



## Native species exploited by marine aquarium trade in Brazil

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**Abstract:** Brazil has an important role in marine ornamental trade, exploiting native species for both international and domestic market. A few works have previously assessed wild species exploited by the Brazilian marine aquarium industry and most of them focused solely on fish. Hence, the present paper intends to address an information gap regarding the species currently traded in the country, as well as concerning their conservation statuses. Thus, different sources of information were investigated and each species was categorized in accordance with existing lists of threatened species. A wide variety of native species was identified in Brazilian marine aquarium trade, including not only fish but also invertebrates, seaweeds and macrophytes. Some of these species were legally protected, but are still commercialized anyway. Such illegal exploitation of native species causes increasing concerns about the sustainability of the activity. Therefore, in order to reduce environmental impacts caused by marine ornamental trade, Brazilian authorities should encourage the implementation of eco-fees, the purchase of eco-labeled aquarium products, the development of sustainable ornamental aquaculture and ecosystem-based management initiatives.

**Keywords:** *Marine aquarium fish, marine invertebrates, seaweeds, marine macrophytes, illegal trade, threatened species.*

## Espécies nativas explotadas pela aquariofilia marinha no Brasil

**Resumo:** O Brasil possui um papel importante no comércio de ornamentais marinhos, utilizando espécies tanto para exportação como para o mercado interno. Poucos trabalhos anteriores descreveram as espécies nativas utilizadas pela indústria brasileira de aquarismo marinho, e a maioria deles era focada exclusivamente no uso de peixes. Assim, o presente trabalho almeja preencher a falta de informação em relação às espécies atualmente exploradas no país, bem como relativas às suas categorias de conservação. Dessa forma, diferentes fontes de informação foram investigadas e cada espécie foi categorizada de acordo com as listas de espécies ameaçadas existentes. Uma grande variedade de espécies foi identificada no comércio do aquarismo marinho brasileiro, o que inclui não somente peixes, mas também invertebrados, macroalgas e macrófitas. Algumas dessas espécies não poderiam ser exploradas, mas mesmo assim seguem sendo comercializadas. Essa utilização ilegal de espécies nativas provoca preocupações frequentes acerca da sustentabilidade dessa atividade. Desse modo, para reduzir os impactos ambientais causados pelo aquarismo marinho, as autoridades brasileiras deveriam incentivar a implementação de taxas-ecológicas, a aquisição de produtos de aquário com selos ecológicos, o desenvolvimento sustentável da aquicultura ornamental e iniciativas de manejo baseadas no ecossistema.

**Palavras-chave:** *Peixes de aquário marinho, invertebrados marinhos, macroalgas marinhas, macrófitas marinhas, comércio ilegal, espécies ameaçadas.*

## Introduction

Marine ornamental trade is a global multi-million dollar industry (~ US\$200-300 million annually), involving the collection of more than 50 million coral reef animals (e.g. fish, corals and a wide variety of invertebrate species) to supply aquaria kept by 2 million hobbyists worldwide (Wabnitz et al. 2003, Rhyne et al. 2012a). It is estimated that the activity targets over 1,800 reef fish species from 125 families, over 150 species of stony corals and hundreds of species of non-coral invertebrates (Rhyne et al. 2012b, Rhyne et al. 2014, Leal et al. 2015).

Since both fish and invertebrates began to be exploited together in the mid 1980s, consumers gradually shifted their preference from fish-only tanks to miniature reef ecosystems (Bruckner 2005, Rhyne et al. 2009, Rhyne et al. 2012a, Murray & Watson 2014) and collectors for the aquarium trade started to act as a peculiar and unprecedented type of generalist predators, targeting both abundant and rare species, including those with critical ecological roles on the reefs (Rhyne et al. 2012b). Unlike freshwater ornamental commerce, where about 90% of fish species are produced in captivity, the great majority of marine tank species is wild-caught and, thus, elicited controversies regarding the sustainability of the activity (Wabnitz et al. 2003, Olivotto et al. 2011, Rhyne et al. 2014), as over-harvesting is among the most serious causes of coral reef degradation worldwide (Bellwood et al. 2004, Rhyne et al. 2014).

Brazil supplies significant quantities of the global marine ornamental market (Wood 2001, Bruckner 2005, Rhyne et al. 2012b) and, as in the other exporting countries, most of the exported organisms are wild-harvested, which also raised concerns about the development of this activity (Gasparini et al. 2005, Nottingham et al. 2005a).

Despite the importance of a wide variety of native organisms for both international and domestic aquarium trade, the great majority of studies available in Brazil focused on the exploitation of marine fish only (Nottingham et al. 2000, Monteiro-Neto et al. 2003, Nottingham et al. 2005a, Nottingham et al. 2005b, Ibama 2008a, Sampaio & Nottingham 2008, Sampaio & Ostrensky, 2013), and very few included the ornamental use of other marine organisms (Gasparini et al. 2005, Ibama 2008b). Thus, the goal of the present study was to list the Brazilian native species used in marine aquarium trade, providing information about their usage and conservation statuses.

## Material and Methods

First, three different lists of species were compiled: (1) fish, (2) invertebrates and (3) seaweeds and aquatic macrophytes.

These inventories were based on the following sources of information: (1) scientific literature, (2) governmental lists, (3) demands of exportation sent to the Brazilian Institute of the Environment and Renewable Natural Resources (Ibama, Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis), (4) author's personal observation, (5) visits to online marine aquarium discussion forums (e.g. <http://www.ipaq.org.br>, <http://www.reefcorner.org>, <http://www.reefforum.net> and <http://www.reefdeep.org/>), (6) Brazilian pet shops websites, and (7) auction websites (<http://www.mercadolivre.com.br>, <http://www.olx.com.br> and <http://www.bomnegocio.com>). Searches on the literature and forums were not structured with specific keywords in order to keep it flexible enough to maximize the detection of relevant information. For instance, for pet-shops websites were used the combinations: “lojas de aquário marinho Brasil”, “aquario

marinho loja”, “peixes ornamentais marinhos Brasil”, “venda de peixes ornamentais marinhos” and “lojas de peixes marinhos Brasil”.

The natural distribution for each species in Brazil was obtained using information from the following databases: <http://www.fishbase.org>, <http://www.iucnredlist.org>, <http://www.marinespecies.org>, as well as specific literature cited in the results section. Official data from Brazilian authorities (IN IBAMA 202/2008 and decree MMA 445/2014) and demands from export companies was also analyzed. Additionally, personal observations while visiting aquarium shops in Fortaleza (Ceará state - CE), supervision of ornamental fish unloading in Fortim (CE), visits to ornamental organisms exporting companies in Fortaleza and an aquaculture farm in Aquiraz (CE) were also used to complement the species lists.

Only species with explicit usage in aquaria were included in the inventories. Therefore, organisms exploited exclusively as handcrafts, souvenirs, curio, or for either medical or magic-religious purposes were not analyzed. The exploitation of species was analyzed concerning specific norms and the threatening statuses of each species were determined based on the Brazilian lists of threatened species and the International Union for Conservation of Nature – IUCN red list of threatened species.

## Results

Exploitation allowance for all species inventoried was analyzed regarding the norms that regulate their usage in Brazil: IN Ibama 202/08 for marine fish and IN MMA 89/06 for seaweeds. As there is a paucity of specific norms for the exploitation of marine invertebrates and marine macrophytes, the only applicable rule is federal law 9,605/98.

Concerning the species' conservation statuses, fish and invertebrate were evaluated according to their classification in the Brazilian list of threatened fish and aquatic invertebrate species (decree MMA 445/14) and the IUCN red list (version 2016-3), both using the same threatening categories: (NE) Not Evaluated, (DD) Data Deficient, (LC) Least Concern, (NT) Near Threatened, (VU) Vulnerable, (EN) Endangered, (CR) Critically Endangered, (EW) Extinct in the Wild or (EX) Extinct. For the analysis of the conservation statuses of seaweeds and aquatic macrophytes, it was used the Brazilian list of threatened flora species (decree MMA 443/14) and again the IUCN red list criteria (version 2016-3).

More than 200 bone and cartilaginous fish species were identified based on 24 different sources of information (Table 1). From this total, only 136 species can be legally exploited according to IN Ibama 202/08. However, according to decree MMA 445/14, some species whose collection is not allowed by IN Ibama 202/08 may be exploited by means of specific authorizations (species categorized as VU) and others can be harvested for scientific research or conservation purposes only (species classified as EN or CR). In addition, Table 1 reports the occurrence of five fish species endemic to Brazilian oceanic islands, two new species from different genera and four updated scientific names for species reported under other synonyms in previous works.

Invertebrates were classified into seven groups: mollusks, cnidarians, crustaceans, echinoderms, polychaetes, ascidians and sponges. The first four were the most representative regarding the number of species, and some of them are included in both the Brazilian list of threatened fish and aquatic invertebrate species and the IUCN red list (Table 2).

