CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

Thirty-third meeting of the Animals Committee
Geneva (Switzerland), 12 – 19 July 2024

REPORT ON USING THE PRODUCTIVITY-SUSCEPTIBILITY ANALYSIS TO ESTIMATE VULNERABILITY OF MARINE AQUARIUM FISH: POTENTIAL TOOL TO IDENTIFY SPECIES IN NEED OF FURTHER ASSESSMENT

This document has been submitted by the United Kingdom of Great Britain and Northern Ireland in relation to agenda item 44.*

* *The geographical designations employed in this document do not imply the expression of any opinion whatsoever on the part of the CITES Secretariat (or the United Nations Environment Programme) concerning the legal status of any country, territory, or area, or concerning the delimitation of its frontiers or boundaries. The responsibility for the contents of the document rests exclusively with its author.*

Report on using the Productivity-Susceptibility Analysis to Estimate Vulnerability of Marine Aquarium Fish: Potential Tool to Identify Species in Need of Further Assessment

Report produced by: Gabrielle Baillargeon[1] and Dr. Andrew Rhyne[2] (University of Leeds[1] and Roger Williams University[2])

Executive Summary:

Our study demonstrates the productivity-susceptibility analysis is a robust, data-limited fishery assessment to **prioritize species in the marine aquarium trade for further assessment, monitoring, and management**. This adaptable framework can be applied at the local, regional, or global scale. The PSA provides the best, global estimate of potential risk to overfishing using available information about species and fisheries dynamics and assigns each species to one of three risk categories based on their productivity, susceptibility, and overall vulnerability scores. These categories estimate the relative risk of overfishing on a global scale:

1. **Least Vulnerable:** Species in this category are highly resilient to fishing pressures and require minimal to no additional monitoring or management.
2. **Moderately Vulnerable:** These species may benefit from some level of trade monitoring to ensure sustainable practices.
3. **Most Vulnerable:** Species in this group are flagged by the PSA as needing further study and closer monitoring. This designation indicates that more detailed assessments are necessary to understand their vulnerability better. It does not imply that they are currently endangered or require immediate protection under international agreements like CITES. Furthermore, the binning of species in the most vulnerable category is based on Gaussian distribution and not cut-off scores. This clustering approach likely groups species that are similar in productivity or susceptibility, and not necessarily overall vulnerability. **The "most vulnerable" category includes species that the model suggests should be examined more closely to understand their true risk.**

Our global analysis includes 306 species that are actively in trade, showing 69 species (19%) should be monitored to ensure that overfishing is not occurring. **We present a complete list of species ranked by PSA vulnerability score from most to least, identifying at risk species to be considered by Parties for further assessment and monitoring (Appendix 1).** Species in the most vulnerable group which are also in the following specialty groups need to be assessed further, including trade monitoring: Endemic species, elasmobranchs, and species the IUCN has declared as Near Threatened, Vulnerable, or Endangered to understand the impact of the aquarium trade on these populations. Our analysis shows that **most teleost fish in the trade are considered sustainable,** with 43% of species classified as least vulnerable and 38% as moderately vulnerable. When expanding the number and diversity of species, the PSA produces consistent and accurate results.

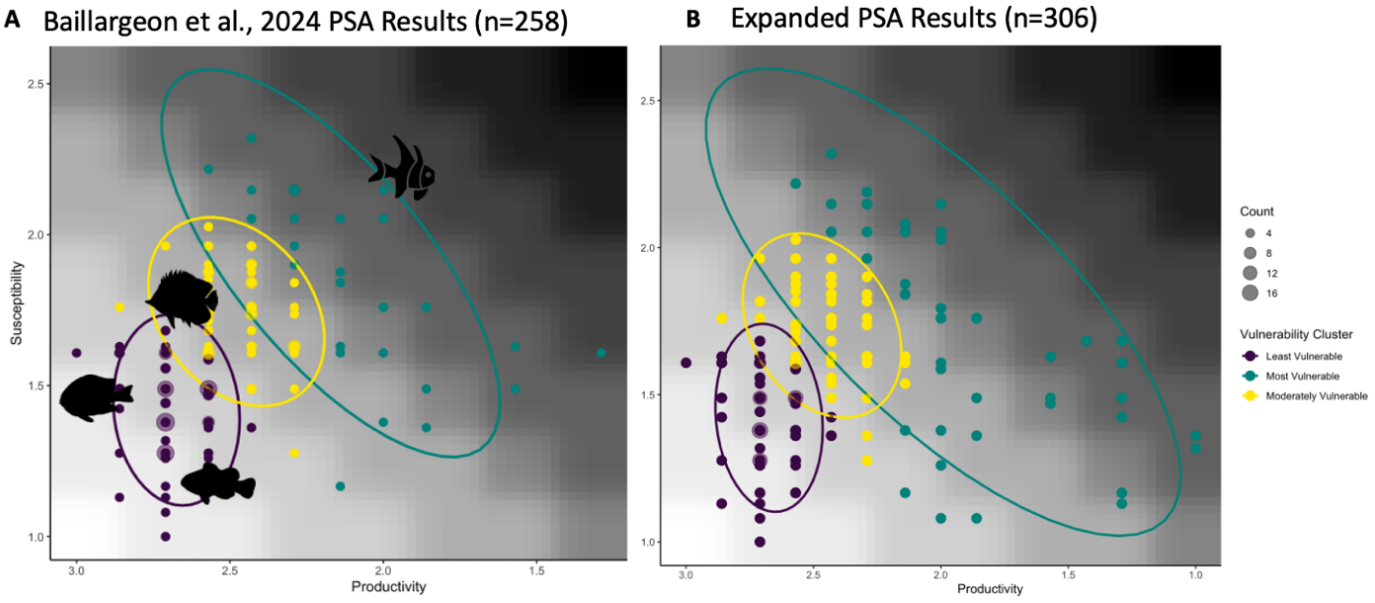

Figure 1. Productivity-Susceptibility Analysis results for the original 258 species evaluated in Baillargeon et al., 2024 (A) compared to the PSA including high priority species identified by other methodologies submitted to the technical workshop (B, n=306). Vulnerability clusters identified using a Gaussian Mixture Model fall into three groups: least vulnerable, moderately vulnerable, and most vulnerable. Fish silhouettes indicate that the families Pomacentridae and Pomacanthidae are most common in the least vulnerable group, Chaetodontidae in the moderately vulnerable group, and highlighting the Bangaii Cardinal fish as highly vulnerable.

Background:

At the 2024 CITES technical workshop on marine ornamental fish, the productivity-susceptibility analysis (PSA) was presented as a **robust and holistic analytical framework to prioritize species for monitoring and management** within the global marine aquarium trade fishery. This data-limited fisheries assessment is widely utilized by food fisheries when sufficient information on catch, effort, gear type, and species biomass data is unavailable thus prohibiting a stock assessment. Notably, the results of PSA assessments do not negate the possibility of localized depletions occurring on reefs due to unknown overharvesting. We presented an expanded and revised PSA (Baillargeon et al., 2024) that included 258 of the top traded species in support of the meeting objective to "consider the conservation priorities and management needs related to the trade in non-CITES listed marine ornamental fishes worldwide". Based on discussions at the technical workshop, an offer was put forward (AC33 Doc 44, point15) to include a greater number of species, including those that came up in other 'high priority' species lists submitted as background documents to that meeting**. Here we present our findings when increasing the total number of species assessed to 306 fish and 42 families across both teleosts and elasmobranchs,** demonstrating that this methodology remains effective when assessing a large and very diverse number of genera.

Results and Discussion:

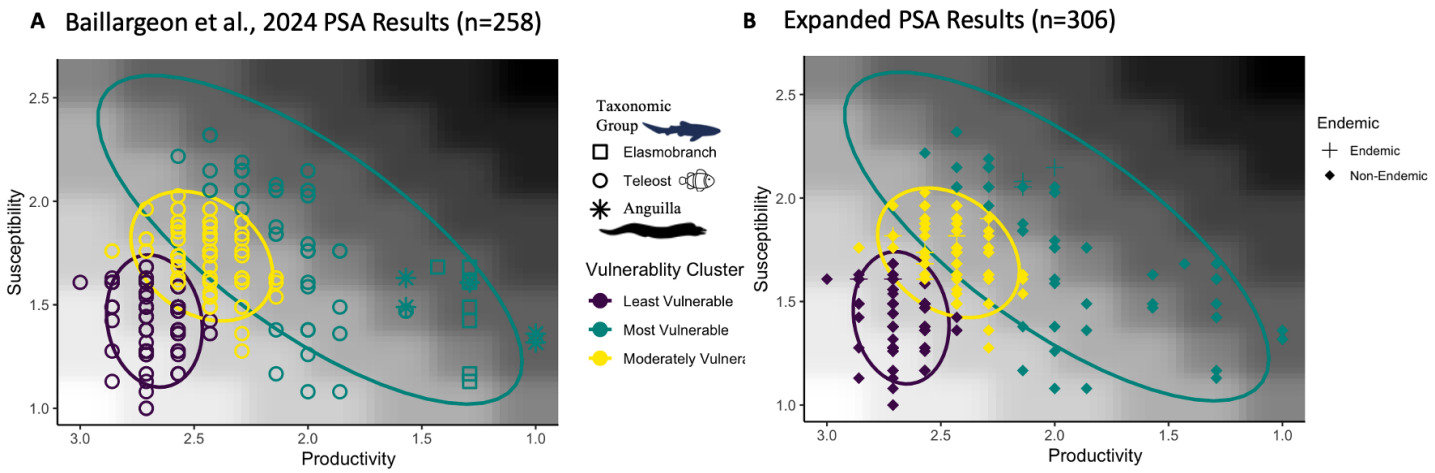

Figure 2. Productivity-Susceptibility Analysis results (n=306) comparing where teleost, teleost – eel, and elasmobranchs fall in the vulnerability clusters (A) and showing the distribution of endemic species in the vulnerability clusters.

