Evaluating Species at Risk in Data-Limited Fisheries:
A Comprehensive Productivity-Susceptibility Analysis of the Most Traded Marine Aquarium Fish

Gabbie Baillargeon, Dr. Andrew Rhyne, Dr. Michael Tlusty

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Gabbie Baillargeon

B.S. Marine Biology & Applied Mathematics

PhD Student at University of Leeds, UK

"Assessing the Sustainability of Marine Aquarium Trade Under Different Management Scenarios"

Research Experience:

- **Assessing sustainability of the data-deficient marine aquarium trade using a semi-quantitative model**
- Analytical chemistry method to **detect illegal cyanide fishing** in aquarium fish
- Functional Response of Pacific Rock Crabs and **Co-Management** of Blue Mussels
- Upstream Protein Processing Extraction and Characterization for a ClimateTech Start-Up

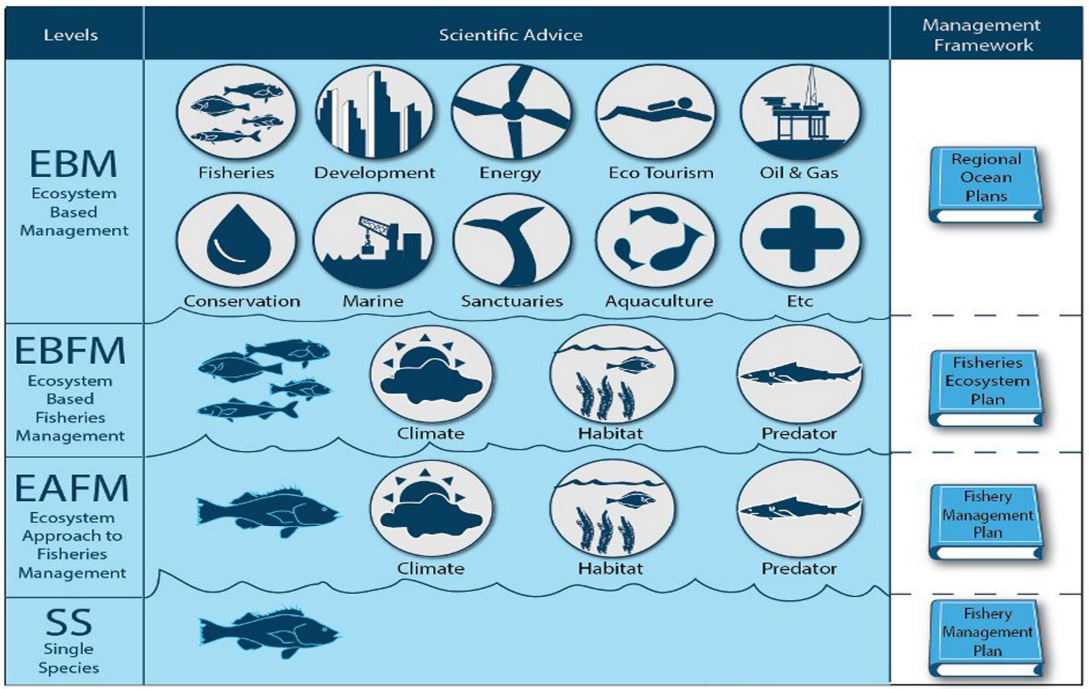
Email: bsgb@leeds.ac.uk

Broad Research Interests:

1. Data-Limited Fisheries Assessments

2. Ecosystem Based Management for Fisheries

3. Fish Biology & Community Dynamics



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Expanding and improving
the PSA from the top 32 to 250
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Key Model Improvements:

1. Rapid and robust assessment for a diverse genera of species
2. Better methods to handle data deficiencies
3. Improved machine learning algorithm to cluster species into sustainability categories