**Table 1.** Marine fish species traded in Brazil for aquarium purposes and their conservation status

Species	Harvesting in accordance with IN 202/08	Brazilian list of threatened fish species (Decree MMA 445/14)	IUCN red list of threatened species	Observation
<b>Osteichthyes</b>				
<i>Abudefduf saxatilis</i> <sup>1;4;9;11;18;19;22;21;23; 24</sup>	Allowed	NE	LC	-
<i>Acanthostracion polygonius</i> <sup>4;9;11;18;19</sup>	Allowed	NE	LC	-
<i>Acanthostracion quadricornis</i> <sup>1;4;7;9; 11;18;19;24</sup>	Allowed	NE	LC	-
<i>Acanthurus bahianus</i> <sup>1;2;6;9;11;18;19;22; 23;24</sup>	Allowed	NE	LC	-
<i>Acanthurus chirurgus</i> <sup>1;2;7;9;11;18;19;22;24</sup>	Allowed	NE	LC	-
<i>Acanthurus coeruleus</i> <sup>1;2;4;6;9;11;18;19; 22;23;24</sup>	Allowed	NE	LC	-
<i>Achirus lineatus</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Alphestes afer</i> <sup>9;11;18;19</sup>	Allowed	DD	LC	-
<i>Aluterus schoepfii</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Aluterus scriptus</i> <sup>1;9;11;18;19</sup>	Allowed	NE	LC	-
<i>Amblycirrhitis pinos</i> <sup>1;4;9;11;18;19;22; 23;24</sup>	Allowed	DD	LC	-
<i>Anisotremus moricandi</i> <sup>4;9;21</sup>	Prohibited	NE	LC	-
<i>Anisotremus surinamensis</i> <sup>9;11;18;19</sup>	Allowed	DD	NE	-
<i>Anisotremus virginicus</i> <sup>1;4;6;8;9;11;18;19; 22;23</sup>	Allowed	NE	LC	-
<i>Antennarius multiocellatus</i> <sup>1;6;18;21</sup>	Prohibited	DD	LC	-
<i>Antennarius striatus</i> <sup>4;11;18;19;21</sup>	Allowed	DD	LC	-
<i>Apogon americanus</i> <sup>11;18;19;21;22;24</sup>	Allowed	NE	NE	-
<i>Apogon maculatus</i> <sup>1</sup>	Prohibited	NE	LC	-
<i>Apogon planifrons</i> <sup>4;11;21</sup>	Prohibited	NE	LC	-
<i>Apogon pseudomaculatus</i> <sup>1;11;18;19;21</sup>	Allowed	NE	LC	-
<i>Archosargus rhomboidalis</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Astrapogon puncticulatus</i> <sup>18</sup>	Prohibited	NE	LC	-
<i>Aulostomus strigosus</i> <sup>9;11;18;19</sup>	Allowed	NE	LC	-
<i>Balistes vetula</i> <sup>1;2;4;6;9;18;21;23;24</sup>	Prohibited	NT	NT	-
<i>Bathygobius soporator</i> <sup>1;11;18;19</sup>	Allowed	NE	LC	-
<i>Batrachoides surinamensis</i> <sup>11;18;19;23</sup>	Allowed	NE	LC	-
<i>Bodianus insularis</i> <sup>12;18;20</sup>	Prohibited	NE	LC	EI
<i>Bodianus pulchellus</i> <sup>1;6;9;11;18;19;21;22; 23;24</sup>	Allowed	NE	LC	-
<i>Bodianus rufus</i> <sup>1;2;4;6;9;11;18;19;21;22;23;24</sup>	Allowed	NE	LC	-
<i>Bothus lunatus</i> <sup>4;9;11;18;19</sup>	Allowed	NE	LC	-
<i>Bothus ocellatus</i> <sup>7;9;11;18;19</sup>	Allowed	NE	LC	-
<i>Calamus</i> spp. <sup>9</sup>	-	-	-	-
<i>Calamus pennatula</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Cantherhines macrocerus</i> <sup>1;4;11;18;19; 21;23; 24</sup>	Allowed	NE	LC	-
<i>Cantherhines pullus</i> <sup>1;4;9;11;18;19;21</sup>	Allowed	NE	LC	-
<i>Canthigaster figueiredoi</i> <sup>1;4;9;11;18;19;21; 24</sup>	Allowed	NE	LC	-
<i>Carangoides crysos</i> <sup>9</sup>	Prohibited	NE	LC	-
<i>Caranx latus</i> <sup>9</sup>	Prohibited	NE	LC	-
<i>Caranx lugubris</i> <sup>9</sup>	Prohibited	NE	LC	-
<i>Centropyge aurantonotus</i> <sup>1;2;4;6;7;9;11; 18;19;21;22;23;24</sup>	Allowed	DD	LC	-
<i>Cephalopholis fulva</i> <sup>1;9;18;19</sup>	Prohibited	NE	LC	-
<i>Chaetodipterus faber</i> <sup>1;6;11;18;19;23</sup>	Allowed	NE	LC	-
<i>Chaetodon ocellatus</i> <sup>1;2;4;6;7;11;18;19;21; 22;23;24</sup>	Allowed	DD	LC	-

Continued Table 1.

Species	Harvesting in accordance with IN 202/08	Brazilian list of threatened fish species (Decree MMA 445/14)	IUCN red list of threatened species	Observation
<i>Chaetodon sedentarius</i> <sup>1;2;4;6;9;11;18;19; 21;22</sup>	Allowed	NE	LC	-
<i>Chaetodon striatus</i> <sup>1;2;4;6;7;9;11;18;19;21; 22;23;24</sup>	Allowed	NE	LC	-
<i>Chilomycterus antennatus</i> <sup>11;18;19;23</sup>	Allowed	NE	LC	-
<i>Chilomycterus antillarum</i> <sup>1;11;18;19</sup>	Allowed	NE	LC	-
<i>Chilomycterus schoepfi</i> <sup>6</sup>	Prohibited	NE	LC	-
<i>Choranthias salmopunctatus</i> <sup>13;18;20</sup>	Prohibited	VU	LC	EI, DN*
<i>Chromis flavicauda</i> <sup>1;4;9;21</sup>	Prohibited	NE	DD	-
<i>Chromis jubauna</i> <sup>4;9;21</sup>	Prohibited	NE	NE	-
<i>Chromis multilineata</i> <sup>1;4;9;11;18;19;21</sup>	Allowed	NE	LC	-
<i>Clepticus brasiliensis</i> <sup>9;11;18;19</sup>	Allowed	NE	LC	-
<i>Conodon nobilis</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Coryphopterus</i> spp. <sup>9</sup>	-	-	-	-
<i>Coryphopterus glaucofraenum</i> <sup>11;18; 19;23</sup>	Allowed	NE	LC	-
<i>Cosmocampus albirostris</i> <sup>10;11;18;19;23</sup>	Allowed	NE	LC	-
<i>Cryptotomus roseus</i> <sup>9</sup>	Prohibited	NE	LC	-
<i>Cychlichthys spinosus</i> <sup>4;11;18;19;21</sup>	Allowed	NE	NE	-
<i>Dactylopterus volitans</i> <sup>1;2;6;9;11;18;19</sup>	Allowed	NE	LC	-
<i>Dermatolepis inermis</i> <sup>9</sup>	Prohibited	NE	NT	-
<i>Diodon holacanthus</i> <sup>4;11;18;19</sup>	Allowed	NE	LC	-
<i>Diodon hystrix</i> <sup>1;6;9;11;18;19;24</sup>	Allowed	NE	LC	-
<i>Diplectrum formosum</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Diplectrum radiale</i> <sup>9;11;18;19</sup>	Allowed	NE	LC	-
<i>Diplodus argenteus</i> <sup>9</sup>	Prohibited	NE	LC	-
<i>Doratonotus megalepis</i> <sup>9;11;18;19;23</sup>	Allowed	NE	LC	-
<i>Dules auriga</i> <sup>11;18;19</sup>	Allowed	NE	NE	-
<i>Echeneis naucrates</i> <sup>1;11;18;19;23</sup>	Allowed	NE	LC	-
<i>Elacatinus figaro</i> <sup>2;4;7;8;9;14;18;20;21;22;23</sup>	Prohibited	VU	NE	-
<i>Emblemariopsis signifer</i> <sup>9</sup>	Prohibited	NE	LC	-
<i>Epinephelus adscensionis</i> <sup>18</sup>	Prohibited	DD	LC	-
<i>Epinephelus itajara</i> <sup>4;20;21</sup>	Prohibited	CR	CR	-
<i>Epinephelus marginatus</i> <sup>9</sup>	Prohibited	VU	EN	-
<i>Epinephelus morio</i> <sup>9</sup>	Prohibited	VU	NT	-
<i>Equetus lanceolatus</i> <sup>1;4;21</sup>	Prohibited	NE	LC	-
<i>Fistularia tabacaria</i> <sup>9;11;18;19</sup>	Allowed	NE	LC	-
<i>Gnatholepis thompsoni</i> <sup>9</sup>	Prohibited	NE	LC	-
<i>Gobiesox strumosus</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Gramma brasiliensis</i> <sup>2;3;4;7;8;9;15;18;20; 21;23</sup>	Prohibited	NT	NE	-
<i>Gymnachirus nudus</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Gymnothorax funebris</i> <sup>1;6;11;18;19;22</sup>	Allowed	DD	LC	-
<i>Gymnothorax miliaris</i> <sup>1;4;8;11;18;19;22;24</sup>	Allowed	NE	LC	-
<i>Gymnothorax moringa</i> <sup>9;11;18;19;24</sup>	Allowed	DD	LC	-
<i>Gymnothorax ocellatus</i> <sup>11;18;19</sup>	Allowed	DD	LC	-
<i>Gymnothorax vicinus</i> <sup>1;9;11;18;19</sup>	Allowed	DD	LC	-
<i>Haemulon aurolineatum</i> <sup>9</sup>	Prohibited	NE	LC	-

Continued Table 1.