Each species is assigned to a predicted risk category based on the combination of their productivity, susceptibility, and vulnerability score thus estimating their relative risk of overfishing on a global scale. The most vulnerable risk cluster represents a higher potential vulnerability of a species to overfishing; however, we use a conservative PSA framework to assess these fish to avoid any underestimating due to data-limitations. For example, when a factor is lacking data, this elevates a species' overall vulnerability to prevent underestimating. However, updated species-level productivity data, annual trade volumes, and localized population assessments can shift the vulnerability score and risk level of a species as better data is entered into the model. The moderately vulnerable category represents fish that may need trade monitoring, whereas the least vulnerable group are highly resilient fishes that would require minimal to no monitoring or management.

Increasing the number of species assessed from 258 to 306 fish did not change the vulnerability cluster assignment of existing species (Figure 1). Instead, 6 species were added to the least vulnerable group, 23 species to the moderately vulnerable, and 19 species to the most vulnerable group. In total, there are 133 fish in the least vulnerable group, 116 in the moderately vulnerable, and 57 in the most vulnerable group (Table 1). This distribution of species is not unexpected as species added to the PSA were drawn from 'high priority' lists developed using different methods. Endemic fish had a range of productivity scores which demarcated those that were least (n=2), moderately (n=8), and most vulnerable (n=3) from each other as their endemism increased their susceptibility scores (Figure 2B). The average vulnerability score for the least and moderately vulnerable groups did not change between the two PSAs, with only a 0.02 increase in average vulnerability score in the most vulnerable cluster. This shows the robustness of the PSA regardless of the number of species or diversity of genera assessed.

This clustering method and vulnerability cut off points were tested by referencing known stock status of species for a range of vulnerability. Given elasmobranchs larger body and slower reproduction, they are inherently more at risk of exploitation at various levels of fishing pressure, and all fell within the 'most vulnerable' cluster with varied susceptibility scores. The Bangaii Cardinalfish (*Pterapogon kauderni)* is classified as Endangered by the IUCN and is ranked most

vulnerable teleost and 13th most vulnerable out of all species assessed. The vulnerability score and clustering of this species is an expected result given the extensive research on its stock status and evidence of aquarium fishing overexploiting the stock. The Blue Tang is a species that is highly sought after in the trade, has a fragmented distribution, but relatively high productivity (p=2.29, s=2.15) and has fallen in the 'most vulnerable' category. This species is a good example of a fish that requires better monitoring, including capturing population abundance and catch data in its native range, to understand if stocks have been overfished given its popularity in the trade. Conversely, many of the damselfishes have low vulnerability scores and fall into the 'least vulnerable' category as they have very high productivity and low-medium susceptibility scores. The Green Chromis (*Chromis viridis)* is an example of a fish that is widely dispersed, heavily targeted, has a shorter lifespan and reaches maturity quickly with frequent spawning events – an example of highly resilient fish to fishing pressure.

For 51 of the 57 species in the most vulnerable group, their vulnerability scores were above 1.1, with a few species having borderline vulnerability scores that aligns more with the moderately vulnerable (Figure 1). Within the vulnerable group, there was a considerable increase in species that fell into this category with low productivity and low-medium susceptibility. Due to lack of life-history data for some species, lower productivity scores were more common as a low score of "1" was assigned to any species that had no species, genus, or family level data. **Any species with a vulnerability score above 1.1 (Table 1, Appendix 1) should be considered for additional analysis (see Recommendations)**. Notably, elasmobranchs have much lower productivity compared to most reef fishes (Figure 2A). Further, the threats posed by the fishery, such as cyanide fishing, do not apply to this group making their susceptibility score low-medium which may not be indicative of their true risk. An elasmobranch and eel marine aquarium fisheries PSA would be a better assessment tool to understand the risks the trade may pose to these species, as this PSA is designed to assess smaller reef fish.

Species within the collated high priority lists underwent expert review to verify if they were common in the marine aquarium trade. This resulted in 26 species of the 103 being identified as not common in the trade due to: food fisheries, limited collection allowed or available, captive-bred only, closure of Hawai'i fishery, only trade for public aquarium use, or simply being very uncommon in trade (Appendix 2). These species should not be prioritized for assessment and those that were run in the PSA and fall into the most vulnerable category (n=4) should be lower priority for further assessment.

The inclusion of the susceptibility factor volume in trade was removed to evaluate the utility of including trade markers in the assessment. It is common in food fishery PSAs to include a metric for harvest pressure, whether catch, effort, or gear type which is the rationale for including volume in trade as a factor. It serves as a proxy for understanding the fishing pressure on one species, and different data sources may differ but most likely the trade volume value will fall into the same broad data bins of either greater than or less than 3,000 individuals traded per year. When this susceptibility factor was removed, an average of 0.02 ± 0.14 increase in vulnerability score resulted (Appendix 4).

Recommendations:

- Encourage the Animals Committee to support use of the **PSA methodology to assess the vulnerability of species to fishing and prioritize species** to focus on for further assessment.
    - Following from the AC33 doc. 44 recommendation S to determine "The best analytical tools to support prioritization of species (e.g. Productivity Sustainability Analysis or other vulnerability analyses, FishBase) to best direct efforts for stock assessments for those species that are highlighted as most potentially vulnerable"
- Encourage Parties to **implement assessment and monitoring** programs for native species that the model predicts are most likely to need further research to ensure sustainable harvest levels. Species in this category include those falling into the most vulnerable group or having a vulnerability score above 1.1 (see list in Table 1 and Appendix 1).
    - Basic life history data, with emphasis on reproductive information, trophic level, and habitat specificity
    - Record and make accessible export volume on a per species basis by region or Party
    - Underwater visual population surveys in fished and non-fished areas within species range
- Prioritize resource investment for species that fall into the most vulnerable group and are commonly traded. This would exclude species listed in Appendix 2 which are not commonly found in the trade due to being:
    - Targeted for public aquariums only, exclusively available from limited collectors, or a species that has been severely reduced in trade due to the closure of the Hawai'i fishery.

- Develop assessments and monitoring programs for elasmobranchs and eels, exclusively, as this PSA is targeted toward reef fish and may be missing productivity data bins and susceptibility factors that are important to include for these species.
- Monitor trade in endemic species, especially those that fall into the 'most vulnerable' classification

Table 1. List of all species (n=57) in the most vulnerable cluster, composing a high priority list for further assessment. Four species fell into this vulnerability classification but are not present in the list due to expert review showing they are not commonly in the trade: *Centropyge potteri* (Hawai'i fishery closure ceases export), *Stegostium tigrium, Aetobatus narnari*, and *Epinephalus lanceolatus* (public aquariums only).

