

Column	Description	Data Source
IUCN Red List Status Assessed	Year of last IUCN Red List assessment	IUCN Red List (IUCN, 2023)
US captive breeding availability	Commercial captive breeding availability following Sweet & Pedersen 2019	Sweet & Pedersen 2019
Japan commercial breeding	Commercial captive breeding availability for the families Chaetodontidae and Pomacanthidae (Satoru Matsumura, Tokyo Sea Life Park, personal communication)	Satoru Matsumura, Tokyo Sea Life Park, personal communication
TokyoSeaLifePark captive breeding	In house captive breeding for the families Chaetodontidae and Pomacanthidae at Tokyo Sea Life Park (Satoru Matsumura, Tokyo Sea Life Park, personal communication)	Satoru Matsumura, Tokyo Sea Life Park, personal communication
WCMC Evidence of captive breeding	Evidence of captive breeding based on the UNEP-WCMC report	UNEP-WCMC, 2022
ZIMS holdings	Number of individuals held by Species360 member institutions	Species360, 2021
TradeDB	Indicates which trade database the species was recorded in	See Box 1
Range States	Range state of the species	IUCN Red List, GBIF
ATD US imports 2004-11	Trade volumes recorded in the Aquarium Trade Database 2004-2011	Rhyne et al., 2015; www.aquariumtradedata.org
TRACES EU imports 14-17	Trade volumes recorded in EU TRACES between 2014-2017	Biondo & Burki, 2019
CH imports 13	Trade volumes reported into Switzerland in 2009	Biondo, 2018

Annex II - Supplementary materials

Supplementary Material S1 - Supplementary Figures and Tables

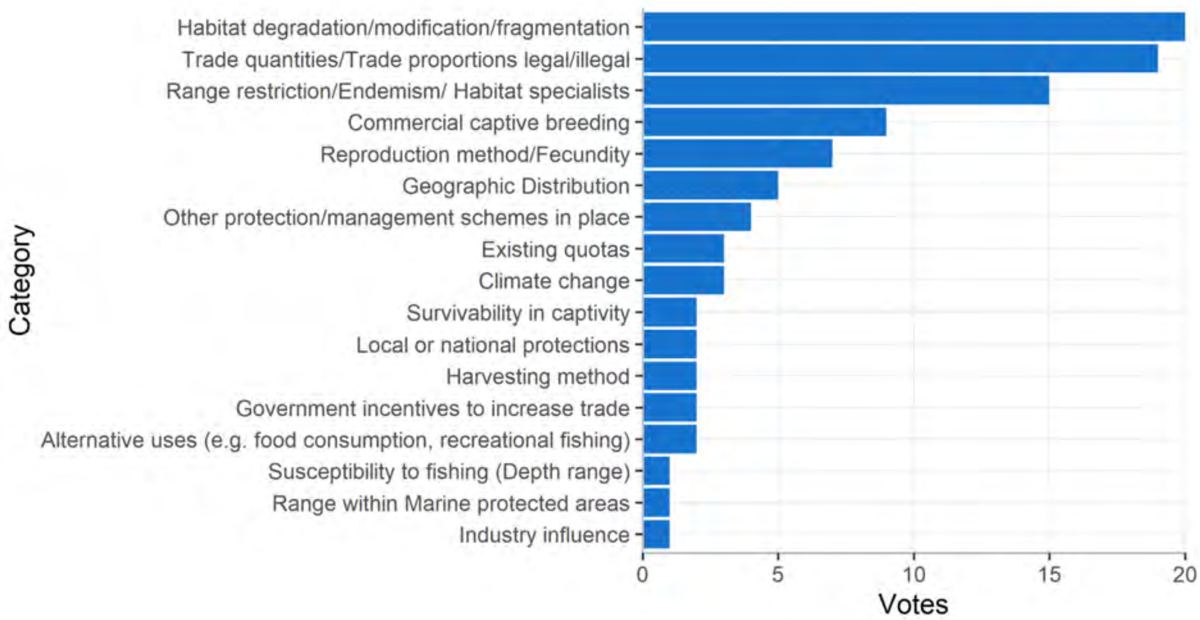

Figure S1. Expert workshop responses to the question "What additional factors or threats make species more vulnerable to trade?".

Table S1. Number of internationally traded species per range state and territory. Distributions are based on GBIF and IUCN Red List. Note that we also included live traded species primarily used for purposes other than the aquarium trade in our analyses which do not occur in tropical waters.

