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The 800-Pound Grouper in the Room: Asymptotic Body Size and Invasiveness of Marine Aquarium Fishes

Robert J. Holmberg [a,b], Michael F. Tlusty [c], Elizabeth Futoma [a], Les Kaufman [c,d,e], James A. Morris [f], Andrew L. Rhyne [a,c,*]

[a] Roger Williams University, Department of Biology and Marine Biology, 1 Old Ferry Rd, Bristol, RI 02809, United States of America
[b] University of Massachusetts Boston, School for the Environment, 100 Morrissey Blvd, Boston, MA 02125, United States of America
[c] New England Aquarium, John H. Prescott Marine Laboratory, 1 Central Wharf, Boston, MA 02110, United States of America
[d] Boston University Marine Program, Department of Biology, 1 Silber Way, Boston, MA 02215, United States of America
[e] Conservation International, 2011 Crystal Dr #500, Arlington, VA 22202, United States of America
[f] National Oceanic and Atmospheric Administration, National Ocean Service, National Centers for Coastal Ocean Science, 101 Pivers Island Rd, Beaufort, NC 28516, United States of America

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ABSTRACT

The global trade in aquatic wildlife destined for home aquaria not only has the potential to be a positive force for conservation, but also has a number of potential risks. The greatest and most documented risk is the potential to translocate species that will become invasive in a new habitat. Although propagule pressure can influence species invasiveness, a high percentage of documented marine aquarium fish that are invasive in the US are uncommon in the trade. Here, the covariation of size with species invasiveness was assessed using a web scraper to collect size, price, life history characteristics, and behavior data from five internet retail stores for 775 species of fish. Fish that routinely exceed 100 cm in total length are traded, nevertheless are typically sold at sizes much smaller than their theoretical maximum. No economic benefit from the sale of species that will outgrow tanks and have a high risk of being released was found. Large fish, including groupers that can achieve weights of 800 pounds, will continue to enter the trade because the growth of aquaculture for commercial food markets is making it easier to acquire these species that also have appealing small life stages, making it easier and less expensive to bring these species into the aquarium trade. The entire trade should consider taking concerted action to limit the trade in fish that are likely to become invasive.

1. Introduction

The global trade in fishes that are kept in private residences as pets (the Aquarium Fish Trade, or AFT) has the potential to become a positive conservation force [1,2]. A sustainable AFT can help promote habitat preservation, environmental stewardship, poverty alleviation, sustainable livelihoods, and the safeguarding of threatened ecosystems, particularly where the ornamental trade contributes substantively to the net value of wild products [1,3]. However, there are also a multitude of potential risks in the trade [2], of which the release and subsequent introduction of nonindigenous species (NIS) is well documented [4,5].

NIS are species that are introduced to and persist in the wild outside of their natural range [6,7]. Some exist temporarily, unable to establish a reproducing population (e.g. horseshoe crabs in California), while others reproduce and become permanently established [8]. Patterns of biological invasions are influenced and shaped by trends in human activities, including the trade and transport of biota [5,9]. The potential to introduce NIS by transporting them across natural boundaries is worthy of attention.

NIS are considered invasive if they rapidly become widespread, establish self-sustaining populations, and their presence and behavior impact the host ecosystem. Examples include lionfish in the western Atlantic Ocean [10], Burmese pythons in Florida [11], and zebra mussels in the Laurentian Great Lakes [12]. The success of invasive NIS is determined in part by specific life history characteristics, susceptibility of an ecosystem to invasion, and influx of potential colonists [13,14]. The latter, also referred to as propagule pressure [15], is measured as an estimate of the frequency and magnitude of release events. Anthropogenic activity plays the most significant role in the movement and transportation of species [16], and is thus a major driver of propagule pressure. As propagule pressure increases, so too does the likelihood of invasion [17].

With an estimated 192 million individual fish (and crustaceans) imported into the United States annually [18], there is astonishing

* Corresponding author. Tel.: 01 401 254 5750; fax: 01 401 254 3310.
E-mail address: arhyne@rwu.edu (A.L. Rhyne).