Species	Family	Taxonomic Designation	Productivity	Susceptibility	Vulnerability	Endemism	Vulnerability Cluster
Myrichthys colubrinus	Ophichthidae	Anguilliformes	1.00	1.36	2.03	No	Most Vulnerable
Myrichthys maculosus	Ophichthidae	Anguilliformes	1.00	1.32	2.03	No	Most Vulnerable
Atelomycterus marmoratus	Atelomycteridae	Elasmobranch	1.29	1.68	1.85	No	Most Vulnerable
Chiloscyllium punctatum	Hemiscyllidae	Elasmobranch	1.29	1.61	1.82	No	Most Vulnerable
Echidna catenata	Muraenidae	Anguilliformes	1.29	1.61	1.82	No	Most Vulnerable
Gymnomuraena zebra	Muraenidae	Anguilliformes	1.29	1.61	1.82	No	Most Vulnerable
Himantura uarnak	Dasyatidae	Elasmobranch	1.29	1.49	1.78	No	Most Vulnerable
Chiloscyllium plagiosum	Hemiscylliidae	Elasmobranch	1.29	1.42	1.77	No	Most Vulnerable
Aetobatus narinari	Aetobatidae	Elasmobranch	1.29	1.17	1.72	No	Most Vulnerable
Taeniura lymma	Dasyatidae	Elasmobranch	1.29	1.13	1.72	No	Most Vulnerable
Stegostoma tigrinum	Stegostomatidae	Elasmobranch	1.43	1.68	1.71	No	Most Vulnerable
Echidna nebulosa	Muraenidae	Anguilliformes	1.57	1.63	1.56	No	Most Vulnerable
Pterapogon kauderni	Apogonidae	Teleost	2.00	2.15	1.52	Endemic	Most Vulnerable
Rhinomuraena quaesita	Muraenidae	Anguilliformes	1.57	1.49	1.51	No	Most Vulnerable
Malacanthus brevirostris	Malacanthidae	Teleost	1.57	1.47	1.50	No	Most Vulnerable
Malacanthus latovittatus	Malacanthidae	Teleost	1.57	1.47	1.50	No	Most Vulnerable
Gomphosus varius	Labridae	Teleost	2.00	2.05	1.45	No	Most Vulnerable
Exallias brevis	Blenniidae	Teleost	2.43	2.32	1.44	No	Most Vulnerable
Ostorhinchus parvulus	Apogonidae	Teleost	2.43	2.32	1.44	No	Most Vulnerable
Siganus uspi	Siganidae	Teleost	2.00	2.03	1.43	No	Most Vulnerable
Chaetodon trifascialis	Chaetodontidae	Teleost	2.29	2.19	1.39	No	Most Vulnerable
Chaetodontoplus caeruleopunctatus	Pomacanthidae	Teleost	2.14	2.08	1.38	Endemic	Most Vulnerable
Diodon holocanthus	Diodontidae	Teleost	1.86	1.76	1.37	No	Most Vulnerable
Diodon hystrix	Diodontidae	Teleost	1.86	1.76	1.37	No	Most Vulnerable
Centropyge potteri	Pomacanthidae	Teleost	2.14	2.05	1.36	Endemic	Most Vulnerable
Zoramia leptacanthus	Apogonidae	Teleost	2.14	2.05	1.36	No	Most Vulnerable
Chaetodon kleinii	Chaetodontidae	Teleost	2.29	2.15	1.35	No	Most Vulnerable
Chaetodon punctatofasciatus	Chaetodontidae	Teleost	2.29	2.15	1.35	No	Most Vulnerable
Chaetodon xanthurus	Chaetodontidae	Teleost	2.29	2.15	1.35	No	Most Vulnerable
Paracanthurus hepatus	Acanthuridae	Teleost	2.29	2.15	1.35	No	Most Vulnerable
Sphaeramia orbicularis	Apogonidae	Teleost	2.29	2.15	1.35	No	Most Vulnerable
Synchiropus marmoratus	Callionymidae	Teleost	2.57	2.22	1.29	No	Most Vulnerable
Pomacanthus semicirculatus	Pomacanthidae	Teleost	2.43	2.15	1.28	No	Most Vulnerable
Ostorhinchus compressus	Apogonidae	Teleost	2.00	1.79	1.28	No	Most Vulnerable
Arothron nigropunctatus	Tetraodontidae	Teleost	2.29	2.05	1.27	No	Most Vulnerable

Ostracion cubicum	Ostraciidae	Teleost	2.29	2.05	1.27	No	Most Vulnerable
Prionurus chrysurus	Acanthuridae	Teleost	2.29	2.05	1.27	No	Most Vulnerable
Lactoria cornuta	Ostraciidae	Teleost	2.00	1.76	1.26	No	Most Vulnerable
Thalassoma lunare	Labridae	Teleost	2.00	1.76	1.26	No	Most Vulnerable
Pervagor melanocephalus	Monacanthidae	Teleost	1.86	1.49	1.24	No	Most Vulnerable
Hemigymnus melapterus	Labridae	Teleost	2.14	1.88	1.23	No	Most Vulnerable
Chaetodon auriga	Chaetodontidae	Teleost	2.14	1.84	1.20	No	Most Vulnerable
Chaetodon lunula	Chaetodontidae	Teleost	2.14	1.84	1.20	No	Most Vulnerable
Chaetodon ephippium	Chaetodontidae	Teleost	2.29	1.96	1.20	No	Most Vulnerable
Gnathanodon speciosus	Carangidae	Teleost	1.86	1.36	1.20	No	Most Vulnerable
Ecsenius pulcher	Blenniidae	Teleost	2.43	2.05	1.20	No	Most Vulnerable
Ecsenius stigmatura	Blenniidae	Teleost	2.43	2.05	1.20	No	Most Vulnerable
Sphaeramia nematoptera	Apogonidae	Teleost	2.43	2.05	1.20	No	Most Vulnerable
Plectorhinchus chaetodonoides	Haemulidae	Teleost	2.00	1.61	1.17	No	Most Vulnerable
Chaetodontoplus duboulayi	Pomacanthidae	Teleost	2.00	1.59	1.16	No	Most Vulnerable
Balistes vetula	Balistidae	Teleost	1.86	1.08	1.15	No	Most Vulnerable
Chromileptes altivelis	Epinephelidae	Teleost	2.00	1.38	1.07	No	Most Vulnerable
Diodon liturosus	Diodontidae	Teleost	2.00	1.38	1.07	No	Most Vulnerable
Balistes punctatus	Balistidae	Teleost	2.00	1.26	1.03	No	Most Vulnerable
Epinephelus lanceolatus	Epinephelidae	Teleost	2.00	1.08	1.00	No	Most Vulnerable
Platax batavianus	Ephippidae	Teleost	2.14	1.38	0.94	No	Most Vulnerable
Coris formosa	Labridae	Teleost	2.14	1.17	0.87	No	Most Vulnerable

Methods:

Species Selection

The top 258 most traded species into the US in 2011 based on scanned invoices of fish entering the country (Rhyne et al., 2015) were evaluated using the PSA (Baillargeon et al., 2024) and presented at the technical workshop in May 2024. Several background documents were submitted at the workshop and presented different frameworks and analytical approaches to identify high priority species for Parties to consider. Across all analyses, high priority species are loosely defined as those species that require further monitoring and management to mitigate the negative effects of the aquarium fishery on their wild population status. By collating high priority species from all submitted documents, a list of approximately 200 fish was produced. After removing species already included in our PSA (Baillargeon et al., 2024; n=75) and those that were noted in Appendix 4 to be exclusively traded for public aquariums (25), the final list consisted of 103 species (Figure 3). A PSA using the same framework as Baillargeon et al., 2024 was then run on as many of the 103 species as possible in the short timeframe between the workshop and July 18th Animals Committee meeting, with species traded at volumes <100 or 0-100 individuals per year according to TRACES (2021-2023) Appendix 4 data, being prioritized for analysis. Additionally, a full PSA was run with and without including volume in trade as a susceptibility factor, to understand the impacts of including trade data in this type of assessment.

Overview of Productivity-Susceptibility Analysis

In our PSA, five productivity and six susceptibility factors were chosen and validated with a model sensitivity analysis. This flexible framework allows it to be adapted to different scales and types of fisheries, but it is essential to modify the factors and data-bins to align with the target group of fish being assessed. Productivity and susceptibility factors were scored for each species individually on a 1−3 (low−high) scale, in line with Patrick *et al.* (2009) and Hobday *et al.* (2011) (see Appendix 3 for scoring matrix). Data for each productivity factor was based on primary literature and supplemented with information from FishBase when necessary. Susceptibility factors data came from published IUCN Red List Assessments (IUCN 2022) and Eschmeyer's Catalog of Fishes (Fricke *et al.* 2023), as well as hobbyists sites to classify aquarium suitability and life stage at harvest. When species level data was unavailable, a congener, closest genetic relative, or family level data was used. In the absence of data, experts on reproductive biology of marine ornamental fish species were consulted.

Productivity is an indirect measurement of a species' ability to reproduce and indicates resiliency to changing environmental conditions (Baillargeon *et al.*, 2020). Five productivity factors: maximum size, mean trophic level, breeding strategy, fecundity, and pelagic larval duration were included in this PSA framework (Appendix 3). A weighted arithmetic mean was used to calculate Productivity, where is the productivity score and is the factor weight. Increasing the factor weight to 2 represents the factor's importance in determining the vulnerability of a species in a fishery.

$$p = \frac{\Sigma_{i=1}^{6} x_i * b_i}{\Sigma_{i=1}^{6} b_i}$$ (Equation 1)

Susceptibility measures the likelihood that fishing pressures will have a negative impact on a species' population (Patrick *et al.* 2009). Susceptibility has a reverse scale from productivity, where high susceptibility translates to a higher vulnerability score. Six susceptibility factors: geographic distribution, encounterability depth, suitability for aquarium keeping, volume in trade, and the life stages harvested, and cyanide were included in this PSA framework. Susceptibility was calculated by using a weighted mean of logarithms expressed as an exponential function, with base 10 raised to the power of the weighted logarithmic mean, where y_i is the susceptibility factor score and ai is the factor weight:

$$10^{\frac{\Sigma_{i=1}^{5} log\, y_i * a_i}{\Sigma_{i=1}^{5} a_i}}$$ (Equation 2)

These factors were quantified in a data-binning process where productivity and susceptibility scores are calculated separately then inputted into the Euclidean distance formula to output the vulnerability score (v). Where p is the mean productivity score, s is the mean susceptibility score, and v is the vulnerability score (equation 3). Vulnerability is functionally the distance from the origin (1,3) of the productivity-susceptibility plot.

$$v = \sqrt{(p-3)^2 + (s-1)^2}$$ (Equation 3)

A semi-supervised machine learning algorithm was implemented to classify all 306 species evaluated into three distinct vulnerability clusters: "most vulnerable", "moderately vulnerable", and "least vulnerable".
This was done using the open-source *R Mclust* package and selecting a model that is set to cluster diagonally from the origin while allowing the volume and shape of each cluster ellipse to differ, with clusters determined by the following three factors: productivity, susceptibility, and vulnerability score of each species.