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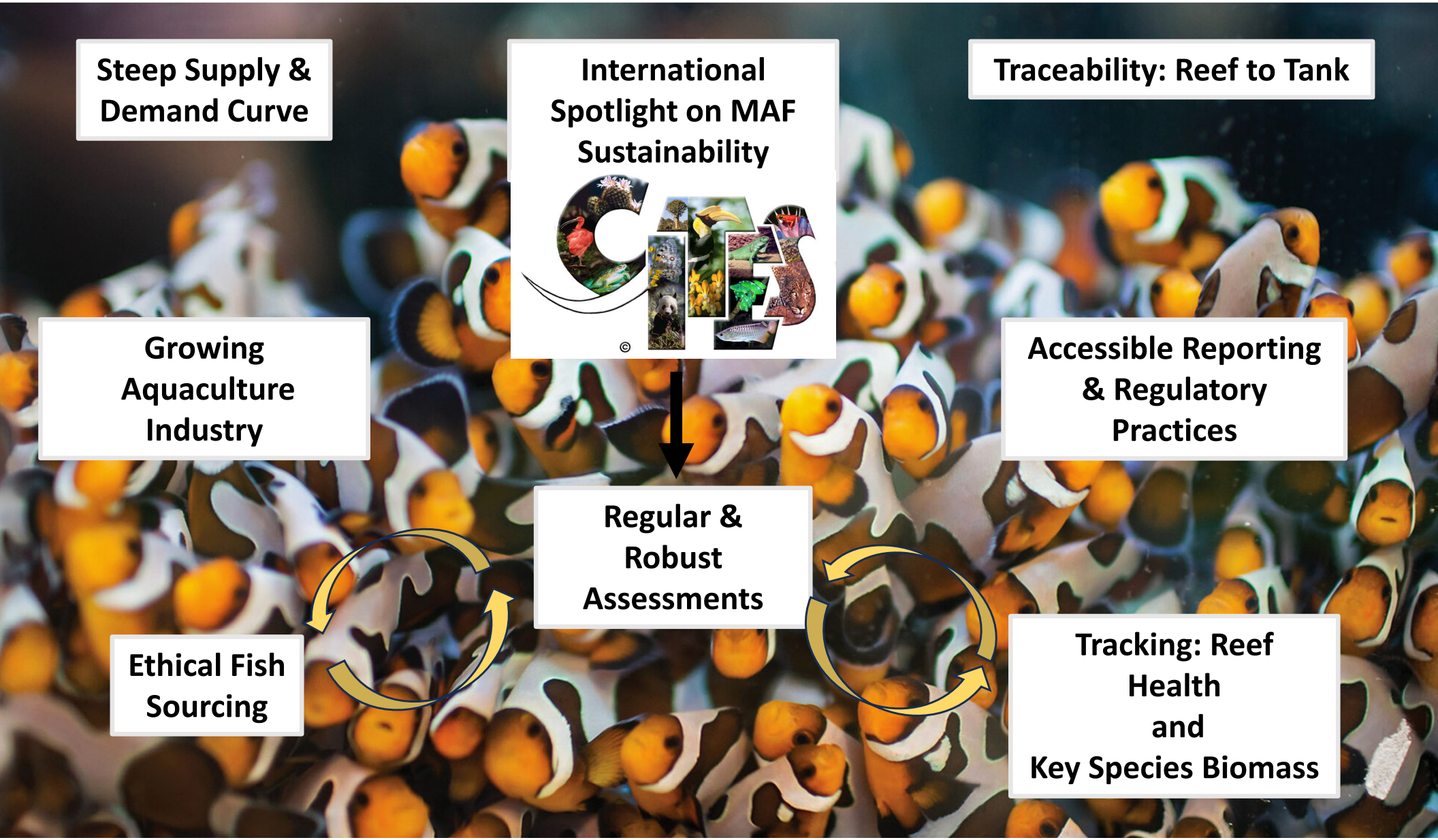
Challenges of the Marine Aquarium Trade

Current Sustainability → Future Sustainability



How can we identify stocks or species at risk of overexploitation from the marine aquarium trade?

MAF are too data-deficient to apply traditional stock assessment methods

- Species Biomass
- Fishing Mortality Indicators
- Age and Size Classes of Stocks
- Reef to Sale Traceability

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Productivity-Susceptibility Analysis

Estimates the potential vulnerability to fishing for a given species based on its life-history and known fishery characteristics

- Productivity: Indirect measurement of a species' ability to reproduce and indicates resiliency to changing environmental conditions
- Susceptibility: Measures the likelihood that fishing pressures will have a negative impact on a species' population

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Vulnerability to Fishing

=

Life History Traits + Fishery Characteristics

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

Framework of the Productivity-Susceptibility Analysis

Productivity Factors
Maximum size
Mean trophic level
Breeding strategy
Fecundity
Pelagic larval duration

Susceptibility Factors
Ecological niche & distribution
Cyanide use
Encounterability depth
Aquarium suitability
Trade volume
Life cycle stage of harvest

Species Vulnerability Score

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Species Vulnerability Score

How does it work?