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potential for the AFT to influence propagule pressure. Invasion success increases when fish are released directly into suitable habitat [8]. The Indo-Pacific lionfish is a *cause célèbre* for AFT invasion. Nonexistent in the region prior to the 1980s, this species has since spread to the entire tropical and subtropical western Atlantic [19]. Its success might be attributed to high potential propagule pressure (it was the 29th most imported marine AFT species in 2005 [20]) coupled with invasive characteristics (facilitating persistence post-release). However, if volume of import is the sole variable influencing propagule pressure, then one should expect to observe a correlation between rank in trade and sightings of nonindigenous AFT species. This is not always the case; indeed, several marine NIS are uncommon in the trade, so their presence cannot be explained by volume of import alone [20]. There must be a selective force influencing the release of marine AFT species that accounts for this discrepancy.

Hobbyists are the most likely vector by which marine AFT species are introduced, as there is little opportunity or incentive for release prior to consumer-level handling [21]. If surrendering unwanted fish is not an option, live release may be tempting as a more humane alternative to euthanasia. Surveys suggest that life history characteristics including size and aggression are compelling reasons for AFT hobbyists to deliberately release specimens into the wild [22]. Fish that are purchased as juveniles and outgrow their captive environment are likely to be released at a large size, enhancing their odds of survival over smaller individuals of the same species. The invasive status of the Burmese python in Florida is evidence of the ecological risk posed by mature, nonindigenous predators that are released at a large size [23].

In addition to wreaking ecological havoc, it is apparent that invasive species cost the United States billions of dollars to manage annually [24]. Augmenting prevention policies is key for managing existing threats and preventing future invasions [25]. With a substantial volume and diversity of marine species available to consumers in the United States [20], potential invasion pathways are numerous. Given the risk of intentional release by consumers, the hypothesis that desirability of "tankbusters" is greatest early in life history was tested here by examining retail size and price versus maximum potential size for marine AFT species sold by vendors in the United States. The need for a comprehensive stakeholder-based management plan in which industry, government, and NGOs develop a moving white list that guides consumers away from high-risk species was highlighted. Finally, the risk pathway model proposed by Zajicek et al. [21] as a framework for understanding the risk at each node in the supply chain was improved upon.

2. Materials and methods

In order to collect retail size and price data for marine AFT species sold in the United States, five representative internet-based vendors that published size and price data for each specimen were chosen. The chosen vendors were Doctors Foster and Smith LiveAquaria.com, BlueZoo Aquatics, Petco, Reefs2Go, and Saltwaterfish.com. Data were collected with respect to retail size (provided as a range), taxonomy, common names, life history stage (juvenile/adult), price, origin (wild/aquaculture), maximum potential size, care level, minimum required tank size, diet, temperament, and compatibility with reef tanks. Not all data were available for each species/size combination. These data were collected using web scraper software (OutWit Hub) optimized for each vendor. Optimization involved writing vendor-specific scrapers capable of locating and collecting relevant data from any number of structurally similar product pages, compiling queries of web addresses from which to collect data, and creating macros with which to automate data collection. Data was collected from each product page just once, between October 12, 2012 and May 23, 2013. Only non-sale prices were collected. No data were recorded for fish listed as hybrids and/or those for which only a genus was given. Retail size ranges and maximum potential lengths (according to vendor) were recorded in metric values. Taxonomic rank was verified with the FishBase Match Names Tool [26]. Maximum potential length (according to literature) was collected for each vendor-available species using web scraper software (OutWit Hub) optimized for FishBase. FishBase data collection took place on March 19, 2013. Fish length is represented by the literature in several ways, reflecting the appropriateness of different methodologies for measuring different taxa. Among the 775 unique vendor-available species, 612 were listed in FishBase as TL (Total Length), 146 as SL (Standard Length), six as OT (Other), five as FL (Fork Length), three as NG (Not Given), and one as WD (Width). For the remaining two species, no data were available. Given the minor discrepancies in measurement among methodologies, none of the reported sizes were adjusted, and maximum size is referred to as TL for the remainder of the analysis.

Because the retail size was typically provided as a range (e.g., small: 1–3 cm), these data were recorded as medians. The median retail size data were compared to price within each species to assess how relative price per cm changed as fish grew larger. Species characteristics (maximum potential length, origin, care level, minimum required tank size, diet, temperament, and compatibility with reef tanks) were assessed to determine if there were differences between fish sizes within the different attributes.