Species	Harvesting in accordance with IN 202/08	Brazilian list of threatened fish species (Decree MMA 445/14)	IUCN red list of threatened species	Observation
<i>Haemulon plumieri</i> <sup>1;9;22</sup>	Prohibited	DD	NE	-
<i>Haemulon steindachneri</i> <sup>9;11;18;19</sup>	Allowed	NE	LC	-
<i>Halichoeres bivittatus</i> <sup>1;4;11;18;19;21</sup>	Allowed	NE	LC	-
<i>Halichoeres brasiliensis</i> <sup>1;4;6;9;11;18;19; 21;23</sup>	Allowed	NE	DD	-
<i>Halichoeres dimidiatus</i> <sup>1;2;4;6;8;9;11;18; 19;21;22;23;24</sup>	Allowed	NE	LC	DN**
<i>Halichoeres penrosei</i> <sup>1;4;6;9;11;18;19;21</sup>	Allowed	NE	LC	DN***
<i>Halichoeres poeyi</i> <sup>1;4;9;11;18;19;21</sup>	Allowed	NE	LC	-
<i>Heteropriacanthus cruentatus</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Hippocampus erectus</i> <sup>1;2;4;6;7;10;11;18;19; 21</sup>	Allowed	VU	VU	-
<i>Hippocampus reidi</i> <sup>1;2;4;5;7;10;11;18;19; 20;21;22</sup>	Allowed	VU	DD	-
<i>Holacanthus ciliaris</i> <sup>1;2;4;6;7;8;9;11;18;19; 21;22;23;24</sup>	Allowed	DD	LC	-
<i>Holacanthus tricolor</i> <sup>2;4;6;7;8;9;11;18;19;21; 22;23;24</sup>	Allowed	DD	LC	-
<i>Holocentrus adscensionis</i> <sup>7;9;11;18;19</sup>	Allowed	NE	LC	-
<i>Hypleurochilus fissicornis</i> <sup>9</sup>	Prohibited	NE	LC	-
<i>Kyphosus</i> spp. <sup>9</sup>	-	-	-	-
<i>Kyphosus incisor</i> <sup>11;18;19</sup>	Allowed	NE	NE	-
<i>Kyphosus sectatrix</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Labrisomus cricota</i> <sup>4;21</sup>	Prohibited	NE	LC	-
<i>Labrisomus kalisherai</i> <sup>9</sup>	Prohibited	NE	NE	-
<i>Labrisomus nuchipinnis</i> <sup>9;11;18;19;21</sup>	Allowed	NE	LC	-
<i>Lactophrys</i> spp. <sup>1</sup>	-	-	-	-
<i>Lactophrys polygonia</i> <sup>6</sup>	Prohibited	NE	NE	-
<i>Lactophrys trigonus</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Lagocephalus laevigatus</i> <sup>7;11;18;19</sup>	Allowed	NE	LC	-
<i>Liopropoma carmabi</i> <sup>4;21;23</sup>	Prohibited	NE	LC	-
<i>Lutjanus analis</i> <sup>1</sup>	Prohibited	NT	VU	-
<i>Lutjanus jocu</i> <sup>9</sup>	Prohibited	NT	NE	-
<i>Lutjanus synagris</i> <sup>9</sup>	Prohibited	NT	NE	-
<i>Malacanthus plumieri</i> <sup>1</sup>	Prohibited	NE	LC	-
<i>Malacoctenus</i> sp. n. <sup>9;18;21;22;23;24</sup>	Prohibited	-	-	NS
<i>Malacoctenus delalandei</i> <sup>9</sup>	Prohibited	NE	LC	-
<i>Melichthys niger</i> <sup>11;18</sup>	Allowed	NE	LC	-
<i>Menticirrhus americanus</i> <sup>11;18</sup>	Allowed	DD	LC	-
<i>Micrognathus</i> sp. <sup>10</sup>	Prohibited	-	-	-
<i>Microphis lineatus</i> <sup>4;21</sup>	Prohibited	NE	NE	DN****
<i>Micropogonias furnieri</i> <sup>19</sup>	Prohibited	NE	LC	-
<i>Microspathodon chrysurus</i> <sup>1;2;3;9;18;21</sup>	Prohibited	VU	LC	-
<i>Mugil curema</i> <sup>9</sup>	Prohibited	DD	LC	-
<i>Mulloidichthys martinicus</i> <sup>9;11;18;19</sup>	Allowed	NE	LC	-
<i>Mullus argentinae</i> <sup>11;18;19</sup>	Allowed	NE	NE	-
<i>Muraena pavonina</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Mycteroperca bonaci</i> <sup>9</sup>	Prohibited	VU	NT	-
<i>Mycteroperca interstitialis</i> <sup>9</sup>	Prohibited	VU	VU	-
<i>Myrichthys breviceps</i> <sup>4;11;18;19</sup>	Allowed	NE	LC	-

Continued Table 1.

Species	Harvesting in accordance with IN 202/08	Brazilian list of threatened fish species (Decree MMA 445/14)	IUCN red list of threatened species	Observation
<i>Myrichthys ocellatus</i> <sup>1;9;11;18;19;22</sup>	Allowed	NE	LC	-
<i>Myripristis jacobus</i> <sup>1;4;9;11;18;19</sup>	Allowed	NE	LC	-
<i>Ocyurus chrysurus</i> <sup>6;9</sup>	Prohibited	NT	NE	-
<i>Odontoscion dentex</i> <sup>9;11;18;19</sup>	Allowed	NE	LC	-
<i>Ogcocephalus</i> spp. <sup>1;6</sup>	-	-	-	-
<i>Ogcocephalus nasutus</i> <sup>1</sup>	Prohibited	NE	LC	-
<i>Ogcocephalus notatus</i> <sup>19</sup>	Prohibited	NE	LC	-
<i>Ogcocephalus vespertilio</i> <sup>1;4;9;11;18;19</sup>	Allowed	NE	NE	-
<i>Oligoplites saliens</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Ophioblennius trinitatis</i> <sup>4;11;18;19;21;23; 24</sup>	Allowed	NE	LC	-
<i>Opistognathus</i> sp. n. <sup>1;4;18;21;23</sup>	Prohibited	-	-	NS
<i>Opistognathus lonchurus</i> <sup>4;21</sup>	Prohibited	NE	LC	-
<i>Orthopristis ruber</i> <sup>9;11;18;19</sup>	Allowed	NE	LC	-
<i>Parablennius marmoreus</i> <sup>4;9;11;18;19;21</sup>	Allowed	NE	LC	-
<i>Parablennius pilicornius</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Paraclinus rubicundus</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Paralonchurus brasiliensis</i> <sup>11;18</sup>	Allowed	NE	LC	-
<i>Paranthias furcifer</i> <sup>9;11;18;19</sup>	Allowed	NE	LC	-
<i>Pareques acuminatus</i> <sup>1;3;4;6;9;11; 18;19;22;23;24</sup>	Allowed	DD	LC	-
<i>Pempheris schomburgkii</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Phaeoptyx pigmentaria</i> <sup>4;11;18;19;21</sup>	Allowed	NE	LC	-
<i>Plectrypops retrospinis</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Pomacanthus arcuatus</i> <sup>1;2;4;6;7;9;11;18;19;21;22;23</sup>	Allowed	DD	LC	-
<i>Pomacanthus paru</i> <sup>1;2;4;6;7;9;11;18;19;21; 22;23;24</sup>	Allowed	DD	LC	-
<i>Pomadasys corvinaeformis</i> <sup>11;18;19</sup>	Allowed	NE	NE	-
<i>Porichthys porosissimus</i> <sup>11;18;19</sup>	Allowed	NE	NE	-
<i>Priacanthus arenatus</i> <sup>9</sup>	Prohibited	NE	LC	-
<i>Prionotus nudigula</i> <sup>11;18;19</sup>	Allowed	NE	NE	-
<i>Prionotus punctatus</i> <sup>1;19</sup>	Prohibited	NE	LC	-
<i>Prognathodes brasiliensis</i> <sup>4;9;11;21</sup>	Prohibited	NE	LC	-
<i>Prognathodes guyanensis</i> <sup>4;11;21</sup>	Prohibited	NE	LC	-
<i>Prognathodes obliquus</i> <sup>4;11;16;18; 20;21</sup>	Prohibited	VU	DD	EI
<i>Pseudocaranx dentex</i> <sup>9</sup>	Prohibited	NE	LC	-
<i>Pseudupeneus maculatus</i> <sup>1;9</sup>	Prohibited	NE	LC	-
<i>Ptereleotris randalli</i> <sup>11;21</sup>	Prohibited	NE	LC	-
<i>Rypticus bitrispinus</i> <sup>9;11;18;19</sup>	Allowed	NE	LC	-
<i>Rypticus saponaceus</i> <sup>9;11;18;19</sup>	Allowed	NE	LC	-
<i>Scartella cristata</i> <sup>4;8;11;18;21;22;23;24</sup>	Allowed	NE	LC	-
<i>Scarus</i> spp. <sup>1</sup>	-	-	-	-
<i>Scarus trispinosus</i> <sup>9;20</sup>	Prohibited	EN	EN	-
<i>Scarus zelindae</i> <sup>4;9;11;18;19;21</sup>	Allowed	VU	DD	-
<i>Scorpaena brasiliensis</i> <sup>1;9;11;18;19</sup>	Allowed	NE	LC	-
<i>Scorpaena isthmensis</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Scorpaena plumieri</i> <sup>1;9;11;18;19</sup>	Allowed	NE	LC	-

Continued Table 1.