- Raw data for each factor is binned into a score of 1-3 (low to high)
- **Weighted factors**
- Using existing databases and individual species searches

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Species Vulnerability Score

Global Score & Vulnerability Classification

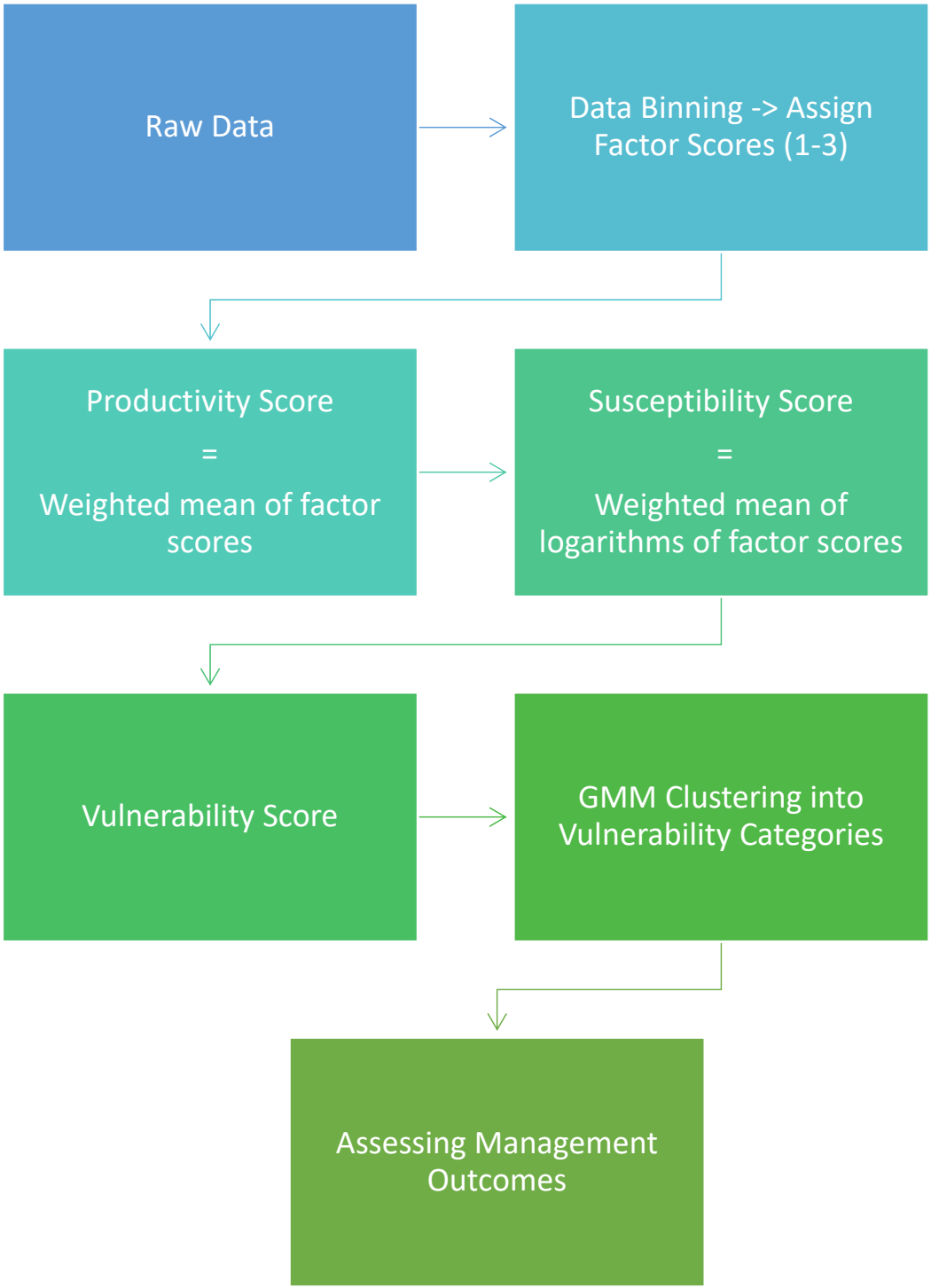
Semi-Supervised Machine Learning Model:

- Least Vulnerable
- Moderately Vulnerable
- Most Vulnerable

PSA Flow Chart

[R Package coming soon to automate!]

Input requirements:
Raw data for 11 factors



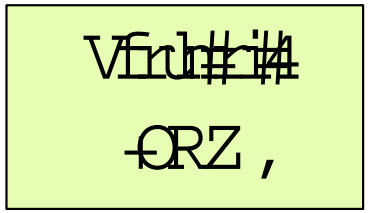
Example Fish: *G. species*

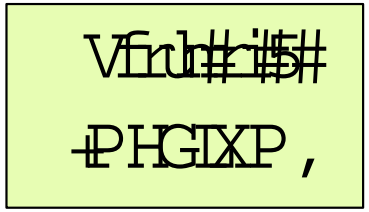
Factor	Data sources
Productivity	
Maximum size	Primary literature, Michael, S. (2005), FishBase
Mean trophic level	FishBase, Primary literature
Breeding strategy	FishBase, Breder and Rosen (1966), Thresher (1984)
Fecundity	Primary literature, Hobbyist forums (i.e.: breedersregistry.org, mbisite.org), FishBase
Pelagic larval duration	Primary literature
Susceptibility	
Ecological niche/distribution	Eschmeyer's Catalog of Fishes, IUCN Red List assessments, FishBase
Cyanide use	Aquariumtradedata.org
Encounterability depth	IUCN Red List assessments
Aquarium suitability	Online hobbyist databases, (LiveAquaria.com, Saltcorner.com, Reeflex.net), Michael, S. (2005)
Trade volume	Aquariumtradedata.org
Life cycle stage of harvest	LiveAquaria.com, BlueZooAquatics.com