The relative value of small and large fish within a species was assessed by determining the ranked maximum price (RMP). For those species in which data were collected for at least four different size ranges ($n=393$), the price data were ranked according to size, and the rank order (%) of the most valuable was determined. The ranked maximum price (RMP) index varied from 1 (the smallest-size fish had the greatest associated price within a species) to 100 (the largest-sized fish had the greatest associated price).

3. Results

The search retrieved 5,296 unique species-size-price records representing 775 unique species available from the five chosen internet-based marine AFT vendors. Vendors accurately represented how large fish could become, as the maximum potential sizes listed within the species information pages were highly correlated ($r^2=0.99$, $p<0.001$) with the maximum potential sizes listed within FishBase [Fig. 1A]. Maximum potential size [26] was not correlated ($r^2=0.05$) to species rank in the AFT (data from [20]). Although vendors accurately listed the maximum potential size of fish, large species tended to be sold at relatively small retail sizes while small species tended to be sold at retail sizes equivalent to or greater than their theoretical maximum size [Fig. 1B]. No species larger than 25 cm were available at a median retail size exceeding maximum potential size as listed in Fishbase [Fig. 1B]. Only 27 (of 5,296) of the median retail sizes were >40 cm, while only 11 were >50 cm. Furthermore, no species larger than 100 cm were available at a median retail size exceeding 50% of maximum potential size [Fig. 1B]. Maximum retail price was not associated with maximum potential size [26]. The highest priced fish tended to be <30 cm TL [Fig. 1C], and large fish did not command a greater overall value than medium and small fish.

The RMP index indicated that the largest size fish within a species commanded the greatest price 53% of the time. Fish greater than 200 cm TL had a RMP index value of 100 [Fig. 2A], probably because they were sold at significantly smaller prices than their theoretical maximum [Fig. 1B]. However, even as the smaller species exceeded their theoretical maximum size, some were still sold at a high RMP [Fig. 2B]. Most fish of substantial value ($>$US $500) had an RMP close to 100 [Fig. 2C]. The one species to contradict this trend was *Chaetodontoplus conspicillatus* (conspicuous angelfish), a species for which the smallest specimens were most valuable, although they sold at sizes that often exceeded the theoretical maximum.