Species	Harvesting in accordance with IN 202/08	Brazilian list of threatened fish species (Decree MMA 445/14)	IUCN red list of threatened species	Observation
<i>Selar crumenophthalmus</i> <sup>9</sup>	Prohibited	NE	LC	-
<i>Selene vomer</i> <sup>1;2;11;18;19;22</sup>	Allowed	NE	LC	-
<i>Seriola</i> spp. <sup>9</sup>	Prohibited	-	-	-
<i>Serranus baldwini</i> <sup>1;9;11;18;19;23</sup>	Allowed	NE	LC	-
<i>Serranus flaviventris</i> <sup>1;9;11;18;19</sup>	Allowed	NE	LC	-
<i>Serranus phoebe</i> <sup>9;11;18;19</sup>	Allowed	NE	LC	-
<i>Sparisoma</i> spp. <sup>7;9</sup>	-	-	-	-
<i>Sparisoma amplum</i> <sup>9;11;18;19</sup>	Allowed	NT	LC	-
<i>Sparisoma axillare</i> <sup>9;11;18;19</sup>	Allowed	VU	DD	-
<i>Sparisoma frondosum</i> <sup>9;11;18;19</sup>	Allowed	VU	DD	-
<i>Sparisoma radians</i> <sup>9;11;18;19</sup>	Allowed	NE	LC	-
<i>Sparisoma tuiupiranga</i> <sup>4;9;21</sup>	Prohibited	NE	NE	-
<i>Sphoeroides greeleyi</i> <sup>9;11;18;19</sup>	Allowed	NE	LC	-
<i>Sphoeroides spengleri</i> <sup>1;9;11;18;19;24</sup>	Allowed	NE	LC	-
<i>Sphoeroides testudineus</i> <sup>11;18;19</sup>	Allowed	DD	LC	-
<i>Stegastes</i> spp. <sup>1</sup>	-	-	-	-
<i>Stegastes fuscus</i> <sup>3;4;9;11;18;19;21;23</sup>	Allowed	NE	LC	-
<i>Stegastes pictus</i> <sup>1;4;9;11;18;19;21</sup>	Allowed	NE	NE	-
<i>Stegastes rocasensis</i> <sup>20</sup>	Prohibited	VU	NE	EI
<i>Stegastes sanctipauli</i> <sup>18;20</sup>	Prohibited	VU	LC	EI
<i>Stegastes uenfi</i> <sup>11;18;19</sup>	Allowed	NE	NE	-
<i>Stegastes variabilis</i> <sup>1;4;9;11;18;19;21;23;24</sup>	Allowed	NE	NE	-
<i>Stephanolepis</i> spp. <sup>7</sup>	-	-	-	-
<i>Stephanolepis hispidus</i> <sup>1;9;11;18;19</sup>	Allowed	NE	LC	-
<i>Stephanolepis setifer</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Stygnobrotula latebricola</i> <sup>4;11;18;19;21</sup>	Allowed	NE	LC	-
<i>Syngnathus</i> sp. <sup>10</sup>	Prohibited	-	-	-
<i>Synodus foetens</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Synodus intermedius</i> <sup>7;9;11;18;19</sup>	Allowed	NE	LC	-
<i>Synodus synodus</i> <sup>9;11;18;19</sup>	Allowed	NE	LC	-
<i>Thalassoma</i> spp. <sup>1</sup>	-	-	-	-
<i>Thalassoma noronhanum</i> <sup>4;6;9;11;18;19;21</sup>	Allowed	NE	LC	-
<i>Thalassophryne montevidensis</i> <sup>11;18;19</sup>	Allowed	NE	NE	-
<i>Thalassophryne nattereri</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Trachinocephalus myops</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Upeneus parvus</i> <sup>11;18;19</sup>	Allowed	NE	LC	-
<i>Xyrichtys novacula</i> <sup>1;4;11;18;19;21</sup>	Allowed	NE	LC	-
<i>Xyrichtys splendens</i> <sup>1;11;18;19</sup>	Allowed	NE	LC	-
<b>Chondrichthyes</b>				
<i>Aetobatus narinari</i> <sup>8</sup>	Prohibited	DD	NT	-
<i>Dasyatis</i> spp. <sup>8</sup>	Prohibited	-	-	-
<i>Dasyatis guttata</i> <sup>1</sup>	Prohibited	NE	DD	-
<i>Dasyatis marianae</i> <sup>8</sup>	Prohibited	DD	DD	-



Continued Table 1.

Species	Harvesting in accordance with IN 202/08	Brazilian list of threatened fish species (Decree MMA 445/14)	IUCN red list of threatened species	Observation
<i>Ginglymostoma cirratum</i> <sup>1,4;20;21</sup>	Prohibited	VU	DD	-
<i>Narcine brasiliensis</i> <sup>1,4;21</sup>	Prohibited	DD	DD	-
<i>Pristis perotteti</i> <sup>17</sup>	Prohibited	NE	NE	-
<i>Rhinobatos</i> spp. <sup>1,4;21;23</sup>	Prohibited	-	-	-
<i>Rhinobatos percellens</i> <sup>1</sup>	Prohibited	DD	NT	-
<i>Rhinoptera bonasus</i> <sup>8</sup>	Prohibited	DD	NT	-
<i>Zapteryx brevirostris</i> <sup>4;21</sup>	Prohibited	VU	VU	-

Sources of information: <sup>1</sup>Monteiro-Neto et al. (2003), <sup>2</sup>Araújo & Albuquerque-Filho (2005), <sup>3</sup>Ferreira et al. (2005), <sup>4</sup>Gasparini et al. (2005), <sup>5</sup>Rosa et al. (2005), <sup>6</sup>Nottingham et al. (2005b), <sup>7</sup>Nottingham et al. (2005a), <sup>8</sup>Sampaio & Rosa (2005), <sup>9</sup>Floeter et al. (2006), <sup>10</sup>Rosa et al. (2006), <sup>11</sup>IN Ibama 202/08, <sup>12</sup>Moura (2008a), <sup>13</sup>Moura (2008b), <sup>14</sup>Moura et al. (2008); <sup>15</sup>Moura & Sazima (2008); <sup>16</sup>Moura (2008c); <sup>17</sup>Charvet-Almeida & Faria (2008); <sup>18</sup>Sampaio & Nottingham (2008), <sup>19</sup>Ibama (2008a), <sup>20</sup>Mohr et al. (2009), <sup>21</sup>Sampaio & Ostrensky (2013), <sup>22</sup>Autor's personal observation, <sup>23</sup>Marine aquarium discussion forums, <sup>24</sup>Brazilian pet shop's websites/ auction webpages. Threatening categories according to the Brazilian list of threatened fish and aquatic invertebrate species (decree MMA 445/14) and the IUCN red list of threatened species (version 2016-3): (NE) Not Evaluated, (DD) Data Deficient, (LC) Least Concern, (NT) Near Threatened, (VU) Vulnerable, (EN) Endangered, (CR) Critically Endangered – for DD and NT species recorded in Brazil see <http://www.icmbio.gov.br> >> biodiversidade >> fauna brasileira >> lista de espécies quase ameaçadas e com dados insuficientes. Observation: (EI) Endemic to Brazilian oceanic islands; (NS) New Species; (DN) Different Name used in references – originally mentioned as (\*) *Anthias salmopunctatus*, (\*\*\*) *Halichoeres cyanocephalus*, (\*\*\*) *Halichoeres maculipinna* and (\*\*\*) *Microphis eigenmanni*.

Table 2. Marine aquarium invertebrates traded in Brazil and their conservation status.

Species	Harvesting in accordance with the Brazilian Environmental Crime Law (9,605/98)	Brazilian list of threatened aquatic invertebrate species (Decree MMA 445/14)	IUCN red list of threatened species	Observation
Mollusks				
<i>Anadara brasiliensis</i> <sup>17</sup>	Allowed	NE	NE	-
<i>Aplysia dactylomella</i> <sup>17</sup>	Allowed	NE	NE	-
<i>Aplysia parvula</i> <sup>17</sup>	Allowed	NE	NE	-
<i>Astraea phoebia</i> <sup>17;20;21</sup>	Allowed	NE	NE	-
<i>Astraea tecta</i> <sup>17;20;21</sup>	Allowed	NE	NE	-
<i>Atrina seminuda</i> <sup>17</sup>	Allowed	NE	NE	-
<i>Berghia</i> sp. <sup>20</sup>	Allowed	-	-	-
<i>Bornella calcarata</i> <sup>18</sup>	Allowed	NE	NE	-
<i>Cassis tuberosa</i> <sup>17</sup>	Allowed	NT	NE	-
<i>Cerithium atratum</i> <sup>19;20;21</sup>	Allowed	NE	NE	-
<i>Charonia variegata</i> <sup>17</sup>	Allowed	NE	NE	-
<i>Chlamys ornata</i> <sup>18</sup>	Allowed	NE	NE	-
<i>Caribachlamys sentis</i> <sup>18</sup>	Allowed	NE	NE	-
<i>Conus</i> spp. <sup>2;18</sup>	Allowed	-	-	-
<i>Cyphoma gibbosum</i> <sup>18</sup>	Allowed	NE	NE	-
<i>Cyphoma macumba</i> <sup>18</sup>	Allowed	NE	NE	-
<i>Cypraea brasiliensis</i> <sup>17</sup>	Allowed	NE	NE	-
<i>Cypraea spurca</i> <sup>17</sup>	Allowed	NE	NE	-
<i>Elysia subornata</i> <sup>20</sup>	Allowed	NE	NE	-
<i>Euvola ziczac</i> <sup>17</sup>	Prohibited	EN	NE	BL
<i>Lima lima</i> <sup>18</sup>	Allowed	NE	NE	-
<i>Lima pellucida</i> <sup>18</sup>	Allowed	NE	NE	-
<i>Loligo plei</i> <sup>17</sup>	Allowed	NE	NE	-



Continued Table 2.