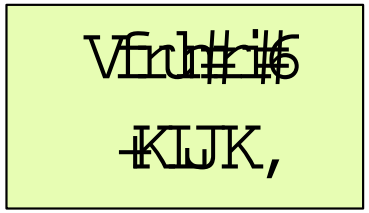
1. Gather raw data
2. Raw data falls into 1 of 3 data bins customized to life-history trends of MAF
3. Data bin corresponds with a factor score of 1-3

Gather Raw Data

for 11 PSA factors







Example Fish: *G. species*

Scoring Ecological Niche and Distribution

Geographic range: Large		Geographic range: Small	
Wide	Narrow	Wide	Narrow
1 Locally abundant over large range in several habitats	2 Locally abundant over large range in specific habitat	2 Locally abundant in several habitats but restricted geographically	3 Locally abundant in specific habitat but restricted geographically
1 Constantly sparse over large range and in several habitats	2 Constantly sparse in specific habitat but over large range	2 Constantly sparse and geographically restricted in several habitats	3 Constantly sparse and geographically restricted in specific habitat

Habitat specificity

Scoring Trade Volume

	Volume in Trade (Rhyne *et al.* 2015)	&	Productivity Score
1	<3000		P = 0.77-1.9
2	**>3000**		**P = 1.9-2.0**
	<3000		P = 0.77-1.9
3	**>3000**		**P = 0.77-1.9**
	All Volumes		P = 2-2.3

Example Fish: *G. species*

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Habitat specificity

Large and Wide Distribution = 1

Scoring Trade Volume

	Volume in Trade (Rhyne *et al.* 2015)	&	Productivity Score
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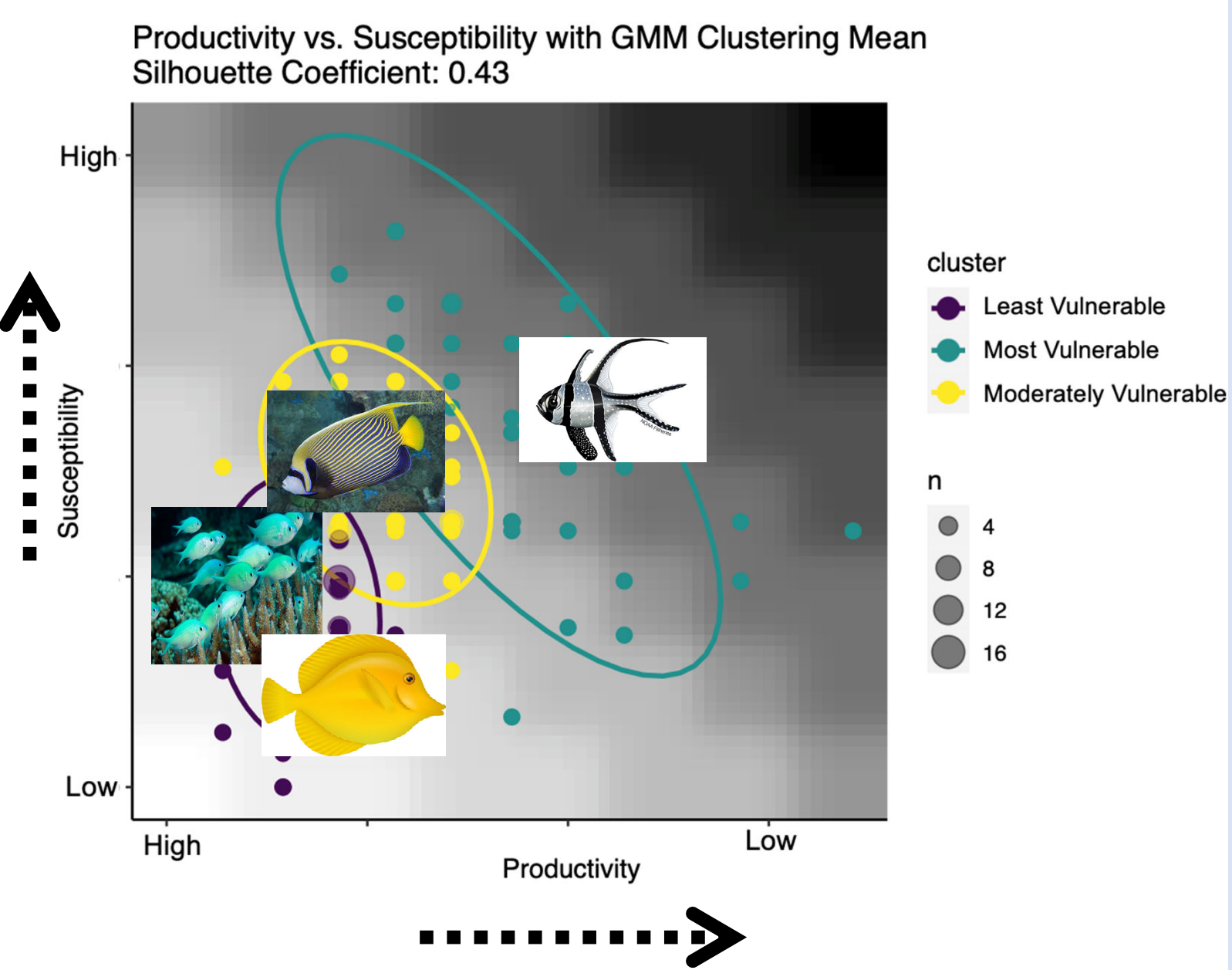
	<3000		P = 0.77-1.9
3	**>3000**		**P = 0.77-1.9**
	All Volumes		P = 2-2.3