Appendix 1. List of all species (n=306), family, order, productivity, susceptibility, and vulnerability score, endemic status, and corresponding vulnerability cluster based on GMM clustering algorithm. Ordered from high to low vulnerability score.

Species	Family	Taxonomic Designation	Productivity	Susceptibility	Vulnerability	Endemic?	Vulnerability Cluster
Myrichthys colubrinus	Ophichthidae	Anguilliformes	1.00	1.36	2.03	No	Most Vulnerable
Myrichthys maculosus	Ophichthidae	Anguilliformes	1.00	1.32	2.03	No	Most Vulnerable
Atelomycterus marmoratus	Atelomycteridae	Elasmobranch	1.29	1.68	1.85	No	Most Vulnerable
Chiloscyllium punctatum	Hemiscyllidae	Elasmobranch	1.29	1.61	1.82	No	Most Vulnerable
Echidna catenata	Muraenidae	Anguilliformes	1.29	1.61	1.82	No	Most Vulnerable
Gymnomuraena zebra	Muraenidae	Anguilliformes	1.29	1.61	1.82	No	Most Vulnerable
Himantura uarnak	Dasyatidae	Elasmobranch	1.29	1.49	1.78	No	Most Vulnerable
Chiloscyllium plagiosum	Hemiscylliidae	Elasmobranch	1.29	1.42	1.77	No	Most Vulnerable
Aetobatus narinari	Aetobatidae	Elasmobranch	1.29	1.17	1.72	No	Most Vulnerable
Taeniura lymma	Dasyatidae	Elasmobranch	1.29	1.13	1.72	No	Most Vulnerable
Stegostoma tigrinum	Stegostomatidae	Elasmobranch	1.43	1.68	1.71	No	Most Vulnerable
Echidna nebulosa	Muraenidae	Anguilliformes	1.57	1.63	1.56	No	Most Vulnerable
Pterapogon kauderni	Apogonidae	Teleost	2.00	2.15	1.52	Endemic	Most Vulnerable
Rhinomuraena quaesita	Muraenidae	Anguilliformes	1.57	1.49	1.51	No	Most Vulnerable
Malacanthus brevirostris	Malacanthidae	Teleost	1.57	1.47	1.50	No	Most Vulnerable
Malacanthus latovittatus	Malacanthidae	Teleost	1.57	1.47	1.50	No	Most Vulnerable
Gomphosus varius	Labridae	Teleost	2.00	2.05	1.45	No	Most Vulnerable
Exallias brevis	Blenniidae	Teleost	2.43	2.32	1.44	No	Most Vulnerable
Ostorhinchus parvulus	Apogonidae	Teleost	2.43	2.32	1.44	No	Most Vulnerable
Siganus uspi	Siganidae	Teleost	2.00	2.03	1.43	No	Most Vulnerable
Chaetodon trifascialis	Chaetodontidae	Teleost	2.29	2.19	1.39	No	Most Vulnerable
Chaetodontoplus caeruleopunctatus	Pomacanthidae	Teleost	2.14	2.08	1.38	Endemic	Most Vulnerable
Diodon holocanthus	Diodontidae	Teleost	1.86	1.76	1.37	No	Most Vulnerable
Diodon hystrix	Diodontidae	Teleost	1.86	1.76	1.37	No	Most Vulnerable
Centropyge potteri	Pomacanthidae	Teleost	2.14	2.05	1.36	Endemic	Most Vulnerable
Zoramia leptacanthus	Apogonidae	Teleost	2.14	2.05	1.36	No	Most Vulnerable
Chaetodon kleinii	Chaetodontidae	Teleost	2.29	2.15	1.35	No	Most Vulnerable
Chaetodon punctatofasciatus	Chaetodontidae	Teleost	2.29	2.15	1.35	No	Most Vulnerable
Chaetodon xanthurus	Chaetodontidae	Teleost	2.29	2.15	1.35	No	Most Vulnerable
Paracanthurus hepatus	Acanthuridae	Teleost	2.29	2.15	1.35	No	Most Vulnerable
Sphaeramia orbicularis	Apogonidae	Teleost	2.29	2.15	1.35	No	Most Vulnerable
Synchiropus marmoratus	Callionymidae	Teleost	2.57	2.22	1.29	No	Most Vulnerable
Pomacanthus semicirculatus	Pomacanthidae	Teleost	2.43	2.15	1.28	No	Most Vulnerable
Ostorhinchus compressus	Apogonidae	Teleost	2.00	1.79	1.28	No	Most Vulnerable
Arothron nigropunctatus	Tetraodontidae	Teleost	2.29	2.05	1.27	No	Most Vulnerable
Ostracion cubicum	Ostraciidae	Teleost	2.29	2.05	1.27	No	Most Vulnerable
Prionurus chrysurus	Acanthuridae	Teleost	2.29	2.05	1.27	No	Most Vulnerable
Lactoria cornuta	Ostraciidae	Teleost	2.00	1.76	1.26	No	Most Vulnerable
Thalassoma lunare	Labridae	Teleost	2.00	1.76	1.26	No	Most Vulnerable

Pervagor melanocephalus	Monacanthidae	Teleost	1.86	1.49	1.24	No	Most Vulnerable
Hemigymnus melapterus	Labridae	Teleost	2.14	1.88	1.23	No	Most Vulnerable
Chaetodon auriga	Chaetodontidae	Teleost	2.14	1.84	1.20	No	Most Vulnerable
Chaetodon lunula	Chaetodontidae	Teleost	2.14	1.84	1.20	No	Most Vulnerable
Chaetodon ephippium	Chaetodontidae	Teleost	2.29	1.96	1.20	No	Most Vulnerable
Gnathanodon speciosus	Carangidae	Teleost	1.86	1.36	1.20	No	Most Vulnerable
Ecsenius pulcher	Blenniidae	Teleost	2.43	2.05	1.20	No	Most Vulnerable
Ecsenius stigmatura	Blenniidae	Teleost	2.43	2.05	1.20	No	Most Vulnerable
Sphaeramia nematoptera	Apogonidae	Teleost	2.43	2.05	1.20	No	Most Vulnerable
Plectorhinchus chaetodonoides	Haemulidae	Teleost	2.00	1.61	1.17	No	Most Vulnerable
Chaetodontoplus duboulayi	Pomacanthidae	Teleost	2.00	1.59	1.16	No	Most Vulnerable
Acanthurus chronixis	Acanthuridae	Teleost	2.29	1.90	1.15	Endemic	Moderately Vulnerable
Koumansetta rainfordi	Gobiidae	Teleost	2.29	1.90	1.15	No	Moderately Vulnerable
Balistes vetula	Balistidae	Teleost	1.86	1.08	1.15	No	Most Vulnerable
Oxymonacanthus longirostris	Monacanthidae	Teleost	2.43	1.96	1.12	No	Moderately Vulnerable
Pomacanthus xanthometopon	Pomacanthidae	Teleost	2.43	1.96	1.12	No	Moderately Vulnerable
Zebrasoma desjardinii	Acanthuridae	Teleost	2.43	1.96	1.12	No	Moderately Vulnerable
Cryptocentrus cyanotaenia	Gobiidae	Teleost	2.57	2.03	1.11	No	Moderately Vulnerable
Heniochus acuminatus	Chaetodontidae	Teleost	2.29	1.84	1.10	No	Moderately Vulnerable
Platax pinnatus	Ephippidae	Teleost	2.29	1.82	1.09	No	Moderately Vulnerable
Chromileptes altivelis	Epinephelidae	Teleost	2.00	1.38	1.07	No	Most Vulnerable
Diodon liturosus	Diodontidae	Teleost	2.00	1.38	1.07	No	Most Vulnerable
Acanthurus lineatus	Acanthuridae	Teleost	2.43	1.90	1.07	No	Moderately Vulnerable
Canthigaster valentini	Tetraodontidae	Teleost	2.43	1.90	1.07	No	Moderately Vulnerable
Halichoeres trispilus	Labridae	Teleost	2.43	1.90	1.07	No	Moderately Vulnerable
Koumansetta hectori	Gobiidae	Teleost	2.43	1.90	1.07	No	Moderately Vulnerable
Pseudocheilinus hexataenia	Labridae	Teleost	2.43	1.90	1.07	No	Moderately Vulnerable
Coris gaimard	Labridae	Teleost	2.14	1.63	1.06	No	Moderately Vulnerable
Dendrochirus brachypterus	Scorpaenidae	Teleost	2.14	1.63	1.06	No	Moderately Vulnerable
Novaculichthys taeniourus	Labridae	Teleost	2.14	1.63	1.06	No	Moderately Vulnerable
Centropyge bispinosa	Pomacanthidae	Teleost	2.57	1.96	1.05	No	Moderately Vulnerable
Centropyge ferrugata	Pomacanthidae	Teleost	2.57	1.96	1.05	No	Moderately Vulnerable
Centropyge nox	Pomacanthidae	Teleost	2.57	1.96	1.05	No	Moderately Vulnerable
Parupeneus cyclostomus	Mullidae	Teleost	2.14	1.61	1.05	No	Moderately Vulnerable
Cirrhilabrus tonozukai	Labridae	Teleost	2.43	1.88	1.05	No	Moderately Vulnerable
Ecsenius bimaculatus	Blenniidae	Teleost	2.43	1.88	1.05	No	Moderately Vulnerable
Naso lopezi	Acanthuridae	Teleost	2.29	1.76	1.04	No	Moderately Vulnerable
Balistes punctatus	Balistidae	Teleost	2.00	1.26	1.03	No	Most Vulnerable

