Evaluating the extinction risk of species targeted in the marine ornamental bony fish trade

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Introduction

The marine ornamental fish trade is a global enterprise and multibillion dollar industry that relies heavily on coral reef resources, extracting millions of individual fishes and invertebrates annually. The popular hobby of ornamental fish keeping continues to grow on a global scale. An increasing trade demand, coupled with the effects of climate change and other anthropogenic stressors, highlight the importance of understanding the impact and long-term sustainability of trade on wild reef fish populations.

While trade data can provide an idea of the volume of species traded, there remain discrepancies in the available information. For example, in the Philippines, the Bureau of Fisheries and Aquatic Resources identified 1,200 marine species in the ornamental fish trade with all individuals sourced from the wild and highlighted the lack of species-specific catch data for over 60% of these species (Muyot *et al.* 2018). In addition, mortality rates throughout the supply chain, from initial capture in the wild through to arrival to the consumer, are largely unreported and unmonitored (Rhyne *et al.* 2015, Baillargeon *et al.* 2020). The limited available data and frequent discrepancies are due in part to the lack of legal requirements to report on non-CITES listed species and their import and export volume. The lack of knowledge of the species' conservation status is particularly important considering most individuals are collected from the wild.

For most species, virtually nothing is known on the impacts of the ornamental fish trade on population status and trends. Moreover, the conservation status of fish utilized for the trade has not been determined for many species. Marine aquarium fishes are typically numerous and wide ranging, but many species are ranked highly vulnerable to overfishing from this trade (Dee *et al.* 2019). There is evidence that localized declines in the abundance of targeted species can occur as a result of overexploitation, particularly for restricted-range species such as the Banggai Cardinalfish, *Pterapogon kauderni* (Thornhill 2012). This highly prized fish, endemic to the Banggai Archipelago in Indonesia, was heavily traded in the 1990s, resulting in dramatic declines and local extirpations; it was listed as Endangered on the International Union for Conservation of Nature (IUCN) Red List (Allen and Donaldson 2007).

Given these concerns, there was an urgent need to evaluate the conservation status of species in the marine ornamental fish trade. Through three phases of work, outlined below, IUCN compiled a list of 2,682 bony fish species found in the ornamental fish trade and conducted IUCN Red List assessments for 589 species. The resulting assessments and underlying species-specific data will support improved prioritization, management, sustainability of the trade and conservation of marine ornamental fishes.
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Objective

The overarching objective of this document is to provide an overview of the marine ornamental fishes in

the IUCN Red List. The document summarises the conservation status of the recently assessed marine ornamental fish species, discusses the major threats to the group and specifically highlights taxa threatened by overexploitation for international trade.

Methods

During an initial project scoping phase, it was identified that no comprehensive list of marine ornamental fish species in trade was available. Thus, as part of phase one of this initiative, we compiled a list of species from three sources:

1. The Marine Aquarium Biodiversity and Trade Flow database, which summarizes the volume of marine ornamental species that entered the United States of America (Rhyne *et al.* 2015). Recording a total of 2,522 species.
2. Biondo (2017), which quantified the trade of marine ornamental fishes in the European region. Recording a total of 1,302 species.
3. Michaels (2005), a reference guide to 667 species of reef aquarium fishes.

The 4,491 species recorded in these three sources were compared and 1,809 duplicates were eliminated. The master list of 2,682 species was then cross-checked against the Catalog of Fishes (Fricke *et al.* 2021), a comprehensive source of the current taxonomic status of fish species, and against the IUCN Red List of Threatened species (IUCN 2021). We then identified 435 species to be assessed, focusing primarily on species in families that are reef inhabitants (e.g., Apogonidae, Gobiidae, and Pomacentridae), as species in these families are important to the trade and many had not yet been assessed.