Example:
- 9,000 trade volume
- P = 1.98

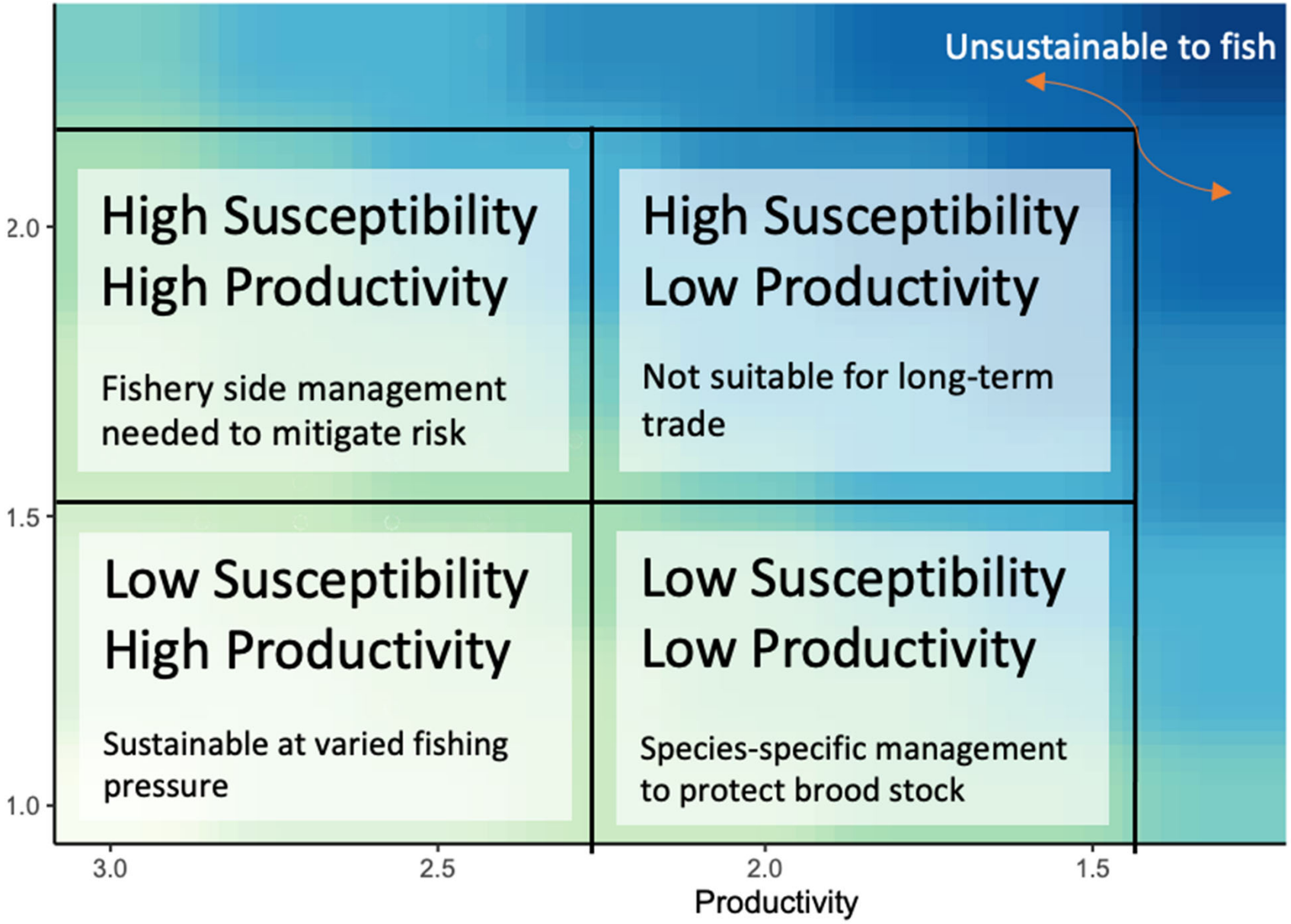
Trade Volume = 2

Key Result: Using available life history characteristics + trade indicators to assess vulnerability to fishing activity of *any fish* in the marine aquarium trade to predict the sustainability of a fish in the trade long-term.

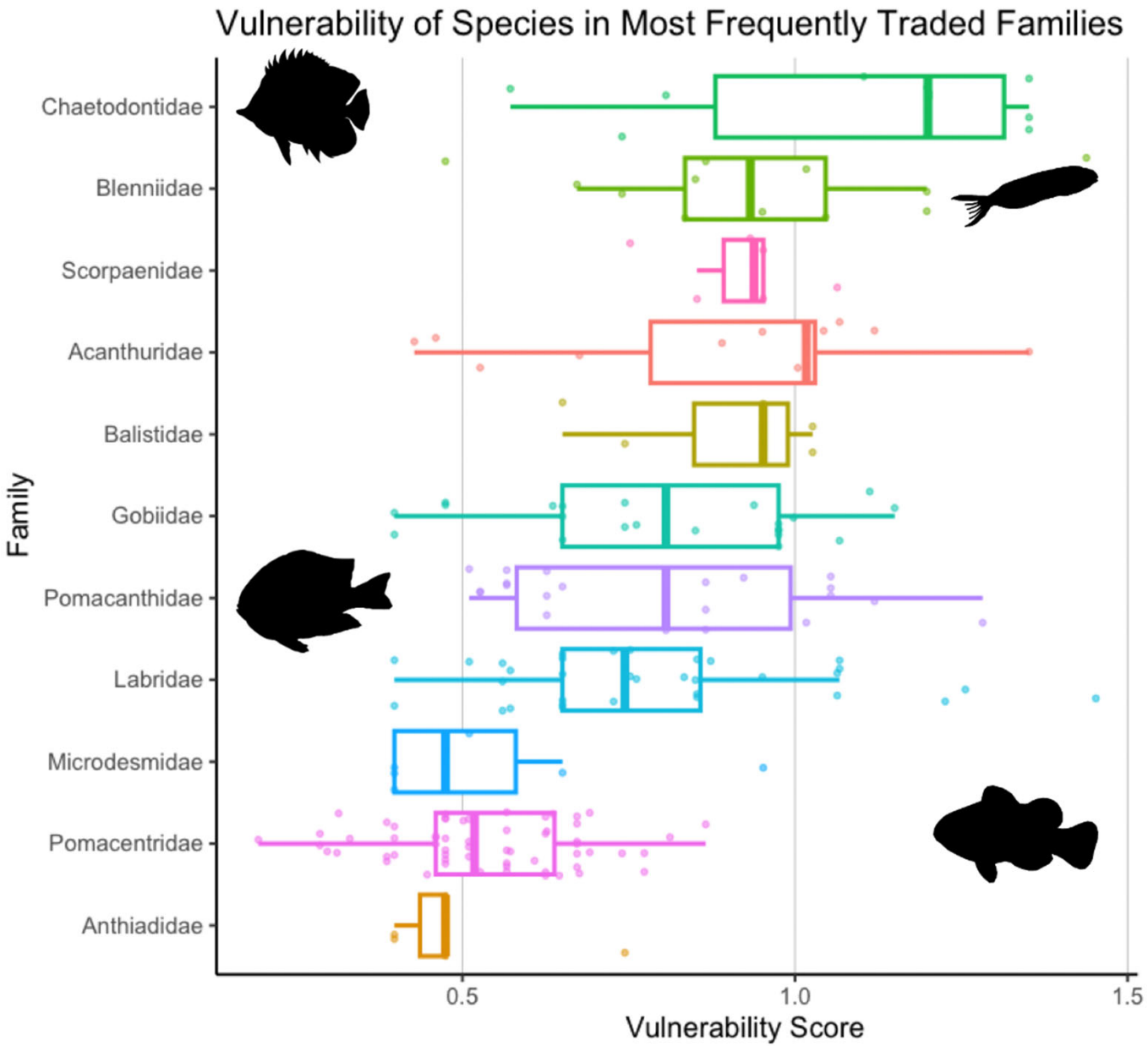


- Top 250 fish in the aquarium trade
- 85% of species fall into moderately or leas vulnerable cluster
- Robust & Accessible Risk Assessment

PSA Management Implications



Estimating Family-Level Vulnerability



- Top 11 most species rich families in the trade
- Family level trends present for productivity factors
- PSA is a tool to predict the vulnerability of fish in the MAT from a holistic and global perspective.