Balistapus undulatus	Balistidae	Teleost	2.29	1.74	1.03	No	Moderately Vulnerable
Melichthys vidua	Balistidae	Teleost	2.29	1.74	1.03	No	Moderately Vulnerable
Naso lituratus	Acanthuridae	Teleost	2.43	1.84	1.02	No	Moderately Vulnerable
Naso vlamingii	Acanthuridae	Teleost	2.43	1.84	1.02	No	Moderately Vulnerable
Pomacanthus imperator	Pomacanthidae	Teleost	2.43	1.84	1.02	No	Moderately Vulnerable
Salarias fasciatus	Blenniidae	Teleost	2.43	1.84	1.02	No	Moderately Vulnerable
Zebrasoma scopas	Acanthuridae	Teleost	2.43	1.84	1.02	No	Moderately Vulnerable
Zebrasoma velifer	Acanthuridae	Teleost	2.43	1.84	1.02	No	Moderately Vulnerable
Synchiropus morrisoni	Callionymidae	Teleost	2.14	1.54	1.01	No	Moderately Vulnerable
Acanthurus japonicus	Acanthuridae	Teleost	2.71	1.96	1.00	No	Moderately Vulnerable
Epinephelus lanceolatus	Epinephelidae	Teleost	2.00	1.08	1.00	No	Most Vulnerable
Elacatinus oceanops	Gobiidae	Teleost	2.57	1.90	1.00	No	Moderately Vulnerable
Pictichromis diadema	Pseudochromidae	Teleost	2.57	1.90	1.00	No	Moderately Vulnerable
Apolemichthys kingi	Pomacanthidae	Teleost	2.43	1.82	1.00	Endemic	Moderately Vulnerable
Larabicus quadrilineatus	Labridae	Teleost	2.43	1.82	1.00	Endemic	Moderately Vulnerable
Gobiodon atrangulatus	Gobiidae	Teleost	2.57	1.88	0.98	No	Moderately Vulnerable
Gobiodon citrinus	Gobiidae	Teleost	2.57	1.88	0.98	No	Moderately Vulnerable
Gobiodon histrio	Gobiidae	Teleost	2.57	1.88	0.98	No	Moderately Vulnerable
Gobiodon okinawae	Gobiidae	Teleost	2.57	1.88	0.98	No	Moderately Vulnerable
Gobiodon rivulatus	Gobiidae	Teleost	2.57	1.88	0.98	No	Moderately Vulnerable
Synchiropus picturatus	Callionymidae	Teleost	2.57	1.85	0.95	No	Moderately Vulnerable
Balistoides conspicillum	Balistidae	Teleost	2.29	1.63	0.95	No	Moderately Vulnerable
Dendrochirus zebra	Scorpaenidae	Teleost	2.29	1.63	0.95	No	Moderately Vulnerable
Nemateleotris decora	Microdesmidae	Teleost	2.29	1.63	0.95	No	Moderately Vulnerable
Odonus niger	Balistidae	Teleost	2.29	1.63	0.95	No	Moderately Vulnerable
Ostorhinchus cyanosoma	Apogonidae	Teleost	2.29	1.63	0.95	No	Moderately Vulnerable
Pterois volitans	Scorpaenidae	Teleost	2.29	1.63	0.95	No	Moderately Vulnerable
Rhinecanthus aculeatus	Balistidae	Teleost	2.29	1.63	0.95	No	Moderately Vulnerable
Acanthurus leucosternon	Acanthuridae	Teleost	2.43	1.76	0.95	No	Moderately Vulnerable
Acreichthys tomentosus	Monacanthidae	Teleost	2.43	1.76	0.95	No	Moderately Vulnerable
Naso tuberosus	Acanthuridae	Teleost	2.43	1.76	0.95	No	Moderately Vulnerable
Platax orbicularis	Ephippidae	Teleost	2.43	1.76	0.95	No	Moderately Vulnerable
Salarias ramosus	Blenniidae	Teleost	2.43	1.76	0.95	No	Moderately Vulnerable
Thalassoma amblycephalus	Labridae	Teleost	2.43	1.76	0.95	No	Moderately Vulnerable
Cryptocentrus cinctus	Gobiidae	Teleost	2.29	1.61	0.94	No	Moderately Vulnerable
Pterois lunulata	Scorpaenidae	Teleost	2.29	1.61	0.94	No	Moderately Vulnerable

Platax batavianus	Ephippidae	Teleost	2.14	1.38	0.94	No	Most Vulnerable
Cirrhitichthys falco	Cirrhitidae	Teleost	2.43	1.74	0.93	No	Moderately Vulnerable
Cirrhitichthys oxycephalus	Cirrhitidae	Teleost	2.43	1.74	0.93	No	Moderately Vulnerable
Dendrochirus biocellatus	Scorpaenidae	Teleost	2.43	1.74	0.93	No	Moderately Vulnerable
Hoplolatilus purpureus	Malacanthidae	Teleost	2.43	1.74	0.93	No	Moderately Vulnerable
Paracirrhites arcatus	Cirrhitidae	Teleost	2.43	1.74	0.93	No	Moderately Vulnerable
Salarias guttatus	Blenniidae	Teleost	2.43	1.74	0.93	No	Moderately Vulnerable
Centropyge bicolor	Pomacanthidae	Teleost	2.57	1.82	0.92	No	Moderately Vulnerable
Acanthurus olivaceus	Acanthuridae	Teleost	2.43	1.68	0.89	No	Moderately Vulnerable
Ostorhinchus margaritophorus	Apogonidae	Teleost	2.43	1.68	0.89	No	Moderately Vulnerable
Coris formosa	Labridae	Teleost	2.14	1.17	0.87	No	Most Vulnerable
Arothron hispidus	Tetraodontidae	Teleost	2.29	1.49	0.87	No	Moderately Vulnerable
Ecsenius midas	Blenniidae	Teleost	2.29	1.49	0.87	No	Moderately Vulnerable
Callogobius amikami	Gobiidae	Teleost	2.71	1.82	0.87	Endemic	Moderately Vulnerable
Centropyge eibli	Pomacanthidae	Teleost	2.71	1.82	0.87	No	Moderately Vulnerable
Centropyge vrolikii	Pomacanthidae	Teleost	2.71	1.82	0.87	No	Moderately Vulnerable
Neopomacentrus nemurus	Pomacentridae	Teleost	2.71	1.82	0.87	No	Moderately Vulnerable
Pomacanthus navarchus	Pomacanthidae	Teleost	2.71	1.82	0.87	No	Moderately Vulnerable
Amphiprion ephippium	Pomacentridae	Teleost	2.57	1.74	0.85	No	Moderately Vulnerable
Bodianus mesothorax	Labridae	Teleost	2.57	1.74	0.85	No	Moderately Vulnerable
Cirrhilabrus lubbocki	Labridae	Teleost	2.57	1.74	0.85	No	Moderately Vulnerable
Gramma brasiliensis	Grammatidae	Teleost	2.57	1.74	0.85	Endemic	Moderately Vulnerable
Hypoplectrus indigo	Serranidae	Teleost	2.57	1.74	0.85	No	Moderately Vulnerable
Pterois antennata	Scorpaenidae	Teleost	2.57	1.74	0.85	No	Moderately Vulnerable
Thalassoma bifasciatum	Labridae	Teleost	2.57	1.74	0.85	No	Moderately Vulnerable
Halichoeres hortulanus	Labridae	Teleost	2.43	1.63	0.85	No	Moderately Vulnerable
Meiacanthus atrodorsalis	Blenniidae	Teleost	2.43	1.63	0.85	No	Moderately Vulnerable
Serranus tortugarum	Serranidae	Teleost	2.43	1.63	0.85	No	Moderately Vulnerable
Valenciennea puellaris	Gobiidae	Teleost	2.43	1.63	0.85	No	Moderately Vulnerable
Dunckerocampus dactyliophorus	Syngnathidae	Teleost	2.43	1.61	0.83	No	Moderately Vulnerable
Ecsenius bicolor	Blenniidae	Teleost	2.43	1.61	0.83	No	Moderately Vulnerable
Cirrhilabrus solorensis	Labridae	Teleost	2.57	1.71	0.83	No	Moderately Vulnerable
Chrysiptera springeri	Pomacentridae	Teleost	2.71	1.76	0.81	No	Moderately Vulnerable
Siganus unimaculatus	Siganidae	Teleost	2.71	1.76	0.81	No	Moderately Vulnerable
Centropyge heraldi	Pomacanthidae	Teleost	2.57	1.68	0.81	No	Moderately Vulnerable
Centropyge tibicen	Pomacanthidae	Teleost	2.57	1.68	0.81	No	Moderately Vulnerable