The IUCN Red List methodology provides a comprehensive and transparent mechanism to evaluate the conservation status of all animal, plant, and fungi species (except microorganisms). Grounded in extinction risk theory, symptoms of high extinction risk, such as high rates of population declines, small geographic ranges, or very small population sizes, are organized into five criteria. These criteria are used to assign a species to one of eight IUCN Red List global categories, representing varying levels of extinction risk (Figure 1). Species for which there is no doubt that the last individual has died are listed as Extinct (EX), and if individuals only remain in captivity, the species is listed as Extinct in the Wild (EW). The quantitative thresholds associated with the five criteria establish clear cut-off points for the placement of each species into one of three threatened categories: Critically Endangered (CR), Endangered (EN), and Vulnerable (VU). Species that do not meet the quantitative thresholds associated with at least one of the threatened categories are assigned Near Threatened (NT). Species with a low risk of extinction are assessed as Least Concern (LC). When data are highly uncertain and a species could plausibly qualify for a wide range of Red List categories, the species is listed as Data Deficient (DD) (Mace *et al.* 2008, IUCN 2019).

Phase one of this project was completed in September 2021 with 275 assessments submitted, phase two was completed in July 2022 with 174 assessments submitted and phase three was completed in March 2024 with 140 assessments submitted. Herein, we report on the 589 total assessments submitted as part of all three phases of this project, 449 of which are published in version 2023-1 of the IUCN Red List.

Results and Discussion

Comparing the three data sources used to identify marine bony fishes in the ornamental trade indicated intersecting, but not completely overlapping species lists (Table 1). After accounting for species replicated across the three data sources and addressing taxonomic discrepancies, a total of 2,682 marine

bony fishes in 145 families have been reported in the marine ornamental trade. Almost 50% of the species are in just seven families – Labridae (wrasses), Pomacentridae (damselfishes), Gobiidae (gobies), Apogonidae (cardinalfishes), Serranidae (sea basses), Chaetodontidae (butterflyfishes), and Blenniidae (blennies). Each of these families is represented by more than 100 species each.

Across the 2,682 marine bony fishes identified as occurring in the marine ornamental trade, 2,093 were published on the IUCN Red List as part of earlier marine bony fish Red Listing initiatives. This initiative therefore targeted the 589 unassessed species, with 275 assessments completed during the first phase (2020-2021), 174 during the second phase (2021-2022) and 140 during the third phase (2023-2024). The list of species, along with the Red List category for each assessed species and the initiative during which it was assessed (Prior, Phase I, Phase II, Phase III) are indicated (Appendix 1). As of March 2024, 449 of these assessments are now published on the IUCN Red List version 2023-1.

Of the 589 species assessed as part of this project, a total of 556 (94%) were listed as Least Concern (LC, Table 2). These species are widely distributed, and although wild-sourced individuals are collected for the ornamental trade, no evidence of global population declines approaching 30% were recorded. Most of the 20 Data Deficient (DD) species (3%) were listed as such due to high taxonomic uncertainty.
Notable DD examples otherwise include the Wideband Clownfish (*Amphiprion latezonatus*), which is known from a relatively limited distribution off eastern Australia and for which little information is available concerning population trends and the potential major threat from exploitation for the marine ornamental trade. Both the Tomini Dottyback (*Pictichromis dinar*) and the Ryukyu Anthias (*Pseudanthias taira*) require further targeted sampling of deep reefs to improve our understanding of their distributions and enable their reclassification in a known Red List category. Furthermore, the Blue Velvet Angelfish (*Centropyge deborae*) is only known from seven specimens discovered for sale in the aquarium trade in Taiwan, Province of China in 2010. These individuals were originally collected in Fiji, however, its true distribution and population status remain unknown.

Overexploitation and habitat degradation are major threats to fishes globally. The majority of the marine ornamental fish trade targets species associated with coral reefs, which are also being negatively impacted by climate-change induced warming waters. Population and harvest data are poorly known for most species with this issue of particular concern for range restricted and endemic species in the ornamental trade. Of the 13 species (2%) listed in categories of elevated extinction risk (i.e., Near Threatened, Vulnerable, Endangered or Critically Endangered), six are damselfishes and clownfishes in the family Pomacentridae that are primarily dependent on live coral and have relatively small ranges.
The primary threat to these species is coral reef loss, with exploitation for the ornamental trade a secondary threat. Further investigation to understand the effect of exploitation for the ornamental trade on their global population trends is recommended.