Range States	Number of species identified in trade
Indonesia	1,260
Australia	1,162
Philippines	1,128
Papua New Guinea	1,045
Japan	1,031
Malaysia	972
Taiwan	942
Solomon Islands	869
USA	863
Palau	860
New Caledonia	813
India	728
Vanuatu	725
Fiji	691
Micronesia	691
Thailand	689
Seychelles	685
Mauritius	676
Mozambique	669
China	652
Tonga	636
Timor-Leste	630
Kenya	618
Madagascar	607
Marshall Islands	588
Tanzania	587
Myanmar	580
Maldives	566
Somalia	563
Samoa	556
Vietnam	554
Yemen	554
South Africa	549
Northern Mariana Islands	542
Reunion	536
American Samoa	530
Kiribati	528
Guam	514
Wallis and Futuna	508
Comoros	506
Sri Lanka	502
French Polynesia	494

Range States	Number of species identified in trade
Djibouti	491
Saudi Arabia	488
Egypt	486
Eritrea	460
Mexico	458
Tuvalu	452
Singapore	448
Christmas Island	446
Sudan	441
Nauru	439
Mayotte	430
Chagos Archipelago	427
Cook Islands	419
Israel	407
Cocos Islands	394
Colombia	376
Tokelau	374
Brunei	372
Niue	370
Jordan	362
Oman	357
Panama	356
Costa Rica	354
Honduras	351
Cambodia	335
Nicaragua	334
French Southern and Antarctic Lands	324
Guatemala	316
Cuba	315
Bahamas	284
Venezuela	269
South Korea	267
Puerto Rico	263
Trinidad	263
Belize	257
Virgin Islands	255
Haiti	249
Grenada	247
Bonaire	246
Jamaica	246
Dominican Republic	244
Grenadines	244
Anguilla	241
Antigua	240
Barbados	238
Nevis	238

Range States	Number of species identified in trade
Dominica	237
Turks and Caicos Islands	237
Saint Lucia	236
Guadeloupe	235
Cayman Islands	234
Montserrat	232
Martinique	231
Saint Martin	225
Curacao	223
Pitcairn Islands	204
Brazil	203
Aruba	198
Bermuda	185
Iran	181
United Arab Emirates	169
Guyana	161
Suriname	156
French Guiana	146
Ecuador	144
Saint Barthelemy	139
Norfolk Island	136
Bahrain	119
El Salvador	116
Kuwait	114
Qatar	114
Pakistan	111
Bangladesh	109
New Zealand	108
Iraq	106
Sao Tome and Principe	84
Equatorial Guinea	81
Peru	78
Cape Verde	73
France	73
Spain	71
Benin	70
Cameroon	70
Ghana	70
Nigeria	70
Gabon	69
Portugal	69
Mauritania	67
Senegal	67
Togo	66
Ivory Coast	63
Liberia	63

Range States	Number of species identified in trade
Sierra Leone	62
Chile	61
Gambia	61
Guinea	60
Guinea-Bissau	60
Greece	59
Saint Helena	58
Morocco	57
Turkey	57
Angola	56
Democratic Republic of the Congo	55
Italy	54
Malta	54
Lebanon	52
Western Sahara	52
Republic of Congo	49
Syria	47
Cyprus	45
Canada	44
Azores	42
Croatia	38
Algeria	36
Libya	36
Tunisia	36
North Korea	34
Monaco	33
Albania	29
Russia	29
Uruguay	29
Slovenia	27
Montenegro	26
Namibia	26
Argentina	23
Bosnia and Herzegovina	20
UK	19
Ukraine	18
Bulgaria	17
Georgia	17
Romania	17
Guernsey	14
Ireland	14
Belgium	13
Jersey	13
Norway	13
Netherlands	11
Sweden	11

Range States	Number of species identified in trade
Denmark	9
Germany	9
Faroe Islands	5
Estonia	4
Falkland Islands	4
Finland	4
Latvia	4
Lithuania	4
Poland	4
Iceland	3
Isle of Man	3
Saint Pierre and Miquelon	3
Palestine	2
Swaziland	2
Greenland	1
Sint Maarten	1

Table S2. Number of species assigned to one or more of the four additional risk factors used in the prioritization framework for research priority categories **B** to **E** for IUCN Red List categories Least Concern (LC), Near threatened (NT), Data Deficient (DD), or Not Evaluated (NE). Note that threatened species (IUCN Red List categories VU, EN, and CR) were not assessed against these categories as they were assigned to research priority **B** based on their threat status (Fig. 4). No data were available for NE species in categories that are only based on IUCN Red List data.