Species	Harvesting in accordance with the Brazilian Environmental Crime Law (9,605/98)	Brazilian list of threatened aquatic invertebrate species (Decree MMA 445/14)	IUCN red list of threatened species	Observation
<i>Lyropecten nodosus</i> <sup>18;19</sup>	Allowed	NE	NE	-
<i>Macrocypraea zebra</i> <sup>20</sup>	Allowed	NE	NE	-
<i>Micromelo undatus</i> <sup>18;20</sup>	Allowed	NE	NE	-
<i>Neritina virginea</i> <sup>19;20;21</sup>	Allowed	NE	LC	-
<i>Octopus vulgaris</i> <sup>2</sup>	Allowed	NE	NE	-
<i>Phidiana lynceus</i> <sup>18</sup>	Allowed	NE	NE	-
<i>Pinna carnea</i> <sup>17</sup>	Allowed	NE	NE	-
<i>Pleurobranchus</i> sp. <sup>18</sup>	Allowed	-	-	-
<i>Pteria colymbus</i> <sup>17</sup>	Allowed	NE	NE	-
<i>Rostanga byga</i> <sup>18</sup>	Allowed	NE	NE	-
<i>Spondylus americanus</i> <sup>18</sup>	Allowed	NE	NE	-
<i>Strombus pugilis</i> <sup>20</sup>	Allowed	NE	NE	-
<i>Stramonita brasiliensis</i> <sup>19</sup>	Allowed	NE	NE	-
<i>Tegula viridula</i> <sup>19;20;21</sup>	Allowed	NE	NE	-
<i>Trachycardium muricatum</i> <sup>17</sup>	Allowed	NE	NE	-
<i>Turbo canaliculatus</i> <sup>18</sup>	Allowed	NE	NE	-
Crustaceans				
<i>Acanthonix</i> sp. <sup>20;21</sup>	Allowed	NE	NE	OM
<i>Alphaeus</i> sp. <sup>20</sup>	Allowed	NE	NE	-
<i>Brachycarpus</i> cf. <i>biunguiculatus</i> <sup>2</sup>	Allowed	NE	NE	-
<i>Calcinus tibicen</i> <sup>2;17;19;20;21</sup>	Allowed	NE	NE	-
<i>Cinetorhynchus rigens</i> <sup>2;20;21</sup>	Allowed	NE	NE	-
<i>Clibanarius</i> spp. <sup>19;20;21</sup>	Allowed	-	-	-
<i>Dardanus venosus</i> <sup>2;20</sup>	Allowed	NE	NE	-
<i>Enoplometopus antillensis</i> <sup>2;18;20</sup>	Allowed	DD	LC	-
<i>Gnathophyllum americanum</i> <sup>18</sup>	Allowed	NE	NE	-
<i>Lepas anatifera</i> <sup>18</sup>	Allowed	NE	NE	-
<i>Lepas anserifera</i> <sup>18</sup>	Allowed	NE	NE	-
<i>Lysmata grabhami</i> <sup>2;17;19;20;21</sup>	Allowed	NE	NE	-
<i>Lysmata rathbunae</i> <sup>17;20</sup>	Allowed	NE	NE	-
<i>Lysmata wurdemanni</i> <sup>2;17;19;20;21</sup>	Allowed	NE	NE	-
<i>Mithrax</i> spp. <sup>20;21</sup>	Allowed	-	-	-
<i>Mithraculus forceps</i> <sup>20</sup>	Allowed	NE	NE	-
<i>Parribacus antarcticus</i> <sup>18</sup>	Allowed	NE	LC	-
<i>Periclimenes</i> aff. <i>pedersoni</i> <sup>2;20</sup>	Allowed	NE	NE	-
<i>Periclimenes</i> aff. <i>yucatanicus</i> <sup>2</sup>	Allowed	NE	NE	-
<i>Petrochirus diogenes</i> <sup>2;17</sup>	Allowed	NE	NE	-
<i>Phimochirus holthuisi</i> <sup>18</sup>	Allowed	NE	NE	-
<i>Platypodiella spectabilis</i> <sup>2;19;20;21</sup>	Allowed	NE	NE	-
<i>Scyllarides aequinoctialis</i> <sup>18</sup>	Allowed	NE	LC	-
<i>Stenopus hispidus</i> <sup>2;17;19;20;21</sup>	Allowed	NE	NE	-

Continued Table 2.

Species	Harvesting in accordance with the Brazilian Environmental Crime Law (9,605/98)	Brazilian list of threatened aquatic invertebrate species (Decree MMA 445/14)	IUCN red list of threatened species	Observation
<i>Stenopus scutellatus</i> <sup>2</sup>	Allowed	NE	NE	-
<i>Stenorhynchus seticornis</i> <sup>2,17;19;20;21</sup>	Allowed	NE	NE	-
<i>Thor</i> aff. <i>amboinensis</i> <sup>2,18</sup>	Allowed	NE	NE	-
Cnidarians				
<i>Actinoporus</i> sp. <sup>2</sup>	Prohibited	-	-	-
<i>Alicia mirabilis</i> <sup>2</sup>	Prohibited	NE	NE	-
<i>Bellactis ilkalysae</i> <sup>2</sup>	Prohibited	NE	NE	-
<i>Carijoa riisei</i> <sup>2</sup>	Prohibited	NE	NE	-
<i>Cerianthomorpha brasiliensis</i> <sup>3</sup>	Prohibited	DD	NE	-
<i>Cerianthus brasiliensis</i> <sup>4</sup>	Prohibited	NE	NE	-
<i>Condylactis gigantea</i> <sup>2,5</sup>	Prohibited	EN	NE	-
<i>Discosoma</i> spp. <sup>2</sup>	Prohibited	-	-	-
<i>Favia grandidieri</i> <sup>2</sup>	Prohibited	NE	NE	-
<i>Heterogorgia uatumani</i> <sup>2</sup>	Prohibited	NE	NE	-
<i>Lophogorgia punicea</i> <sup>2</sup>	Prohibited	NE	NE	-
<i>Lophogorgia violacea</i> <sup>2</sup>	Prohibited	NE	NE	-
<i>Madracis decactis</i> <sup>2</sup>	Prohibited	NE	LC	-
<i>Meandrina brasiliensis</i> <sup>2</sup>	Prohibited	DD	DD	-
<i>Millepora alcicornis</i> <sup>2,6</sup>	Prohibited	NE	LC	-
<i>Millepora brasiliensis</i> <sup>2</sup>	Prohibited	DD	DD	-
<i>Montastrea cavernosa</i> <sup>2</sup>	Prohibited	NE	NE	-
<i>Muricea flamma</i> <sup>2</sup>	Prohibited	NE	NE	-
<i>Muriceopsis sulphurea</i> <sup>2</sup>	Prohibited	NE	NE	-
<i>Mussismilia brasiliensis</i> <sup>2</sup>	Prohibited	VU	DD	-
<i>Mussismilia hartii</i> <sup>2</sup>	Prohibited	EN	DD	-
<i>Mussismilia hispida</i> <sup>2</sup>	Prohibited	NE	DD	-
<i>Palythoa caribaeorum</i> <sup>2</sup>	Prohibited	NE	NE	-
<i>Phyllogorgia dilatata</i> <sup>2,7</sup>	Prohibited	DD	NE	-
<i>Plexaurella grandiflora</i> <sup>2</sup>	Prohibited	NE	NE	-
<i>Plexaurella regia</i> <sup>2</sup>	Prohibited	NE	NE	-
<i>Porites branneri</i> <sup>2</sup>	Prohibited	NE	NT	-
<i>Scolymia wellsii</i> <sup>2</sup>	Prohibited	NE	DD	-
<i>Siderastrea stellata</i> <sup>2</sup>	Prohibited	NE	DD	-
<i>Zoanthus</i> spp. <sup>2</sup>	Prohibited	-	-	-
Echinoderms				
<i>Asterina stellifera</i> <sup>8;16</sup>	Prohibited	NE	NE	-
<i>Astropecten brasiliensis</i> <sup>16</sup>	Prohibited	VU	NE	-
<i>Astropecten marginatus</i> <sup>16</sup>	Prohibited	NE	NE	-
<i>Astrophyton</i> sp. <sup>2</sup>	Prohibited	-	-	-
<i>Echinaster</i> spp. <sup>2</sup>	Prohibited	-	-	-
<i>Echinaster (Othilia) brasiliensis</i> <sup>2,9</sup>	Prohibited	NE	NE	-

Continued Table 2.

Species	Harvesting in accordance with the Brazilian Environmental Crime Law (9,605/98)	Brazilian list of threatened aquatic invertebrate species (Decree MMA 445/14)	IUCN red list of threatened species	Observation
<i>Echinaster (Othilia) echinophorus</i> <sup>2,10</sup>	Prohibited	NE	NE	-
<i>Echinaster (Othilia) guyanensis</i> <sup>2</sup>	Prohibited	NE	NE	-
<i>Echinometra lucunter</i> <sup>20</sup>	Prohibited	NE	NE	-
<i>Eucidaris tribuloides</i> <sup>2,11,20</sup>	Prohibited	NE	NE	-
<i>Linckia guildingii</i> <sup>2,12,19</sup>	Prohibited	VU	NE	-
<i>Lytechinus variegatus</i> <sup>20</sup>	Prohibited	VU	NE	-
<i>Luidia clathrata</i> <sup>16</sup>	Prohibited	NE	NE	-
<i>Luidia senegalensis</i> <sup>16</sup>	Prohibited	VU	NE	-
<i>Narcissia trigonaria</i> <sup>2,13</sup>	Prohibited	NE	NE	-
<i>Ophioderma</i> spp. <sup>2</sup>	Prohibited	-	-	-
<i>Oreaster reticulatus</i> <sup>14</sup>	Prohibited	VU	NE	-
<i>Tropiometra carinata</i> <sup>20</sup>	Prohibited	NE	NE	-
Polychaetes				
<i>Eurythoe complanata</i> <sup>15</sup>	Prohibited	NE	NE	-
<i>Spirobranchus</i> spp. <sup>2</sup>	Prohibited	NE	NE	-
Ascidians				
<i>Botrylloides nigrum</i> <sup>20</sup>	Prohibited	NE	NE	IE
<i>Polycarpa insulsa</i> <sup>20</sup>	Prohibited	NE	NE	IE
<i>Styela plicata</i> <sup>20</sup>	Prohibited	NE	NE	-
Sponges				
<i>Aplysina fulva</i> <sup>1</sup>	Prohibited	NE	NE	-
<i>Axinyssa</i> sp. <sup>1</sup>	Prohibited	-	-	-
<i>Drarmacidon reticulatum</i> <sup>1,22</sup>	Prohibited	NE	NE	-
<i>Tethya</i> sp. <sup>1</sup>	Prohibited	-	-	-