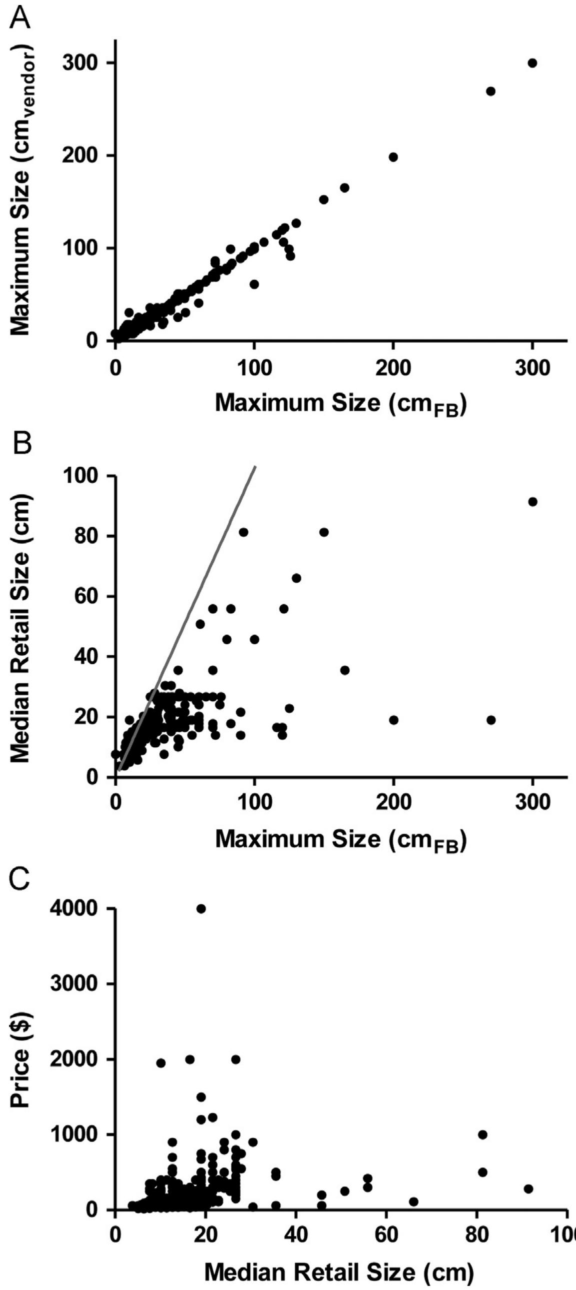

Fig. 1. (A) The maximum potential size of fish (cm TL) as published on a vendor web page compared to the maximum potential size according to literature as published in FishBase [26]. (B) The largest median retail size of a species sold on the internet compared to the maximum potential size according to literature as published in FishBase. Observations to the left of the 1:1 reference line indicate fish that are claimed to be sold at a size larger than their theoretical maximum size. (C) A comparison of unadjusted price to the largest median retail size of a fish species.

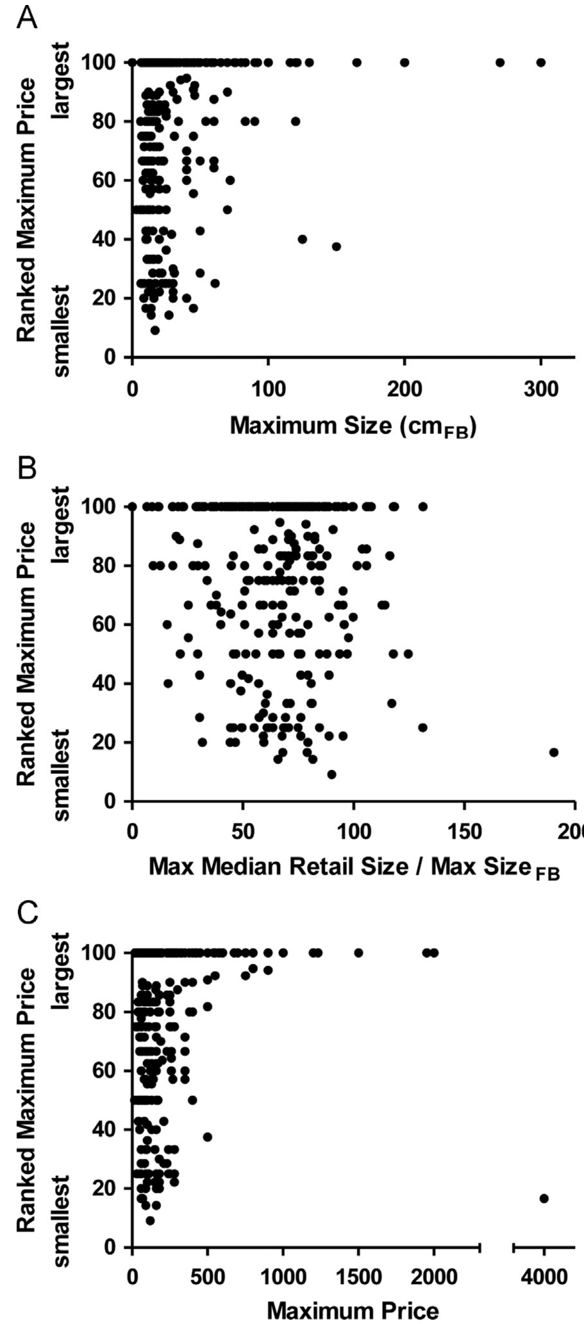

Fig. 2. A comparison of the ranked maximum price (values of 100 indicate the largest size of a species of fish is the most valuable) to the (A) maximum theoretical size based on FishBase [26], (B) the relative retail size of a species based on its theoretical maximum, and (C) the maximum unadjusted price.

A total of 113 species in these data exceeded 40 cm $TL_{(max)}$, with some exceeding 100 cm TL. These fish tended to be exclusively available at a relatively small retail size [Fig. 1B]. For example, we selected four families: Serranidae (groupers), Haemulidae (grunts), Ephippidae (spadefishes), and Lutjanidae (snappers). All contain species that are commonly available as juveniles, yet seldom available as full-size adults [Fig. 3]. In contrast to these rather extreme examples, the lionfish of Scorpaenidae achieve moderate size. Nevertheless, within this family, Florida recently banned imports of *Pterois spp.* in reaction to the invasion of *P. volitans/miles* (FWC Rule 68-5.005), disregarding life history data. The results suggest that while the aforementioned species complex grows the largest among lionfish in the trade, at least one member of the unregulated *Dendrochirus* genus outgrows half of the *Pterois spp.* [Fig. 3].