A highlight for conservation concern that resulted from this initiative is the Vulnerable assessment of the Barber Goby (*Elacatinus figaro*), a shallow reef species endemic to Brazil that grows no larger than 4.5 centimeters in length. This brilliantly colored species is popular in the ornamental trade, and due to overexploitation by fishers to supply the international market, it has undergone a global population decline of at least 30% over the past 10 years. Despite a fishing ban in place for this species since 2004, poaching continues, and wild-captured individuals are smuggled via exportation through neighboring countries. Documented degradation of the coral and rocky reefs that the species depends on represents an additional stressor. Species-specific conservation recommendations emphasized in recently published literature include improving legislation and enforcement of fishing regulation, as well as

supporting the development of captive breeding of this species. Population monitoring across the species' range is also needed, especially in areas where its status is poorly known.

Another species assessed as Vulnerable during this initiative is Naoko's Fairy Wrasse (*Cirrhilabrus naokoae*). This coral reef species has a restricted range in Sumatra, Indonesia and was described in 2009 based on a few individuals for sale in the aquarium trade in Japan. It is threatened by pervasive reef degradation and exploitation for the aquarium trade in which it is highly prized due to its rarity.
Research on the population status, ecology and threats to this species is urgently needed.

As of 2011, there are 35 different families represented within the top 257 marine bony fishes imported into the United States of America, which is the primary country importing fish for aquaria use (Rhyne *et al.* 2015). The most diverse group are the damselfishes (60 species), with other significant groups including include the blennies, surgeonfishes, butterflyfishes, gobies, wrasses, and angelfishes (each comprising 10-36 species, see Annex I). Within these 257 species, there are six threatened species, one of which includes the Banggai Cardinalfish. The primary threat to the other five species (*Gobiodon axillaris*, *G. reticulatus*, *Oxymonacanthus longirostris*, *Amblyglyphidodon ternatensis* and *Chrysiptera hemicyanea*) is the loss of branching corals in the genus *Acropora*. These fish species are dependent on acroporid corals for habitat and food, and due to the severe global-level declines in these particularly sensitive coral species, these fish were inferred to have undergone a >30% decline and are listed as Vulnerable. Removal for the aquarium trade is a secondary threat that requires further research to understand the impact to these species' populations.

Across all 2,682 species identified for this initiative 91 species (3%) are listed in categories of elevated extinction risk (i.e., Near Threatened, Vulnerable, Endangered or Critically Endangered). A total of 2,450 species (91%) are listed as Least Concern, and 141 species (5%) are listed as Data Deficient. The inclusion of some of these species in future versions of a list of marine fish in the ornamentals trade may require further investigation as market demand may have shifted since they were last assessed for the Red List or their use in aquaria may be negligible in general. According to available documentation included in the Red List assessment, 1,599 (60%) of these species occur in international trade for either human consumption and/or the ornamentals trade. International trade is identified as a driver of the Near Threatened or threatened status of 24 species, with exploitation for the ornamentals trade identified for 14 of these species (Table 4), including eight species of seahorses, the Humphead Wrasse (*Cheilinus undulatus*) and five other reef fishes with restricted ranges. The other 10 species are relatively large-bodied fishes that are heavily exploited by commercial fisheries and have high international market value, including four groupers. Priorities for research include the 52 species listed as Data Deficient that are known to be exploited for the ornamentals trade, especially 9 species that are identified within the top ~250 species frequently imported into the United States of America (Annex 1).

As a result of this initiative, a knowledge gap was filled on the conservation status of the extensive diversity of fishes in the trade. These 589 new assessments also contributed towards completing the world's ~17,000 marine bony fishes, which is the group that represents the largest gap within the world's vertebrates on the IUCN Red List. Therefore, the results from this Red List initiative not only contributed to our understanding of conservation priorities for widely traded marine species, but also highlighted potential biodiversity loss and conservation needs in the marine realm on a global level. Future Red List work is needed to update assessments within the marine ornamental fishes that are more than 10 years old.

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Tables

Table 1: Marine bony fishes reported as part of the marine ornamental trade in three major data sources.

DATA SOURCE	NUMBER OF SPECIES
Michaels (2005)	2,522
Rhyne *et al*. (2015)	1,302
Biondo (2017)	667

Table 2: IUCN Red List status of the 589 species assessed as part of phase one, two and three of the ornamental marine fishes initiative.

CATEGORY	NUMBER OF SPECIES
Critically Endangered	0
Endangered	2
Vulnerable	8
Near Threatened	3
Least Concern	556
Data Deficient	20

Table 3: IUCN Red List status of the 2,682 species identified for this ornamental marine fishes Red List initiative.