Source or information: <sup>1</sup>Sampaio et al., (2004); <sup>2</sup>Gasparini et al. (2005); <sup>3</sup>Pires & Castro (2008a); <sup>4</sup>Pires & Castro (2008b); <sup>5</sup>Pires & Castro (2008c); <sup>6</sup>Pires & Castro (2008d); <sup>7</sup>Castro & Pires (2008); <sup>8</sup>Brites et al. (2008a); <sup>9</sup>Ventura et al. (2008a); <sup>10</sup>Ventura et al. (2008b); <sup>11</sup>Ventura et al. (2008c); <sup>12</sup>Brites et al. (2008b); <sup>13</sup>Brites et al. (2008c); <sup>14</sup>Brites et al. (2008d); <sup>15</sup>Amaral et al. (2008); <sup>16</sup>Amaral et al. (2010); <sup>17</sup>Authorization of exportation issued by Ibama; <sup>18</sup>Authorization of exportation requested but not issued by Ibama; <sup>19</sup>Author's personal observation; <sup>20</sup>Marine aquarium discussion forums; <sup>21</sup>Brazilian pet shop's websites/auction webpages; <sup>22</sup>Hajdu et al (2011). Threatening categories according to the Brazilian list of threatened fish and aquatic invertebrate species (decree MMA 445/14) and the IUCN red list of threatened species (version 2016-3): (NE) Not Evaluated, (DD) Data Deficient, (LC) Least Concern, (NT) Near Threatened, (VU) Vulnerable, (EN) Endangered. Observations: (BL) Although law 9,605/98 allows collection of mollusks, the species cannot be harvested since it is classified as EN in the Brazilian List of threatened fish and aquatic invertebrate species, (OM) Originally Misidentified as *Xenocarcinus* sp. or *Macropodia longirostris*, (IE) Incidental Exploitation attached to "liverocks".

Even though law 9,605/98 allows exploitation of mollusks and crustaceans (because they are defined as fishing resources), it prohibits the usage of species that figure in the Brazilian List of threatened fish and aquatic invertebrate species, as well as of those other invertebrates not defined as fishing resources (cnidarians, echinoderms, polychaetes, ascidians and sponges). Hence, exploitation of the bivalve *Euvola ziczac* (Linnaeus, 1758) is forbidden because it is classified as EN, according to decree MMA 445/14.

Table 2 also presents species that were misidentified in marine aquarium discussion forums and Brazilian pet shop's websites or auction webpages, besides organisms that were incidentally exploited attached to liverocks.

It was also recorded the use of seaweeds and saltwater macrophytes in marine tanks throughout the country (Table 3) and the great majority of species is neither cited in the Brazilian list of threatened flora species (decree MMA 443/14) nor in the IUCN red list of threatened species. The only exception is *Halophila decipiens* Ostenfeld, which is categorized as Least Concern (LC) solely in the IUCN red list.

**Table 3.** Seaweeds and aquatic macrophytes used in marine aquarium trade in Brazil

Species	Harvesting in accordance with IN 89/06	Brazilian list of threatened flora species (Decree MMA 443/14)	IUCN red list of threatened species
Green seaweeds (Chlorophyta)			
<i>Acetabularia calyculus</i> <sup>2</sup>	Allowed	NE	NE
<i>Bryopsis</i> sp. <sup>2</sup>	Allowed	-	-
<i>Caulerpa prolifera</i> <sup>2</sup>	Allowed	NE	NE
<i>Caulerpa racemosa</i> <sup>2</sup>	Allowed	NE	NE
<i>Caulerpa sertularioides</i> <sup>2</sup>	Allowed	NE	NE
<i>Caulerpa taxifolia</i> <sup>2</sup>	Allowed	NE	NE
<i>Chaetomorpha linum</i> <sup>2,4</sup>	Allowed	NE	NE
<i>Chaetomorpha</i> sp. <sup>2,3</sup>	Allowed	-	-
<i>Codium</i> sp. <sup>2</sup>	Allowed	-	-
<i>Halimeda</i> sp. <sup>2</sup>	Allowed	-	-
<i>Udotea</i> sp. <sup>2</sup>	Allowed	-	-
Red seaweeds (Rodophyta)			
<i>Acanthophora</i> sp. <sup>2</sup>	Allowed	-	-
<i>Ceramium</i> sp. <sup>2</sup>	Allowed	-	-
<i>Chondria</i> sp. <sup>2</sup>	Allowed	-	-
<i>Gracilaria</i> sp. <sup>2</sup>	Allowed	-	-
<i>Jania</i> sp. <sup>2</sup>	Allowed	-	-
<i>Lithothamnium</i> spp. <sup>1</sup>	Allowed	-	-
Brown seaweeds (Phaeophyta)			
<i>Dictyota cervicomis</i> <sup>2</sup>	Allowed	NE	NE
<i>Lobophora</i> sp. <sup>2</sup>	Allowed	-	-
<i>Padina</i> sp. <sup>2</sup>	Allowed	-	-
Macrophytes (Sea grasses)			
<i>Halophila decipiens</i> <sup>2</sup>	Not applicable	NE	LC
<i>Halodule</i> sp. <sup>2</sup>	Not applicable	-	-

Source of information: <sup>1</sup>Ibama (2008a); <sup>2</sup>Marine aquarium discussion forums; <sup>3</sup>Author's personal observation; <sup>4</sup>Brazilian pet shop's websites/auction webpages. Threatening categories according to the Brazilian list of threatened flora species (decree MMA 443/15) and the IUCN red list of threatened species (version 2016-3): (NE) Not Evaluated, (LC) Least Concern.

## Discussion

Web surveys have been successfully used to investigate aquarium trade worldwide (Kay & Hoyle 2001; Walters et al. 2006; Keller & Lodge 2007) and specifically in Brazil, this tool has been used to access the commerce of freshwater species (Magalhães & Jacobi 2010; Magalhães et al 2017).

Many native species traded by the marine aquarium industry in Brazil figure in Brazilian lists of threatened species and, currently, it is much easier to compare these species with those categorized in the IUCN red list. Preceding Brazilian lists of threatened species (IN MMA 05/04 and IN MMA 52/05) had their own categories and classification criteria, but most recent Brazilian lists (decree MMA 443/14 and decree MMA 445/14) followed the IUCN red list patterns,

which allow more reliable comparisons and avoid mismatches already detected - agreements regarding categories increase credibility of red lists, while disagreements can either do the opposite or demonstrate that in particular cases a species may locally present a distinctive threatening degree compared to the general reality along its whole distribution (Bender et al. 2012). Bony fishes represent the great majority of the exploited species. Despite only 136 species can be legally commercialized according to IN Ibama 202/08, about 70 others are illegally traded in Brazil. This situation not only demonstrates a lack of more effective control and inspection by the Brazilian authorities (e.g. Ibama) but also indicates that many dealers and tank owners (i.e., aquarium hobbyists) simply either ignore or unknow the norms that regulate the exploitation of marine aquarium organisms. Such illegal trade is specially worrying because some organisms are included in the

Brazilian list of threatened species under really threatening conservation statuses (e.g. EN or CR categories) or maybe worse, whose statuses are simply unknown (e.g. NE or DD categories).

Among many fish species, the barber goby *Elacatinus figaro* Sazima, Moura & Rosa, 1997 (VU, in accordance with decree MMA 445/14) and the Brazilian basslet *Grama brasiliensis* Sazima, Gasparini & Moura, 1998 (whose harvesting was prohibited until December 2014, for being categorized as threatened with extinction by an older norm - IN MMA 05/04) were frequently cited by different sources of information investigated, indicating that, despite the prohibition of exploitation imposed by IN Ibama 202/08, both species are commonly found in ornamental trade.

This statement is corroborated through the seizure by Ibama of 18 *E. figaro* specimens, that were being illegally traded by means of the Brazilian postal service in 2010 (Gurjão et al. 2017), and another confiscation of *E. figaro* and *G. brasiliensis* specimens, at Guarulhos international airport, during the 2014 Fifa World Cup in Brazil. (<http://www.ibama.gov.br/publicadas/pagina-19-20>). Another aspect that deserves special attention regarding the exploitation of the *E. figaro* is the potential negative ecological effect in reef areas, since it is a recognized cleaner species that plays an important role at cleaning stations and thus, in maintaining the functioning of the marine ecosystem (Sazima et al. 2000, Campos & Sá-Oliveira 2011). Considering the Brazilian list of threatened species and the distribution of the fish traded, it must be highlighted that *Choranthias salmopunctatus* (Lubbock & Edwards, 1981), *Prognathodes obliquus* (Lubbock & Edwards, 1980), *Stegastes rocasensis* (Emery, 1972) and *S. sanctipauli* Lubbock & Edwards, 1981 are endemic to Brazilian oceanic islands (e.g. Rocas Atoll and St Peter and St Paul's Archipelago - SPSPA) and, hence, their populations are more vulnerable to exploitation due to isolation (Mohr et al. 2009). Even considering the fragile aspects of these isolated populations and the prohibition of harvesting individuals at Brazilian oceanic islands by IN Ibama 202/08, almost all of them were already recorded as being captured for the aquarium industry – the only exception is *C. salmopunctatus*, which, despite never observed in the Brazilian ornamental market, is a desired species, specially by the millionaire Asian commerce, due to its unique characteristics (e.g. attractive color, rarity: low density/absolute number, and is the only species of the genus in Brazil) and extremely restricted geographic distribution (endemic to SPSPA: very limited horizontal and depth ranges) (Luiz-Júnior et al. 2007, Sampaio & Nottingham 2008).