PSA as a Data-Rich Alternative to FishBase Vulnerability

Species	PSA Vulnerability	GMM Cluster Vulnerability	FishBase Vulnerability Score	FishBase Vulnerability Category
Chromis viridis	0.67	Least	10	Low
Echidna nebulosa	1.56	Most	60	High
Pterapogon kauderni	1.52	Most	19	Low
Paracanthurus hepatus	1.35	Moderately	21	Low
Dascyllus aruanus	0.67	Least	26	Low to moderate
Pomacanthus imperator	1.02	Moderately	68	High to very high
Pteris volitans	0.95	Least	34	Low to Moderate

- In total, there is 26% overlap between FishBase and this PSA vulnerability index
- *Chiloscyllium punctatum, Diodon hystrix, Echidna nebulosa,* and *Rhinomuraena quaesita* are the only overlapping species in the top 15 sp. most vulnerable group

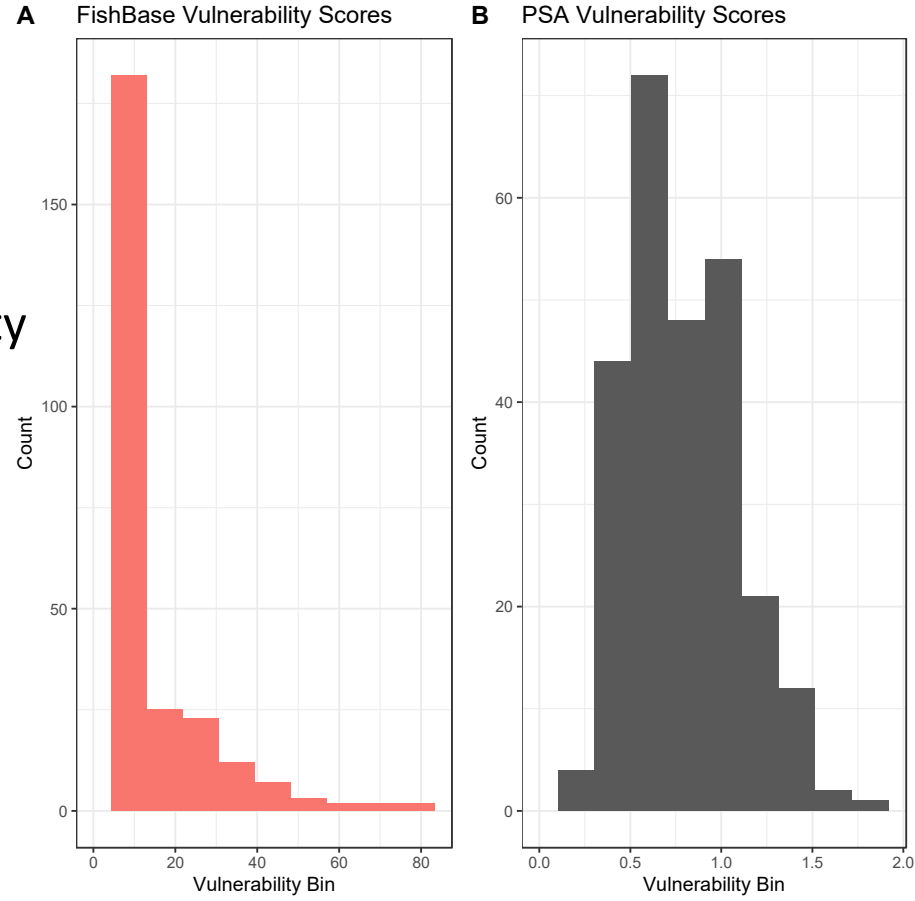
PSA as a Data-Rich Alternative to FishBase Vulnerability