Finally, larger fish were less likely to be bred in captivity and to be reef safe, and were more likely to be difficult to care for and aggressive in temperament [Supp. Fig. 1]. The minimum suggested tank size did not increase with the median retail size [Supp. Fig. 1].

4. Discussion

Invasive species pose a serious threat to ecosystem integrity, and consequently, human well-being. It is important to develop and implement risk management strategies, especially in areas of high risk. Aquatic species represent one such risk, given a large

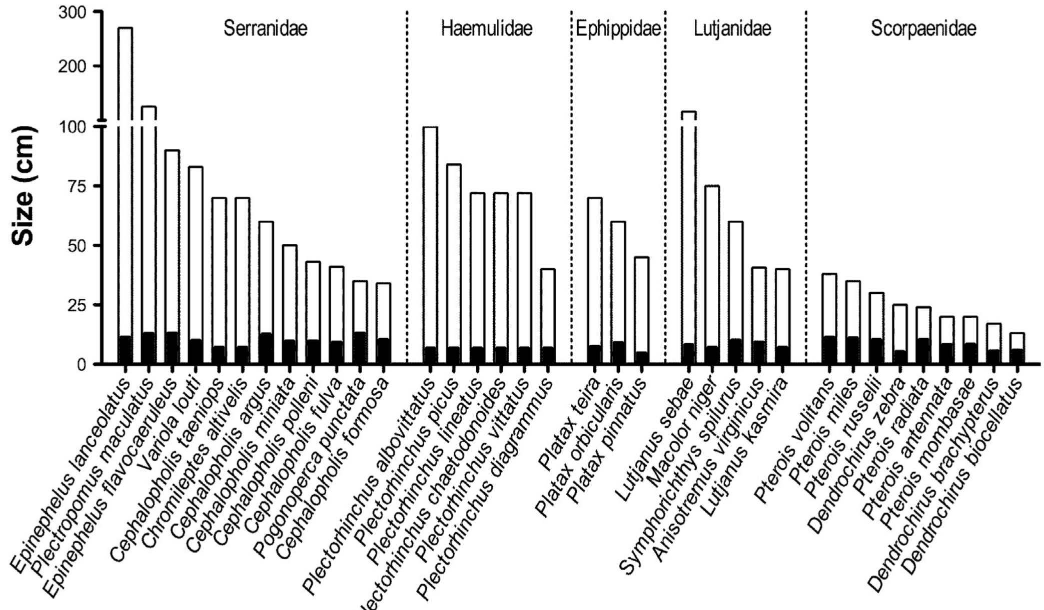

Fig. 3. Average median retail size (solid bars), compared to the maximum potential size (Fishbase) for common large species of marine fish in the aquarium trade including Serranidae (groupers), Haemulidae (grunts), Ephippidae (spadefishes), Lutjanidae (snappers), and the lionfish of Scorpaenidae.

geographical area over which introduction is conceivable. Zajicek et al. [21] implicated the consumer as the most likely vector of marine AFT introductions. However, the consumer has access to and possession of high-risk species because they were made available by the trade. Any risk assessment must start from choke points, and for AFT species, explicitly discouraging the importation and sale of high-risk species is the most precautionary approach. Here, a suite of factors that make AFT species high-risk are identified. Species that grow exceptionally large (referred to as "tankbusters"), which are more likely to be aggressive and less likely to be reef-safe (and thus difficult to care for), are poor candidates for inclusion in the AFT [1].

Current AFT management recommendations aiming to prevent the spread and release of NIS include selling only males or only females of a species to prevent unwanted reproduction [27]. It is important to note, however, that this approach will not eliminate genetic impacts of NIS, as hybridization with indigenous species can occur. Stopping the flow of potential NIS at several points along the value chain [28] is a more aggressive approach. This could include provision of correct information regarding species life history characteristics, and educating the public about the consequences of introducing NIS [29,30]. An example of cooperation toward managing this risk is the Habitattitude campaign, formed by an alliance of the Pet Industry Joint Advisory Council, U.S. Fish and Wildlife Service, and the National Oceanic and Atmospheric Administration. The goals of Habitattitude include protecting the environment from unwanted pets, ensuring the proper and careful selection of pets, and finding alternatives for releasing pets [31]. Although Habitattitude provides information, this voluntary program does not eliminate unwise purchases by naïve consumers. "Tankbusters" should be recognized as largely unsuitable for inclusion in the AFT. Furthermore, vendors should take full responsibility for their inventory and be required to buy back any large species they sell, regardless of the size at which they are sold. If stores were held accountable for oversized fish, they would likely be more hesitant to sell them initially. Current laws prohibiting the return of unwanted fish to vendors may compound efforts to control propagule pressure. Florida, an exceptionally high-risk location for marine NIS introductions, disallows the sale, barter, or trade of any saltwater product without a valid license (Florida Statute 379.361a).