Ecsenius tigris	Blenniidae	Teleost	2.57	1.68	0.81	Endemic	Moderately Vulnerable
Forcipiger flavissimus	Chaetodontidae	Teleost	2.57	1.68	0.81	No	Moderately Vulnerable
Synchiropus sycorax	Callionymidae	Teleost	2.57	1.68	0.81	Endemic	Moderately Vulnerable
Coryphopterus personatus	Gobiidae	Teleost	2.29	1.36	0.80	No	Moderately Vulnerable
Pomacanthus annularis	Pomacanthidae	Teleost	2.43	1.56	0.80	No	Moderately Vulnerable
Zebrasoma flavescens	Acanthuridae	Teleost	2.43	1.54	0.78	No	Moderately Vulnerable
Amphiprion akindynos	Pomacentridae	Teleost	2.86	1.76	0.77	No	Moderately Vulnerable
Amphiprion percula	Pomacentridae	Teleost	2.86	1.76	0.77	No	Moderately Vulnerable
Pholidichthys leucotaenia	Pholidichthyidae	Teleost	2.29	1.28	0.77	No	Moderately Vulnerable
Gobiodon reticulatus	Gobiidae	Teleost	2.57	1.63	0.76	No	Moderately Vulnerable
Paracheilinus cyaneus	Labridae	Teleost	2.57	1.63	0.76	No	Moderately Vulnerable
Calloplesiops altivelis	Plesiopidae	Teleost	2.43	1.49	0.75	No	Moderately Vulnerable
Cetoscarus bicolor	Labridae	Teleost	2.43	1.49	0.75	No	Moderately Vulnerable
Manonichthys polynemus	Pseudochromidae	Teleost	2.43	1.49	0.75	No	Moderately Vulnerable
Pseudocheilinus ocellatus	Labridae	Teleost	2.43	1.49	0.75	No	Moderately Vulnerable
Pterois radiata	Scorpaenidae	Teleost	2.43	1.49	0.75	No	Moderately Vulnerable
Chaetodontoplus meredithi	Pomacanthidae	Teleost	2.57	1.61	0.74	Endemic	Moderately Vulnerable
Halichoeres chloropterus	Labridae	Teleost	2.57	1.61	0.74	No	Moderately Vulnerable
Halichoeres melanurus	Labridae	Teleost	2.57	1.61	0.74	No	Moderately Vulnerable
Macropharyngodon meleagris	Labridae	Teleost	2.57	1.61	0.74	No	Moderately Vulnerable
Mirolabrichthys tuka	Anthiadidae	Teleost	2.57	1.61	0.74	No	Moderately Vulnerable
Paragobiodon lacunicola	Gobiidae	Teleost	2.57	1.61	0.74	No	Moderately Vulnerable
Rhinecanthus verrucosus	Balistidae	Teleost	2.57	1.61	0.74	No	Moderately Vulnerable
Valenciennea strigata	Gobiidae	Teleost	2.57	1.61	0.74	No	Moderately Vulnerable
Chelmon rostratus	Chaetodontidae	Teleost	2.71	1.68	0.74	No	Least Vulnerable
Ophioblennius atlanticus	Blenniidae	Teleost	2.71	1.68	0.74	No	Least Vulnerable
Plectroglyphidodon aureus	Pomacentridae	Teleost	2.71	1.68	0.74	No	Least Vulnerable
Cirrhilabrus exquisitus	Labridae	Teleost	2.57	1.59	0.73	No	Least Vulnerable
Cirrhilabrus rubripinnis	Labridae	Teleost	2.57	1.59	0.73	No	Least Vulnerable
Oxycirrhites typus	Cirrhitidae	Teleost	2.57	1.59	0.73	No	Least Vulnerable
Synchiropus splendidus	Callionymidae	Teleost	2.57	1.59	0.73	No	Least Vulnerable
Acanthurus achilles	Acanthuridae	Teleost	2.43	1.42	0.71	No	Least Vulnerable
Amphiprion allardi	Pomacentridae	Teleost	2.71	1.63	0.69	No	Least Vulnerable
Amphiprion bicinctus	Pomacentridae	Teleost	2.71	1.63	0.69	No	Least Vulnerable
Acanthurus coeruleus	Acanthuridae	Teleost	2.43	1.36	0.68	No	Least Vulnerable
Amblyglyphidodon aureus	Pomacentridae	Teleost	2.43	1.36	0.68	No	Least Vulnerable
Amphiprion akallopisos	Pomacentridae	Teleost	2.71	1.61	0.67	No	Least Vulnerable
Amphiprion frenatus	Pomacentridae	Teleost	2.71	1.61	0.67	No	Least Vulnerable

Atrosalarias fuscus	Blenniidae	Teleost	2.71	1.61	0.67	No	Least Vulnerable
Chromis viridis	Pomacentridae	Teleost	2.71	1.61	0.67	No	Least Vulnerable
Chrysiptera parasema	Pomacentridae	Teleost	2.71	1.61	0.67	No	Least Vulnerable
Dascyllus aruanus	Pomacentridae	Teleost	2.71	1.61	0.67	No	Least Vulnerable
Pomacentrus alleni	Pomacentridae	Teleost	2.71	1.61	0.67	No	Least Vulnerable
Pseudochromis fridmani	Pseudochromidae	Teleost	2.71	1.61	0.67	Endemic	Least Vulnerable
Amblygobius phalaena	Gobiidae	Teleost	2.57	1.49	0.65	No	Least Vulnerable
Bodianus bimaculatus	Labridae	Teleost	2.57	1.49	0.65	No	Least Vulnerable
Centropyge loriculus	Pomacanthidae	Teleost	2.57	1.49	0.65	No	Least Vulnerable
Cirrhilabrus flavidorsalis	Labridae	Teleost	2.57	1.49	0.65	No	Least Vulnerable
Cirrhilabrus jordani	Labridae	Teleost	2.57	1.49	0.65	No	Least Vulnerable
Halichoeres chrysus	Labridae	Teleost	2.57	1.49	0.65	No	Least Vulnerable
Nemateleotris magnifica	Microdesmidae	Teleost	2.57	1.49	0.65	No	Least Vulnerable
Paracheilinus carpenteri	Labridae	Teleost	2.57	1.49	0.65	No	Least Vulnerable
Paracheilinus filamentosus	Labridae	Teleost	2.57	1.49	0.65	No	Least Vulnerable
Pictichromis paccagnellorum	Pseudochromidae	Teleost	2.57	1.49	0.65	No	Least Vulnerable
Pictichromis porphyrea	Pseudochromidae	Teleost	2.57	1.49	0.65	No	Least Vulnerable
Stonogobiops nematodes	Gobiidae	Teleost	2.57	1.49	0.65	No	Least Vulnerable
Stonogobiops xanthorhinica	Gobiidae	Teleost	2.57	1.49	0.65	No	Least Vulnerable
Xanthichthys auromarginatus	Balistidae	Teleost	2.57	1.49	0.65	No	Least Vulnerable
Amphiprion latezonatus	Pomacentridae	Teleost	2.86	1.63	0.65	No	Least Vulnerable
Abudefduf saxatilis	Pomacentridae	Teleost	2.57	1.47	0.64	No	Least Vulnerable
Cryptocentrus leptocephalus	Gobiidae	Teleost	2.57	1.47	0.64	No	Least Vulnerable
Doryrhamphus excisus	Syngnathidae	Teleost	2.57	1.47	0.64	No	Least Vulnerable
Synchiropus ocellatus	Callionymidae	Teleost	2.57	1.47	0.64	No	Least Vulnerable
Zanclus cornutus	Zanclidae	Teleost	2.57	1.47	0.64	No	Least Vulnerable
Apolemichthys trimaculatus	Pomacanthidae	Teleost	2.71	1.56	0.63	No	Least Vulnerable
Chaetodontoplus mesoleucus	Pomacanthidae	Teleost	2.71	1.56	0.63	No	Least Vulnerable
Pomacentrus chrysurus	Pomacentridae	Teleost	2.71	1.56	0.63	No	Least Vulnerable
Pygoplites diacanthus	Pomacanthidae	Teleost	2.71	1.56	0.63	No	Least Vulnerable
Amphiprion biaculeatus	Pomacentridae	Teleost	2.86	1.61	0.62	No	Least Vulnerable
Amphiprion ocellaris	Pomacentridae	Teleost	2.86	1.61	0.62	No	Least Vulnerable
Centropyge deborae	Pomacanthidae	Teleost	2.86	1.61	0.62	Endemic	Least Vulnerable
Chrysiptera hemicyanea	Pomacentridae	Teleost	2.86	1.61	0.62	No	Least Vulnerable
Pomacentrus moluccensis	Pomacentridae	Teleost	2.86	1.61	0.62	No	Least Vulnerable
Valenciennea longipinnis	Gobiidae	Teleost	2.71	1.54	0.61	No	Least Vulnerable
Amphiprion melanopus	Pomacentridae	Teleost	3.00	1.61	0.61	No	Least Vulnerable
Chaetodon collare	Chaetodontidae	Teleost	2.57	1.38	0.57	No	Least Vulnerable
Macropharyngodon bipartitus	Labridae	Teleost	2.57	1.38	0.57	No	Least Vulnerable
Macropharyngodon ornatus	Labridae	Teleost	2.57	1.38	0.57	No	Least Vulnerable
Monodactylus argenteus	Monodactylidae	Teleost	2.57	1.38	0.57	No	Least Vulnerable
Parupeneus barberinoides	Mullidae	Teleost	2.57	1.38	0.57	No	Least Vulnerable