FB Score: 19 (low)
PSA: High Vulnerability

FB Score: 21 (low)
PSA: Moderate Vulnerability

FB Score: 34 (moderate)
PSA: Low Vulnerability
* Invasive

FB Score: 26 (moderate)
PSA: Low Vulnerability



Prioritization List

Species	Family	*P*	*S*	*V*	Rank in trade	IUCN data	*Availability as captive-bred (Pouil et al. 2019)*
Top 10 most vulnerable species							
Chiloscyllium punctatum	Hemiscyllidae	1.29	1.61	1.82	251	NT	Moderate
Echidna nebulosa	Muraenidae	1.57	1.63	1.56	70	LC	-
Pterapogon kauderni	Apogonidae	2.00	2.15	1.52	9	EN	Common
Rhinomuraena quaesita	Muraenidae	1.57	1.49	1.51	277	LC	-
Gomphosus varius	Labridae	2.00	2.05	1.45	168	LC	-
Exallias brevis	Blenniidae	2.43	2.32	1.44	95	LC	-
Ostorhinchus parvulus	Apogonidae	2.43	2.32	1.44	170	LC	-
Diodon hystrix	Diodontidae	1.86	1.76	1.37	105	LC	-
Diodon holocanthus	Diodontidae	1.86	1.76	1.37	160	LC	-
Zoramia leptacanthus	Apogonidae	2.14	2.05	1.36	104	LC	Scarce
Top 10 least vulnerable species							
Chrysiptera unimaculata	Pomacentridae	2.86	1.13	0.19	203	LC	-
Chromis opercularis	Pomacentridae	2.71	1.00	0.29	176	LC	-
Amblypomacentrus breviceps	Pomacentridae	2.71	1.00	0.29	224	LC	-
Neoglyphidodon nigroris	Pomacentridae	2.71	1.08	0.30	37	LC	Has been bred in captivity
Pomacentrus amboinensis	Pomacentridae	2.86	1.28	0.31	132	LC	Has been bred in captivity
Neoglyphidodon oxyodon	Pomacentridae	2.71	1.13	0.31	49	LC	-
Dischistodus prosopotaenia	Pomacentridae	2.71	1.17	0.33	261	LC	-
Neoglyphidodon melas	Pomacentridae	2.71	1.26	0.39	33	LC	Scarce
Amblyglyphidodon curacao	Pomacentridae	2.71	1.26	0.39	92	LC	Has been bred in captivity
Amblyglyphidodon ternatensis	Pomacentridae	2.71	1.26	0.39	107	VU	Has been bred in captivity

*

✓

ASSESSMENTS ON THE SUSTAINABILITY OF THE TRADE

ASSESSMENT

ASSESSMENT STATUS

ACTION

Are there any previous species specific trade assessments?

YES

Did the assessment find significant risk of population declines related to international trade?

YES

Is there already active management **and** monitoring of the trade?

YES

NO

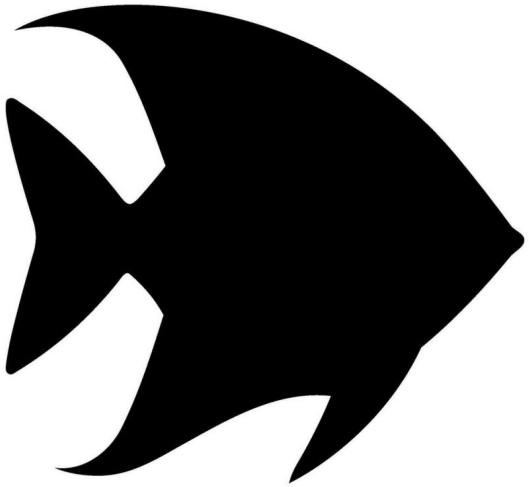
No new assessment needed currently

Need species specific assessment

<u>Where to use PSA?</u>

Assessment of SKI Priority A-C species

Applicable to any fish in the trade



Proposed Outcomes:

- **Prioritize the 38 species** that fall into the high risk group for further research
- **Adopt this PSA framework for annual, global risk assessments of MAF**
  - Quickly screen species with high vulnerability to overfishing
- PSA is the most **robust and easily applicable** fishery assessment available for data-limited marine aquarium fish
  - Industry standard for initial assessment
- Base initial management interventions on Productivity and Susceptibility Scores

Future Research: Closing the Data Gap

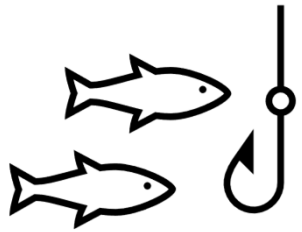
Indonesia small-scale stock assessments for 5-7 key species in the marine aquarium trade

Call for Collaboration:

Access to field sites to gather data

Community Engagement:

- Fisher communities
- NGOs
- Hobbyists and public aquariums



Tracking flow of Trade
&
Catch Trends

Special Thank You To:
Dr. Andy Rhyne
Dr. Michael Tlusty
Alice Wynn
Jem Baldisimo

Dr. Josie South
Dr. Maria Beger

Read more here!

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Thank You for Listening

Further Questions? Email bsgb@leeds.ac.uk

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