Of particular interest were the families Serranidae (groupers), Haemulidae (grunts), Ephippidae (spadefishes), and Lutjanidae (snappers). All contain species that are commonly available as juveniles, yet seldom available as full-size adults [Fig. 3]. These species are of particular concern as they are unsuitable for most home aquaria beyond more than a few weeks of their early life histories. This may instigate release events, thereby increasing propagule pressure. Of these species, the panther grouper (*Chromileptes altivelis*) has been repeatedly observed free-swimming in Florida waters [32]. Furthermore, many of these species are cultured for food, and are expected to become more widely available within the AFT. Although currently the smaller species are bred in captivity [Fig. 3], this trend may change in the future with the increase in food fish aquaculture production and cross-purposing juvenile fish for the aquarium trade.

Given the potential to influence propagule pressure, it seems imprudent to allow the sale of species that quickly and routinely outgrow their captive environment. This is doubly valid given that there appears to be no strong economic incentive to sell the larger species [Fig. 1C]. If the sale of large fish continues to be a problem (it appears likely given the development of candidate AFT species including sweetlips and groupers through aquaculture [33]), and if the industry does not act, external regulations may be required. In fact, introductions of marine ornamentals that quickly outgrow typical home aquaria are already occurring. The southeast coast of Florida is a hotspot for marine ornamental introductions [34] where Schofield et al. [32] documented several species of large marine ornamental species such as bamboo sharks (*Chiloscyllium punctatum*), white-banded triggerfish (*Rhinecanthus aculeatus*), blackbelly triggerfish (*Rhinecanthus verrucosus*), peacock hind (*Cephalopholis argus*), and humpback grouper (*Chromileptes altivelis*). These species likely exceed 30–40 cm TL within one to two years.

To increase the robustness of any preventive measures, the AFT should be fully engaged in framing future actions [35]. Accordingly, the creation of a multi-stakeholder workgroup is hereby proposed to curate an adaptable list of species with high invasive potential, which would then be voluntarily disallowed (except for permitted activities). Balanced multi-stakeholder workgroups (including industry, non-governmental organizations and other civil society actors) have been shown to provide positive and effective social and environmental regulation for production and sourcing practices within a given industry [36]. Until there is a better understanding of all factors involved in determining invasive potential, regulated quotas and caps are not sufficient given that a number of species are seldom traded yet potentially invasive [20]. The multi-stakeholder working group would have the latitude to create exceptions to general rules based upon a deeper understanding of the species trade and biology, and aquarist habits. For example, if a guideline was set to prohibit species that exceed 30–40 cm TL from the trade in order to reduce the occurrence of NIS in Florida, the working group may choose to exclude moray eels from the list. Despite their length, moray eels do not require as much space as pelagic species, and thus may not qualify as high-risk “tankbusters”. The multi-stakeholder workgroup could condone the sale of moray eels while reserving the right to limit them in the future should research suggest they are high-risk.

Additionally, a multi-stakeholder working group could easily recommend disallowing the importation or trade of a known invasive species to or from a given region. Exclusion zones may be considered that weigh the relative risk of a species becoming established based on habitat suitability, a concept that is considered for managing invasive plants [37]. A tropical species has much higher probability of becoming established in the waters of south Florida or the Caribbean than in the Northeast or Midwest where either no marine habitats exist or winter water temperatures fall well below the thermal minimums for tropical species.

A multi-stakeholder group could also work to encourage control efforts focused on removal of invasive species. The Indo-Pacific lionfish is an example of this. Given the rapid spread of lionfish throughout the western Atlantic Basin, there is a great need to create economic incentives to maintain a high fishing morality to limit negative ecosystem impacts. Allowing and even encouraging Atlantic lionfish to be collected for the trade could provide an economic incentive for the removal of small, pre-reproductive specimens, something that the seafood industry cannot do. Currently, the ban on *Pterois spp.* in Florida prohibits their importation from the Caribbean, thus limiting the utilization of this potentially mitigating incentive.