Some authors mention the aquarium trade of certain fish that could not be identified further than the genus level, but that comprise species listed in decree MMA 445/14: *Micrognathus* (*M. erugatus* – CR), *Scarus* (*S. trispinosus* – EN and *S. zelindae* – VU), *Sparisoma* (*S. axillare* – VU, *S. frodosum* – VU and *S. rocha* – VU), *Stegastes* (*S. rocasensis* – VU, *S. sanctipauli* – VU and *S. trinidadensis* – VU), *Dasyatis* (*D. centroura* – CR and *D. colarensis* – VU) and *Rhinobatos* (*R. horkelli* – CR and *R. lentiginosus* – VU) (Monteiro et al. 2003, Gasparini et al. 2005, Nottingham et al. 2005a, Sampaio & Rosa 2005, Rosa et al. 2006), thus, it is possible that other threatened species have been exploited by the Brazilian marine aquarium industry.

Other important threatened species are the longsnout (*Hippocampus reidi* Ginsburg, 1933) and lined (*Hippocampus erectus* Perry, 1810) seahorses. These species have received particular attention from the scientific community and Brazilian governmental authorities, who

decided to keep them with the lowest exportation quota (250 specimens of each species/exporter/year). This is because populations pressed by aquarium harvesting activities had shown lower densities and smaller individuals (Ibama 2007, 2008a). However, the effectiveness of such measure is questionable since untrained and ill-intentioned dealers used to mislabel specimens of either *H. erectus* or *H. reidi* as they were *Hippocampus kuda* Bleeker, 1852 (Monteiro-Neto et al. 2003), while field surveys demonstrated that only *H. reidi* was actually exported, and the given quota could be doubled if 250 *H. reidi* were traded under the name of *H. erectus* (Rosa et al. 2011). Furthermore, there is still controversy about the distribution and taxonomy of Brazilian seahorses. Despite most authors state that *H. reidi* has a wider distribution along the Brazilian coast, while *H. erectus* is more restricted to southeastern and southern regions. However, evidences suggest that both species may have a continuous distribution along the Brazilian coast (Silveira 2011). Moreover, while *H. reidi* and *H. erectus* are the only valid names for the Brazilian seahorses (Fishbase 2017), a revision of the genus *Hippocampus* not only revealed that individuals identified in Brazil as *H. erectus* are morphologically and genetically similar to *Hippocampus patagonicus* Piacentino & Luzzatto, 2004 (Silveira et al. 2014), but also indicated the existence of a highly population limited to northeastern Brazil, distinguishable from these two previously mentioned species (Ibama 2009, Rosa et al. 2011).

Taxonomic problems are also on traded labrid, opistognatid and labrosomid fish. After revalidation of some Brazilian wrasse species and reevaluation of their distribution (Rocha & Rosa 2001, Rocha 2004), it is likely that specimens referred as *Halichoeres radiatus* (Linnaeus, 1758), *Halichoeres cyanocephalus* (Bloch, 1791) and *Halichoeres maculipinna* (Müller & Troschel, 1848) in previous works were actually misidentified, and should be, in fact, the labrids *Halichoeres brasiliensis* (Bloch, 1791), *Halichoeres dimidiatus* (Agassiz, 1831) and *Halichoeres penrosei* Starks, 1913, respectively. Another possible mistake occurred for *Opistognathus aurifrons* (Jordan & Thompson, 1905), which shall be in fact a new species of the same genus - *Opistognathus* sp. n. - (Sampaio & Nottingham 2008) and a third taxonomic incongruity is related to the forbidden exploitation of a new labrosomid species - *Malacotenus* sp. n. (Floeter et al. 2003) -, which have been erroneously commercialized as a blenid, called 'red blenny'. Additionally, preceding articles also recorded the presence of *Microphis eigenmanni* in the Brazilian ornamental trade, which is a not valid synonym of *Microphis lineatus* (Kaup, 1856) (Fishbase 2017). Similarly, *Canthigaster figueiredoi* Moura & Castro, 2002, used to be referred as *Canthigaster rostrata* (Bloch, 1786) in previous works (Sampaio & Nottingham 2008). Therefore, some fish scientific names recorded here may be different from those reported on original papers, but are in accordance with the most recent synonyms used (Fishbase, 2017).

With regards to unthreatened species, angelfish have been systematically recorded among the most exploited species by the Brazilian marine aquarium industry (Nottingham et al. 2000, Monteiro-Neto et al. 2003, Gasparini et al. 2005, Nottingham et al. 2005A, Feitosa et al. 2015) and despite the paucity of updated information about the exploitation of marine fish, the most recent official data available indicate that (Linnaeus, 1758), *Holocanthus tricolor* (Bloch, 1795), *Pomacanthus paru* (Bloch, 1787), *Pomacanthus arcuatus* (Linnaeus, 1758) and *Centropyge aurantonotus* Burgess, 1974, are still the most targeted species (Ibama 2008a). Another fact that corroborates this



statement is the growing demand for pomacanthids in the international market throughout the years, which lead the Brazilian authorities to attribute differentiated exportation quotas to them - substantially higher than the ones given to the other species by means of the IN Ibama 202/08. Additionally, the illegal exploitation of rare specimens from isolated populations of *H. ciliaris* (e.g. wholly yellow, blue or white morphs and other unique color variants, endemic to SPSPA) (Feitoza et al. 2003, Luiz-Júnior 2003), whose individual prices in the Japanese market can achieve up to US\$8.900,00, can decrease the genetic diversity (Gasparini et al. 2005) or even put these oddities in risk of extinction by means of an Anthropogenic Allee Effect (Courchamp et al. 2006).

None of the cartilaginous fish identified could be exploited according to IN Ibama 202/08, but such restriction is not entirely complied by the Brazilian aquarium industry. The clandestine harvest of these species is especially serious due to the fact that some sharks (*Ginglymostoma cirratum* (Bonnaterre, 1788), *Zapteryx brevirostris* (Müller & Henle, 1841) and rays (*Rhinobatus horkelii* Müller & Henle, 1841, *Rhinobatus lentiginosus* Garman, 1880, *Dasyatis centroura* (Mitchill, 1815) and *Dasyatis colarensis* Santos, Gomes & Charvet-Almeida, 2004) are listed in decree MMA 445/14. Illegal collections of *G. cirratum* and rhinobatids for the ornamental trade are not uncommon (Monteiro-Neto et al. 2003, Gasparini et al. 2005, Mohr et al. 2009). On the other hand, the harvest of sawfish for the same purpose seems to be rarer, despite newborn individuals be ordered by the aquarium industry (Charvet-Almeida & Faria, 2008). Regarding the trade of unthreatened sharks and rays, most species are sporadically harvested, with exception of *Narcine brasiliensis* (Olfers, 1831) and *Rhinobatos percellens* (Walbaum, 1792), whose captures involve a great number of newborn individuals and possibly are concentrated at a nursery site in Todos os Santos Bay, Bahia state, Northeastern Brazil (Sampaio & Rosa 2005).

Concerning invertebrates, the exploitation of bivalves for marine aquarium purposes seems to be negligible in Brazil, when compared to other organisms. However, in 2005, one of the Brazilian most famous aquarium company requested Ibama's authorization to export these organisms. The company granted the demand for six species (*Anadara brasiliiana* (Lamarck, 1819), *Atrina seminuda* (Lamarck, 1819), *Euvola ziczac* (Linnaeus, 1758), *Pinna carnea* Gmelin, 1791, *Pteria colymbus* (Roding, 1798) and *Trachycardium muricatum* (Linnaeus, 1758)) - noting that exports of *E. ziczac* occurred prior to its inclusion as EN in the Brazilian list of threatened fish and aquatic invertebrate species in 2014-, but despite export of other species were not authorized for different reasons, they are still legally exploitable for the domestic market according to Federal Law 9,605/98.

Distinct groups of gastropods are explored by the Brazilian aquarium industry. The prosobranchs *Cerithium atratum* Born, 1778, *Neritina virginea* Linnaeus, 1758 and *Tegula viridula* (Gmelin, 1791) are widely commercialized as aquarium 'clean-up crew' or 'algae cleaners', due to their feeding habit of grazing on unwanted algae. Other prosobranchs are not frequently traded, but Brazilian aquarium dealers requested Ibama to give them authorization to export *Cassia tuberosa* (Linnaeus, 1758), *Charonia variegata* (Lamarck, 1816), *Conus* spp., *Cyphoma gibbosum* (Linnaeus, 1758), *Cyphoma macumba* Petuch, 1979, *Cypraea brasiliensis* Lorenz & Hubert, 1993, *Cypraea spurca* Linnaeus, 1758 and *Turbo canaliculatus* Hermann, 1781. The harvest of *Macrocypraea zebra* (Linnaeus, 1758) and *Strombus pugilis*

Linnaeus, 1758 for marine tanks was mentioned at discussion forums and one of the authors observed a *Stramonita brasiliensis* Claremont & Reid, 2011 specimen being sold at an aquarium pet shop, in Ceará state, Northeastern Brazil. However, since *S. brasiliensis* is a predatory sea snail and may feed on other mollusks inside marine tanks, it is possible that the species was mistakenly harvested and unintentionally being sold as a hermit crab carrying a mollusk empty shell.

Concerning opisthobranchs, it shall be highlighted not only the maintenance of *Elysia subornata* (Verrill, 1901) individuals by aquarium hobbyists but also spawnings of the species inside tanks, described in discussion forums. In addition, nudibranchs of the genus *Berghia* are wanted in marine aquariums to eradicate the undesirable sea anemone *Aiptasia* sp.

In spite of only two cephalopod species were recorded in the present inventory, it must be considered the possibility of exploitation of a third species, *Octopus insularis* Leite, Haimovici, Molina & Warnke, 2008 - a recently described species from the *O. vulgaris* complex that might have been misidentified as the latter, due to their pattern of distribution along the Brazilian coast and other similarities (Leite et al. 2008).

At discussion forums, unidentified chitons (Polyplacophora) were also mentioned as being kept in marine aquariums either for controlling excessive growth of algae or for revolving sediments. In many cases, these organisms were reported to be collected incidentally, attached to fouled rocks placed into tanks.