Data Source	Other Risk Category	IUCN RL Category				Total
		LC	NT	DD	NE	
IUCN RL, GBIF	*Endemic*	185	4	32	12	249
IUCN RL	*Decreasing population trend*	41	11	10	0	85
IUCN RL	*Habitat degradation, fragmentation, or conversion*	202	13	24	0	257
IUCN RL, FishBase, FAO	*Used for food or sports fishing*	389	11	21	13	450
Total		817	39	87	25	1,041

Table S3. Availability of species recorded with individuals commercially available in the US between February 2018 to August 2019 (Sweet & Pedersen, 2019).

Research Priority	Common	Low/ Moderate	Scarce	None	Number of species with commercial breeding in US
A	22	13	9	65	146
B	1	2	1	12	170
C	0	2	0	1	158
D	2	15	8	47	632
E	11	11	13	79	1,202
Total	36	43	31	204	2,308

Supplementary Material S2 - Outdated IUCN Red List assessments

This prioritization framework relies heavily on the IUCN Red List assessments. We found that 1,020 species (38.9% of traded species) were assessed before 2011, therefore these assessments are considered out-of-date according to the IUCN Red List guidelines (Table 4). We recommend urgent reassessment for the 118 species with outdated assessments classified as research priority **A**. Additionally, 140 (5.3%) species identified in the trade are not yet evaluated (NE) by the IUCN Red List, meaning we lack information for some aspects of the prioritization framework.

Table S4. Number of species with IUCN Red List assessment updated after 2011 and before 2011 per research priority.

Last IUCN RL Assessment	Research Priority					
	Priority A	Priority B	Priority C	Priority D	Priority E	Total Number of Species
2011-2020	129	114	23	428	768	1,462
Before 2011	118	48	30	276	548	1,020
Not Assessed	8	24	108	0	0	140
Total	255	186	161	704	1,316	2,622

Supplementary Material S3 - Captive breeding of CITES-listed species

CITES Parties have previously expressed concern about the deliberate misuse of captive source codes to launder wild-caught specimens as captive-bred in international markets (CITES, 2016). This document primarily centers around species that have not yet been listed in CITES. However, within this context, we also chose to provide a preliminary analysis of the captive breeding efforts of CITES-listed species and their presence in public aquaria.

All CITES-listed species (19 spp.) that were traded under a captive source code (i.e., D, F, C) have been reported to have been successfully bred in captivity (Table 6). Most of these species (14 spp., 73.7%) are also registered in ZIMS holdings.

Table S5. *Ex-situ* management opportunities for CITES-listed marine species recorded with captive trade in the CITES Trade Database (source codes D, F, or C). Note that "none" in the US commercial captive breeding availability column indicates that the species has been successfully bred in captivity, but no individuals were available commercially in the US between February 2018 and August 2019. Total importer and exporter recorded quantities of captive trade (source codes D, F, or C) in the CITES Trade Database between 2010-2020 are given.

Species	CITES Listing	Number of individuals in Species360 institutions	US commercial captive breeding availability	CITES Trade Volume (C, D F, 2010-2020)	
				Importer reported quantities	Exporter reported quantities
Hippocampus kuda	II	104	Common	168,751	202,309
Hippocampus comes	II	261	Common	63,481	134,578
Hippocampus reidi	II	2,014	Common	40,427	118,200
Hippocampus barbouri	II	114	Common	5,870	8,604
Hippocampus abdominalis	II	1,492	Common	4,304	18,077
Hippocampus ingens	II	57	Low/Moderate	2,668	10,162
Hippocampus zosterae	II	518	Scarce	1,658	1,738
Hippocampus spinosissimus	II	20	None	1,223	1,539
Hippocampus histrix	II	0	None	1,137	5,650
Hippocampus erectus	II	1,518	Common	1,020	1,990
Holacanthus clarionensis	II	2	Low/Moderate	238	463
Hippocampus angustus	II	0	None	130	90
Hippocampus whitei	II	53	None	121	139
Hippocampus kelloggi	II	0	None	100	0
Hippocampus guttulatus	II	61	None	54	100
Cheilinus undulatus	II	15	None	1	2
Hippocampus breviceps	II	0	None	0	10
Hippocampus hippocampus	II	175	None	0	12
Hippocampus subelongatus	II	0	None	0	100