CATEGORY	NUMBER OF SPECIES
Critically Endangered	1
Endangered	9
Vulnerable	53
Near Threatened	29
Least Concern	2449
Data Deficient	141

Table 4: IUCN Red List status of 14 Near Threatened or threatened species which are primarily threatened by exploitation for the international marine ornamental trade.

SCIENTIFIC NAME	COMMON NAME	RED LIST CATEGORY (YEAR)	CITES APPENDIX
Cheilinus undulatus	Humphead Wrasse	Endangered (2004)	II
Choerodon schoenleinii	Blackspot Tuskfish	Near Threatened (2004)	Not listed
Cirrhilabrus naokoae	Naoko's Fairy Wrasse	Vulnerable (Not yet published)	Not listed
Ecsenius tigris	Tiger Blenny	Vulnerable (2014)	Not listed
Elacatinus figaro	Barber Goby	Vulnerable (2022)	Not listed
Hippocampus barbouri	Barbour's Seahorse	Vulnerable (2017)	II
Hippocampus comes	Tiger-tail Seahorse	Vulnerable (2015)	II
Hippocampus erectus	Lined Seahorse	Vulnerable (2017)	II
Hippocampus histrix	Thorny Seahorse	Vulnerable (2017)	II
Hippocampus kuda	Spotted Seahorse	Vulnerable (2014)	II
Hippocampus mohnikei	Japanese Seahorse	Vulnerable (2017)	II
Hippocampus reidi	Long-snout Seahorse	Near Threatened (2017)	II
Hippocampus spinosissimus	Hedgehog Seahorse	Vulnerable (2017)	II
Pterapogon kauderni	Banggai Cardinalfish	Endangered (2007)	Not listed

Figures

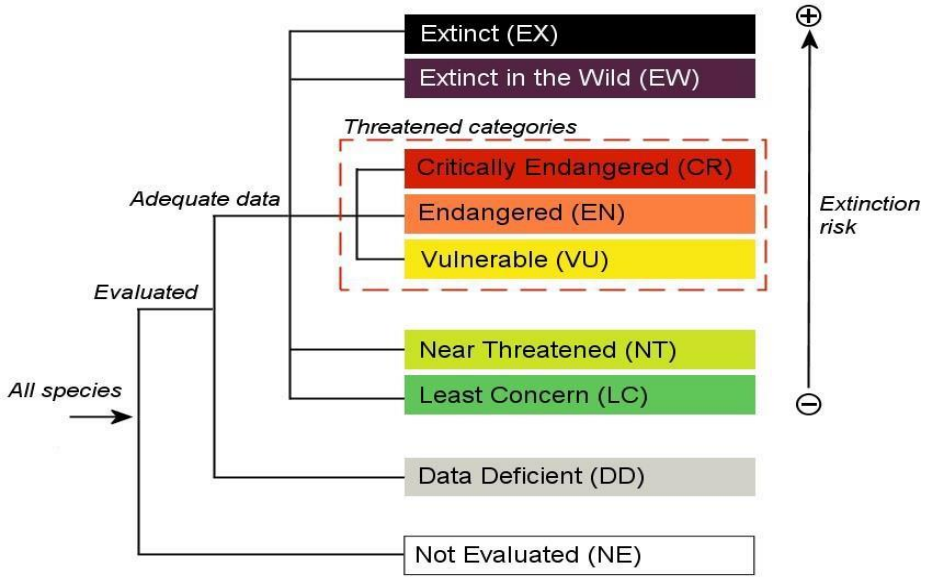

Figure 1: Structure of the nine IUCN Red List Categories (IUCN 2012), into which all animal, plant, and fungi species (except microorganisms) can be classified.

Annex 1

List of 2,682 marine bony fishes reported as occurring in the marine ornamental trade. The CITES Appendix listing, Red List category and assessment year are indicated. The top 257 marine bony fishes imported into the United States of America as of 2011, according to Rhyne *et al.* (2015), are also identified. Furthermore, utilization type (e.g., human consumption or ornamental trade or both) is categorised, presence in international trade (yes or no) and whether international trade is a threat driver of the status of species listed as Near Threatened, Vulnerable, Endangered or Critically Endangered.