The growth of aquaculture for commercial food markets is making it easier to find a number of large fish that have appealing small life stages. This makes it easier and less expensive to bring these species into the aquarium trade. This will increase the propagule pressure from these species. Creating a not-for-sale species list is a step that must be undertaken by a coalition of the willing. If not, the continued appearance of invasive species will force draconian regulatory action that will have a large suite of unintended consequences, and will greatly limit the trade. Given the rich biodiversity of the trade, removing a small handful of species from commercial trade that pose the greatest risk should be viewed as a positive step.

Role of the funding source

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.marpol.2014.10.024.

References

[1] Tlusty MF, Rhyne AL, Kaufman L, Hutchins M, Reid GM, Andrews C, et al. Opportunities for public aquariums to increase the sustainability of the aquatic animal trade. Zoo Biol 2013;32::1–12.

[2] Tlusty MF. The benefits and risks of aquacultural production for the aquarium trade. Aquaculture 2002;205::203–19.

[3] Rhyne AL, Tlusty MF, Kaufman L. Is sustainable exploitation of coral reefs possible? A view from the standpoint of the marine aquarium trade Curr Opin Environ Sustain 2014;7::101–7.

[4] Capps KA, Flecker AS. Invasive aquarium fish transform ecosystem nutrient dynamics. P Roy Soc B: Bio Sci 2013;280.

[5] Padilla DK, Williams SL. Beyond ballast water: aquarium and ornamental trades as sources of invasive species in aquatic ecosystems. Front Ecol Environ 2004;2::131–8.

[6] Richardson DM, Pyšek P, Rejmánek M, Barbour MG, Panetta FD, West CJ. Naturalization and invasion of alien plants: concepts and definitions. Divers Distrib 2000;6:93–107.

[7] Colautti RI, MacIsaac HJ. A neutral terminology to define ‘invasive'species. Divers Distrib 2004;10:135–41.

[8] Courtenay W, Stauffer J. The introduced fish problem and the aquarium fish industry. J World Aquacult Soc 1990;21:145–59.

[9] Hulme PE, Pyšek P, Nentwig W, Vilà M. Will threat of biological invasions unite the European Union. Science 2009;324:40–1.

[10] Hamner R, Freshwater D, Whitfield P. Mitochondrial cytochrome b analysis reveals two invasive lionfish species with strong founder effects in the western Atlantic. J Fish Biol 2007;71:214–22.

[11] Dove CJ, Snow RW, Rochford MR, Mazzotti FJ. Birds consumed by the invasive Burmese python (Python molurus bivittatus) in Everglades National Park, Florida, USA. Wilson J Ornithol 2011;123:126–31.

[12] Holland RE. Changes in planktonic diatoms and water transparency in Hatchery Bay, Bass Island area, western Lake Erie since the establishment of the zebra mussel. J Great Lakes Res 1993;19:617–24.

[13] Cassey P, Blackburn TM, Jones KE, Lockwood JL. Mistakes in the analysis of exotic species establishment: source pool designation and correlates of introduction success among parrots (Aves: Psittaciformes) of the world. J Biogeogr 2004;31:277–84.

[14] Pimentel D, Zuniga R, Morrison D. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecol Econ 2005;52:273–88.

[15] Lockwood JL, Cassey P, Blackburn T. The role of propagule pressure in explaining species invasions. Trends Ecol Evol 2005;20:223–8.

[16] García-Berthou E. The characteristics of invasive fishes: what has been learned so far? J Fish Biol 2007;71:33–55.

[17] Cohen J, Mirotchnick N, Leung B. Thousands introduced annually: the aquarium pathway for non-indigenous plants to the St Lawrence Seaway. Front Ecol Environ 2007;5:528–32.

[18] Barker DG, Barker TM. Review: reducing the risks of the wildlife trade by KF. Smith, M. Behrens, and LM. Schloegel. Bull Chicago Herpetol Soc 2009;44:96–7.

[19] Schofield PJ. Geographic extent and chronology of the invasion of non-native lionfish (Pterois volitans [Linnaeus 1758] and P. miles [Bennett 1828]) in the Western North Atlantic and Caribbean Sea. Aquat Invas 2009;4:473–9.