Stegastes lacrymatus	Pomacentridae	Teleost	2.57	1.38	0.57	No	Least Vulnerable
Amphiprion sebae	Pomacentridae	Teleost	2.71	1.49	0.57	No	Least Vulnerable
Centropyge argi	Pomacanthidae	Teleost	2.71	1.49	0.57	No	Least Vulnerable
Centropyge multicolor	Pomacanthidae	Teleost	2.71	1.49	0.57	No	Least Vulnerable
Dascyllus melanurus	Pomacentridae	Teleost	2.71	1.49	0.57	No	Least Vulnerable
Dascyllus reticulatus	Pomacentridae	Teleost	2.71	1.49	0.57	No	Least Vulnerable
Dascyllus trimaculatus	Pomacentridae	Teleost	2.71	1.49	0.57	No	Least Vulnerable
Gramma loreto	Grammidae	Teleost	2.71	1.49	0.57	No	Least Vulnerable
Gramma melacara	Grammidae	Teleost	2.71	1.49	0.57	No	Least Vulnerable
Holacanthus ciliaris	Pomacanthidae	Teleost	2.71	1.49	0.57	No	Least Vulnerable
Pycnochromis retrofasciatus	Pomacentridae	Teleost	2.71	1.49	0.57	No	Least Vulnerable
Siganus vulpinus	Siganidae	Teleost	2.71	1.49	0.57	No	Least Vulnerable
Stegastes leucostictus	Pomacentridae	Teleost	2.71	1.49	0.57	No	Least Vulnerable
Centropyge flavissima	Pomacanthidae	Teleost	2.57	1.36	0.56	No	Least Vulnerable
Cirrhilabrus cyanopleura	Labridae	Teleost	2.57	1.36	0.56	No	Least Vulnerable
Cirrhilabrus filamentosus	Labridae	Teleost	2.57	1.36	0.56	No	Least Vulnerable
Cirrhilabrus rubriventralis	Labridae	Teleost	2.57	1.36	0.56	No	Least Vulnerable
Acanthurus pyroferus	Acanthuridae	Teleost	2.71	1.44	0.53	No	Least Vulnerable
Chrysiptera brownriggii	Pomacentridae	Teleost	2.71	1.44	0.53	No	Least Vulnerable
Genicanthus lamarck	Pomacanthidae	Teleost	2.71	1.44	0.53	No	Least Vulnerable
Genicanthus melanospilos	Pomacanthidae	Teleost	2.71	1.44	0.53	No	Least Vulnerable
Centropyge acanthops	Pomacanthidae	Teleost	2.57	1.28	0.51	No	Least Vulnerable
Halichoeres iridis	Labridae	Teleost	2.57	1.28	0.51	No	Least Vulnerable
Nemateleotris helfrichi	Microdesmidae	Teleost	2.57	1.28	0.51	No	Least Vulnerable
Amphiprion clarkii	Pomacentridae	Teleost	2.86	1.49	0.51	No	Least Vulnerable
Amphiprion perideraion	Pomacentridae	Teleost	2.86	1.49	0.51	No	Least Vulnerable
Amphiprion polymnus	Pomacentridae	Teleost	2.86	1.49	0.51	No	Least Vulnerable
Microspathodon chrysurus	Pomacentridae	Teleost	2.86	1.49	0.51	No	Least Vulnerable
Pycnochromis margaritifer	Pomacentridae	Teleost	2.57	1.26	0.50	No	Least Vulnerable
Chrysiptera cyanea	Pomacentridae	Teleost	2.71	1.38	0.47	No	Least Vulnerable
Chrysiptera rex	Pomacentridae	Teleost	2.71	1.38	0.47	No	Least Vulnerable
Meiacanthus grammistes	Blenniidae	Teleost	2.71	1.38	0.47	No	Least Vulnerable
Nemanthias dispar	Anthiadidae	Teleost	2.71	1.38	0.47	No	Least Vulnerable
Neopomacentrus filamentosus	Pomacentridae	Teleost	2.71	1.38	0.47	No	Least Vulnerable
Pomacentrus bankanensis	Pomacentridae	Teleost	2.71	1.38	0.47	No	Least Vulnerable
Pomacentrus caeruleus	Pomacentridae	Teleost	2.71	1.38	0.47	No	Least Vulnerable
Pomacentrus coelestis	Pomacentridae	Teleost	2.71	1.38	0.47	No	Least Vulnerable
Pomacentrus philippinus	Pomacentridae	Teleost	2.71	1.38	0.47	No	Least Vulnerable
Pomacentrus simsiang	Pomacentridae	Teleost	2.71	1.38	0.47	No	Least Vulnerable
Pseudanthias randalli	Anthiadidae	Teleost	2.71	1.38	0.47	No	Least Vulnerable
Ptereleotris evides	Microdesmidae	Teleost	2.71	1.38	0.47	No	Least Vulnerable
Pyronotanthias lori	Anthiadidae	Teleost	2.71	1.38	0.47	No	Least Vulnerable
Serranocirrhitus latus	Anthiadidae	Teleost	2.71	1.38	0.47	No	Least Vulnerable

Signigobius biocellatus	Gobiidae	Teleost	2.71	1.38	0.47	No	Least Vulnerable
Valenciennea sexguttata	Gobiidae	Teleost	2.71	1.38	0.47	No	Least Vulnerable
Acanthochromis polyacanthus	Pomacentridae	Teleost	2.57	1.17	0.46	No	Least Vulnerable
Acanthurus triostegus	Acanthuridae	Teleost	2.57	1.17	0.46	No	Least Vulnerable
Azurina cyanea	Pomacentridae	Teleost	2.57	1.17	0.46	No	Least Vulnerable
Chromis analis	Pomacentridae	Teleost	2.57	1.17	0.46	No	Least Vulnerable
Cirrhitichthys aprinus	Cirrhitidae	Teleost	2.57	1.17	0.46	No	Least Vulnerable
Dischistodus pseudochrysopoecilus	Pomacentridae	Teleost	2.86	1.42	0.45	No	Least Vulnerable
Ctenochaetus tominiensis	Acanthuridae	Teleost	2.71	1.32	0.43	No	Least Vulnerable
Choerodon fasciatus	Labridae	Teleost	2.71	1.28	0.40	No	Least Vulnerable
Chrysiptera talboti	Pomacentridae	Teleost	2.71	1.28	0.40	No	Least Vulnerable
Labroides dimidiatus	Labridae	Teleost	2.71	1.28	0.40	No	Least Vulnerable
Opistognathus aurifrons	Opistognathidae	Teleost	2.71	1.28	0.40	No	Least Vulnerable
Plectroglyphidodon fasciolatus	Pomacentridae	Teleost	2.71	1.28	0.40	No	Least Vulnerable
Pomacentrus auriventris	Pomacentridae	Teleost	2.71	1.28	0.40	No	Least Vulnerable
Pseudanthias pleurotaenia	Anthiadidae	Teleost	2.71	1.28	0.40	No	Least Vulnerable
Pseudanthias squamipinnis	Anthiadidae	Teleost	2.71	1.28	0.40	No	Least Vulnerable
Ptereleotris heteroptera	Microdesmidae	Teleost	2.71	1.28	0.40	No	Least Vulnerable
Ptereleotris microlepis	Microdesmidae	Teleost	2.71	1.28	0.40	No	Least Vulnerable
Ptereleotris zebra	Microdesmidae	Teleost	2.71	1.28	0.40	No	Least Vulnerable
Serranus tigrinus	Serranidae	Teleost	2.71	1.28	0.40	No	Least Vulnerable
Valenciennea helsdingenii	Gobiidae	Teleost	2.71	1.28	0.40	No	Least Vulnerable
Valenciennea wardii	Gobiidae	Teleost	2.71	1.28	0.40	No	Least Vulnerable
Amblyglyphidodon curacao	Pomacentridae	Teleost	2.71	1.26	0.39	No	Least Vulnerable
Amblyglyphidodon ternatensis	Pomacentridae	Teleost	2.71	1.26	0.39	No	Least Vulnerable
Neoglyphidodon melas	Pomacentridae	Teleost	2.71	1.26	0.39	No	Least Vulnerable
Chrysiptera rollandi	Pomacentridae	Teleost	2.71	1.17	0.33	No	Least Vulnerable
Dischistodus prosopotaenia	Pomacentridae	Teleost	2.71	1.17	0.33	No	Least Vulnerable
Neoglyphidodon oxyodon	Pomacentridae	Teleost	2.71	1.13	0.31	No	Least Vulnerable
Pomacentrus amboinensis	Pomacentridae	Teleost	2.86	1.28	0.31	No	Least Vulnerable
Neoglyphidodon nigroris	Pomacentridae	Teleost	2.71	1.08	0.30	No	Least Vulnerable
Amblypomacentrus breviceps	Pomacentridae	Teleost	2.71	1.00	0.29	No	Least Vulnerable
Chromis opercularis	Pomacentridae	Teleost	2.71	1.00	0.29	No	Least Vulnerable
Chrysiptera unimaculata	Pomacentridae	Teleost	2.86	1.13	0.19	No	Least Vulnerable

Appendix 2: Expert review of species that were listed as common in the marine aquarium trade. Species scientific name, common name, and trade marker that indicates why they are not common in the hobby trade are presented below as a subset of the 103 'high priority' species list from Appendix 4 of AC33. Note that the Hawai'i aquarium fishery was shut down which now limits the number of fish traded for species that were regularly sourced from Hawai'i.

Species	**Common Name**	**Trade Marker**
Epinephelus lanceolatus	Giant grouper	Public Aquarium Only
Aetobatus narinari	Whitespotted eagle ray	Public Aquarium Only
Stegostoma tigrinum	Zebra shark	Public Aquarium Only
Lutjanus analis	Mutton snapper	Public Aquarium Only
Sphyraena jello	Pickhandle barracuda	Public Aquarium Only
Bolbometopon muricatum	Green humphead parrotfish	Food Fisheries or Public Aquarium Only
Pastinachus sephen	Cowtail stingray	Food Fisheries or Public Aquarium Only
Nebrius ferrugineus	Tawny nurse shark	Food Fisheries or Public Aquarium Only
Elacatinus figaro	Barber goby	Captive-Bred Only
Amphiprion mccullochi	Whitesnout anemonefish	Captive-Bred Only
Epinephelus fuscoguttatus	Brown-marbled grouper	Food Fisheries
Acanthurus achilles	Achilles tang	Hawai'i Collection Closed
Zebrasoma flavescens	Yellow tang	Hawai'i Collection - Not in Trade
Centropyge potteri	Russet angelfish	Hawai'i Collection - Not in Trade
Gymnothorax dovii	Finespotted moray	Limited Collection Available
Bodianus frenchii	Foxfish	Limited Collection Available
Halichoeres adustus	Black wrasse	Limited Collection Available
Semicossyphus pulcher	California sheephead	Limited Collection Available
Holacanthus limbaughi	Clipperton angelfish	Limited Collection Available
Sebastes constellatus	Starry rockfish	Limited Collection Available
Hemiscyllium hallstromi	Papuan epaulette shark	Limited Collection Available
Rhinoptera neglecta	Australian cownose ray	Limited Collection Available
Acanthurus chronixis	Chronixis surgeonfish	Commonly Misidentified *A. pyroferus*
Chiloscyllium hasseltii	Hasselt's bambooshark	Rare in Trade
Torpedo sinuspersici	Variable torpedo ray	Rare in Trade
Triakis scyllium	Banded houndshark	Rare in Trade

Appendix 3: Scoring matrix for PSA factors for productivity and susceptibility with corresponding weight and scoring bin based on raw data parameters.

Productivity Factors	Score 1	Score 2	Score 3	Factor Weight
Maximum Size (cm)[1]	>60	30-60	<30	2
Trophic Level[1]	>3.5	2.5-3.5	<2.5	1
Breeding Strategy[1]	Live bearer/mouthbrooder with a fecundity score of 1, or a broadcast/demersal spawner with a fecundity score of 1	Distinct pairing, demersal spawner	Broadcast Spawner, demersal spawner with high parental care, or mouthbrooder with a fecundity score of 2 or 3 (above 1,000)	1
Fecundity (number of eggs produced yearly)[1]	<1,000	1,000-15,000	>15,000	2
Pelagic Larval Duration (days)[1]	>30	14-30	<14	1
Susceptibility Factors	**Score 3**	**Score 2**	**Score 1**	**Factor Weight**
Volume in trade (scaled on productivity score)[1]	Greater than 3,000 traded and p=0.77-1.9	Greater than 3,000 traded and p=1.9-2.0 OR Less than 3,000 and p=0.77-1.9	<3,000 total volume in trade OR p=2-2.3 at any trade volume	2
Ecological niche + Geographic distribution[2]	Small geographic range/Narrow habitat specificity	1. Large geographic range/Narrow habitat specificity 2. Small geographic range/Wide habitat specificity	Large geographic range/Wide habitat specificity	2
Cyanide Use[1]	1. Country of Export: Indonesia, Philippines, Vietnam 2. Family: Chaetodontidae, Pomacanthidae, Acanthuridae	No rating of 2 for this category	Score of 1 if conditions in score 3 do not apply	1
Encounterability depth (m)[1]	<10	10-30	>30	1
Aquarium Suitability[1]	"Difficult" care level (grows very large, complex diet, aggressive, high tank mortality rate)	"Moderate" care level	"Easy" care level: (remains at small size, resilient to environmental changes, non-aggressive, less likely to need replacing)	1
Life cycle stage of harvest 1: Recruit, 2: Juvenile, 3: Subadult, 4: Adult	Harvested at juvenile and adult stages. (1,2,3,4), (1,2,3), (2,3), (2,3,4)	Harvested only at adult stage (3), (3,4), (4)	Only harvested at juvenile stage (1), (1,2), (2)	2

[1]Adapted from Baillargeon, et al (2020)

[2]Adapted from (Rabinowitz, 1981)

Appendix 4. Changes to vulnerability score by species when removing volume in trade as a susceptibility factor.

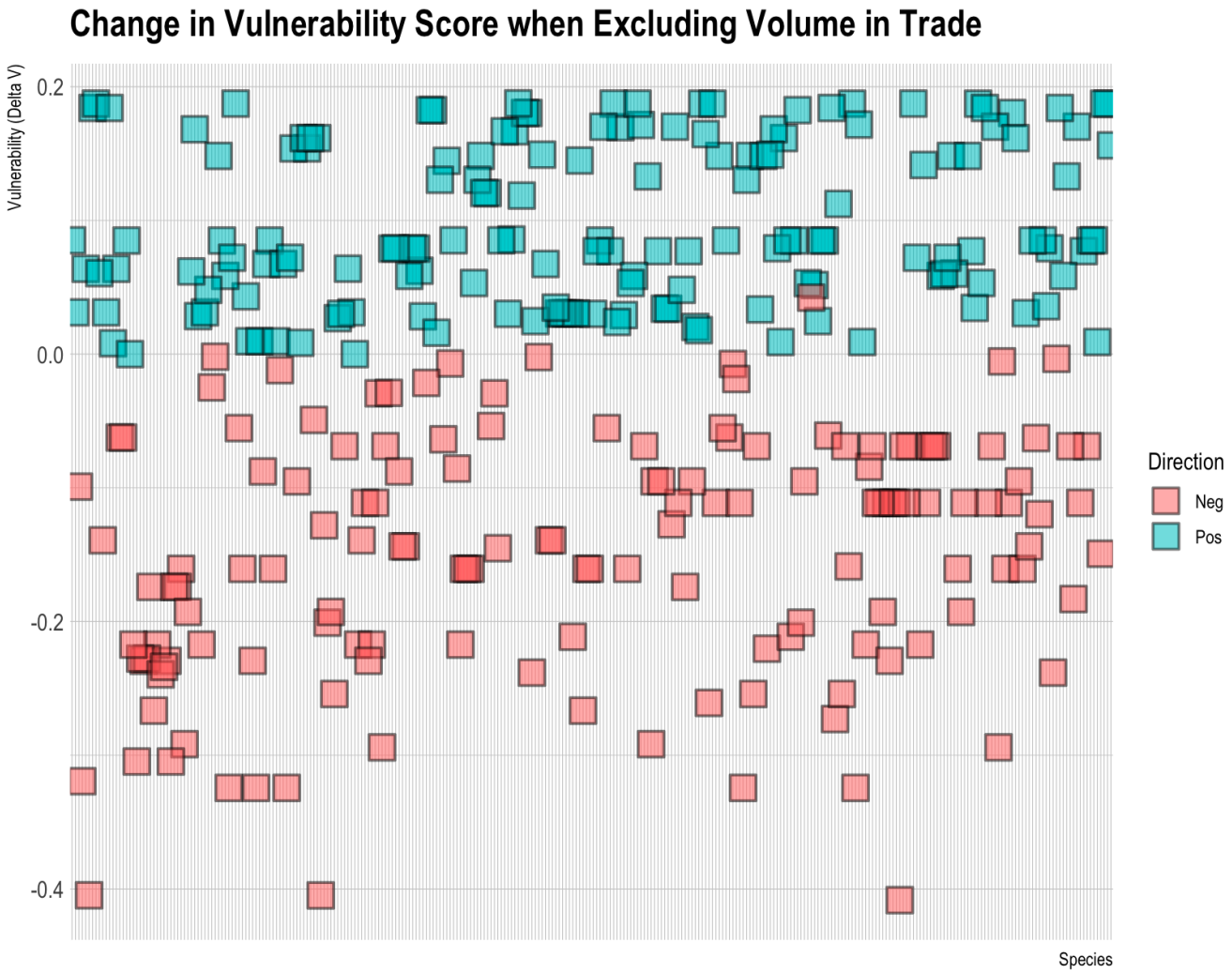

Figure 4. Change in the vulnerability score for all species assessed when comparing the inclusion of volume in trade to removing it as a susceptibility factor. Red indicates the vulnerability score increased and blue indicates the vulnerability score decreased when excluding volume in trade as a factor.