[20] Rhyne AL, Tlusty MF, Schofield PJ, Kaufman LES, Morris JS, Bruckner A. Revealing the appetite of the marine aquarium fish trade: the volume and biodiveristy of fish imported into the United States. PloS One 2012. http://dx.doi.org/10.1371/journal.pone.0035808.

[21] Zajicek P, Hardin S, Watson C. A Florida marine ornamental pathway risk analysis. Rev Fisher Sci 2009;17:156–69.

[22] Gertzen E, Familiar O, Leung B. Quantifying invasion pathways: fish introductions from the aquarium trade. Can J Fish Aquat Sci 2008;65:9.

[23] Dorcas ME, Willson JD, Reed RN, Snow RW, Rochford MR, Miller MA, et al. Severe mammal declines coincide with proliferation of invasive Burmese pythons in Everglades National Park. P Natl Acad Sci 2012;109:2418–22.

[24] National Invasive Species Council (2001) Meeting the invasive species challenge: national invasive species management plan. National Invasive Species Council, Washington, DC, pp. 80.

[25] Pimentel D, Lach L, Zuniga R, Morrison D. Environmental and economic costs of nonindigenous species in the United States. BioScience 2000;50:53–65.

[26] Froese R, Pauly D. (2011) FishBase. World Wide Web electronic publication, 〈www.fishbase.org〉.

[27] Magalhães AL, Jacobi CM. Asian aquarium fishes in a neotropical biodiversity hotspot: impeding establishment, spread and impacts. Biol Invas 2013;15:2157–63.

[28] Chucholl C. Invaders for sale: trade and determinants of introduction of ornamental freshwater crayfish. Biol Invas 2013;15:125–41.
[29] Chang AL, Grossman JD, Spezio TS, Weiskel HW, Blum JC, Burt JW, et al. Tackling aquatic invasions: risks and opportunities for the aquarium fish industry. Biol Invas 2009;11:773–85.
[30] Copp G, Garthwaite R, Gozlan R. Risk identification and assessment of non-native freshwater fishes: a summary of concepts and perspectives on protocols for the UK. J Appl Ichthyol 2005;21:371.
[31] Reaser JK, Meyers NM. Habitattitude: getting a backbone about the pet release pathway. Manag Vertebrate Invasive Species 2007;40:63–71.
[32] Schofield PJ, Morris JA, Akins L. (2009) *Field guide to nonindigenous marine fishes of Florida*. US Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, National Centers for Coastal Ocean Science.
[33] Leu MY, Meng PJ, Siong Tew K, Kuo J, Hung CC. Spawning and development of larvae and juveniles of the Indian Ocean oriental sweetlips, Plectorhinchus vittatus (Linnaeus, 1758), in the aquarium. J World Aquacult Soc 2012;43:595–606.
[34] Semmens BX, Buhle ER, Salomon AK, Pattengill-Semmens CV. A hotspot of non-native marine fishes: evidence for the aquarium trade as an invasion pathway. Mar Ecol Prog Ser 2004;266:239–44.
[35] Tlusty MF, Rhyne AL, Dowd S, Kaufman L. Controlling the destiny of the trade: proacive steps no can address the major impediments to developing a more sustainable ornamental fish industry. OFI J 2014;75:23–6.
[36] Moog S, Spicer A, Böhm S. The politics of multi-stakeholder initiatives: the crisis of the forest stewardship council. J Bus Ethics 2014:1–25.
[37] Crall AW, Jarnevich CS, Panke B, Young N, Renz M, Morisette J. Using habitat suitability models to target invasive plant species surveys. Ecol Appl 2013;23:60–72.

Glossary

Elephant in the Room: A metaphorical idiom for truth that is ignored or unaddressed. In the title of our manuscript, we substitute “elephant” with “grouper”, referencing the elephantine growth of some aquarium fish and the lack of regulation involving the life history characteristics of those fish.

800-Pound Gorilla: A metaphorical idiom for a formidable entity that is difficult to compete with or control. Here we combine with ‘Elephant in the Room’ to reference the adult weight of the bumblebee grouper (*Epinephelus lanceolatus*) and characterize it and similar species as imposing.

Tankbusters: Fish species available to consumers in the aquarium trade that grow too large to be suitable for most home aquaria.