None of the crustaceans recorded here figure in decree MMA 445/14. The hermit crabs *Calcinus tibicen* (Herbst, 1791) and *Clibanarius* spp. are widely commercialized as members of the aforementioned 'clean up crew', while *Dardanus venosus* (H. Milne Edwards, 1848) is wanted for aesthetic reasons, since the species often has a sea anemone attached to its shell. Other uncommon hermit crabs are wanted by marine tank owners because of their unique size and beauty, e.g. the giant hermit crab *Petrochirus diogenes* (Linnaeus, 1758) and the red-strip hermit crab *Phimochirus holthuisi* (Provenzano, 1961), respectively.

Concerning other crabs, while *Platypodiella spectabilis* (Herbst, 1794) and *Stenorhynchus seticornis* (Herbst, 1788) are traded mainly for their color pattern and unique features, respectively - in spite of the latter also act as a cleaner of reef fish (Medeiros et al. 2011), the algae-eating crabs *Mithrax* spp. and *Mithraculus forceps* (Milne-Edwards, 1875) (Olivotto et al. 2011), are desired to control the growth of unwanted bubble algae *Valonia* spp. inside tanks. It was recorded a probable taxonomic mistake in the identification of the decorator crab mentioned at discussion forums and sold online through pet shop websites. The species is mentioned as 'gorgonian spider-crab' or simply as 'gorgonian spider', under the scientific names *Xenocarcinus* sp. or *Macropodia longirostris* (Fabricius, 1775). However, as both genres are not reported for Brazil (L. E. A. Bezerra pers. comm.) and the crab advertised is very cheap and, so, presumably not imported, it is more likely to be another majiid crustacean, the Brazilian decorator crab *Acanthonyx* sp.

Besides their beauty, shrimps *Stenopus hispidus* (Olivier, 1811) and *Lysmata grabhami* (Gordon, 1935) are known for removing ectoparasites from reef fish, while *Lysmata wurdemanni* (Gibbes, 1850) and *Lysmata rathbunae* Chace, 1970 are wanted to control population of *Aiptasia* sp. inside tanks. Gasparini et al (2005) also reported the trade of the gold coral banded shrimp, *Stenopus scutellatus* Rankin, 1898, but the occurrence of the species was not mentioned at any other source

of information investigated here. The other shrimps *Cinetorhynchus rigens* (Gordon, 1936), *Thor* aff. *amboinensis*, *Periclimenes* aff. *yucatanicus* and *Periclimenes* aff. *pedersoni* are unusually sold in Brazilian market, despite their conspicuous body shape, color pattern, and behavioral characteristics, including the known cleaning activities of the latter (Floeter et al. 2007). The snapping shrimp *Alpheus* sp., also infrequently traded, is kept specially to control flatworm populations inside marine tanks. Since there are 29 species of the genus *Alpheus* in Brazil, including *A. rudolphi* spec. nov. - a new snapping shrimp of the *Alpheus armatus* species complex (Almeida & Anker 2011), – it was not possible to determine whether one or more species of the genus is traded.

Despite unattractive featured for ornamental purposes, the potential exploitation of the barnacles *Lepas anatifera* Linnaeus, 1758 and *Lepas anserifera* Linnaeus, 1767, and the lobsters *Gnathophyllum americanum* Guérin-Méneville, 1855, *Parribacis antarcticus* (Lund, 1793) and *Scyllarides aequinoctialis* (Lund, 1793) was also recorded, since authorization from Ibama to export these organisms alive was also requested. The dwarf reef lobster, *Enoplometopus antillensis* Lütken, 1865, also had its request of authorization for exportation denied by Ibama, but, differently from the other lobsters, this species is attractive to aquarium hobbyists at discussion forums due to its bright color and small size and, so, is still traded inside the country.

The recorded cnidarians belonged to distinct subgroups (sea anemones, octocorals, fire corals, besides other hard and soft corals) and among this wide variety of organisms, only three species are considered threatened in Brazil: *Condylactis gigantea* Weinland, 1860 (EN), *Mussismilia braziliensis* (Verrill 1868) (VU) and *Mussismilia harttii* (Verrill, 1868) (EN). Special attention shall be given to the illegal exploitation of *C. gigantea*, due to its intensive harvest by the ornamental industry in southeastern Brazil and its local extinction at Arraial do Cabo region, Rio de Janeiro state (Gasparini et al. 2005). Through discussion forums it was observed the illegal trade of sea whips, usually called ‘monkey-tail gorgonian’ and ‘fox-tail gorgonian’. Despite forum members refer to them as members of the family Plexauridae, not only the precise identification of these two gorgonians is impossible based exclusively on common names, but also it is unknown whether or not they are recorded here, since this inventory mentions the plexaurid species *Plexaurella grandiflora* Verrill, 1912 and *Plexaurella regia* Barreira & Castro, 1986.

The echinoderms listed were clearly dominated by sea stars, demonstrating the importance of a wide variety of species to the Brazilian aquarium trade. It is worth notice that some echinoderm species are threatened with extinction in Brazilian waters and authorities should give special attention to ban the harvest of two species: *Linckia guildingii* Gray, 1840, which have been traded illicitly through the Brazilian postal service (Gurjão et al. 2017) and *Eucidaris tribuloides* (Lamarck, 1816), which is constantly mentioned at discussion forums as being used in marine aquariums. Although sea cucumbers are not listed in the tables presented here, because it was not possible to identify the species traded, it was recorded the illegal selling of holothurians at discussion forums, under the common names ‘giant sea cucumber’, ‘detritivorous sea cucumber’ and ‘burrowing sea cucumber’.

Differently from the other polychaetes identified here (*Spirobranchus* spp. and *Eurythoe complanata* (Pallas, 1766)), desired because of their beauty, *Diopatra cuprea* (Bosc, 1802) (categorized as VU in the Brazilian official list of threatened species) is indirectly used for

ornamental purposes, as a source of food for some marine fish species (Steiner & Amaral, 2008). In addition, exploitation of other unreported native polychaetes is likely to happen in Brazil, since the country supplies the UK ornamental market with such worms (Murray et al. 2012).

Tunicates were also recorded among organisms used in marine aquariums in Brazil. While *Botrylloides nigrum* Herdman, 1886, *Styela plicata* Lesuer, 1823 and possibly one unidentified didemnid seems to be unintentionally harvested adhered to live rocks taken from the wild and set into marine tanks, other species sold as ‘black ascidian’ and ‘red ascidian’ are deliberately traded by discussion forum members. As there was no photo of the black ascidian advertised, species could not be surely identified. However, due to its wide distribution throughout tropical waters, including Brazilian coast (Lotufo 2002), the possibility of the latter be the solitary *Phallusia nigra* Savigny, 1816 cannot be disregarded. Concerning the red ascidian, photos resembled *Polycarpa insulsa* (Sluiter, 1898). Although uncommon, previous studies had already recorded the presence of tunicates, as well as sponges, on other marine ornamental foreign markets (Wabnitz et al. 2003, Murray & Watson 2014).

The four sponge species identified here, *Aplysina fulva* (Pallas, 1766), *Axinyssa* sp., *Drumacidon reticulatum* (Ridley & Dendy, 1886) and *Tethya* sp. are usually called ‘yellow sponge’, ‘finger’, ‘red ball’ and ‘yellow ball’, respectively (Sampaio et al. 2004). Discussion forums showed that sponges known as ‘red ball’ and ‘yellow ball’ are traded through the internet, however it was not possible to assure the species’ identity based exclusively on common names. Additionally, the exploitation of a subspheric morphotype of *D. reticulatum*, called ‘sponge-ball’ and previously cited as *Pseudaxinella reticulata* (Ridley & Dendy, 1886), by the Brazilian aquarium industry have already been reported (Hajdu et al. 2011).

In Brazil, aquarium trade of seaweeds is extremely rare, since traditionally the co-habitation of corals and macroalgae is not wanted because seaweeds are avid competitors inside tanks, limiting coral growth. In most cases, macroalgae, e.g. *Chaetomorpha* spp., are kept solely in the aquarium’s sump, aiming nitrogen and phosphorus removal. However, a few tank owners share their experience at discussion forums, keeping ‘marine planted aquariums’ rather than coral reef systems and, thus, seaweeds had been used associated to the sea grasses, e.g. *Halophila decipiens* Ostenfeld and *Halodule* sp. Due to the low relevance of ‘marine planted aquariums’ compared to ‘mini reef systems’ little attention has been paid to the exploitation of those resources, with exception of Ibama (2008a), which briefly mentioned the usage of macrophytes and *Lithothamnium* spp. in Brazilian aquarium trade.

The wide variety of native species inventoried in the present work demonstrates that Brazil is following the global trend of keeping diversified marine life in aquaria, which have caused increasing concern about the sustainability of reef ecosystems’ exploitation (Wabnitz et al. 2003, LeGore et al. 2005, Calado 2006, LeGore et al 2008, Smith et al. 2010, Murray et al. 2012, Reynoso et al. 2012, Rhyne et al. 2012b).

The indiscriminate removal of pomacanthids (a true ‘keystone guild’) from reef ecosystems, for instance, might have serious negative reflexes (e.g. excessive sponge growth and less juveniles serving as ‘cleaners’) on community structure and these impacts caused to the reef might be greater than their abundance suggest (Gasparini et al. 2005). Similarly to other fish kept in aquaria, such as surgeonfish (mainly living



plant consumers) and parrotfish (primarily detrital aggregates feeders), angelfish perform vital ecological roles in coral reef trophodynamics (e.g. controlling sponge and tunicate densities) (Hourigan et al. 1989, Hill 1998, Sazima et al. 1999, Andréa et al. 2007, Konow & Bellwood 2011, Batista et al. 2012, Reis et al. 2012) and, thus, their overexploitation and inter-specific relationships had also being object of concern (Hill 1998, Comeros-Raynal et al. 2012). Nevertheless, the potential impact of fisheries targeting aquarium reef fish in Brazil is difficult to be evaluated, because little is known about the distribution of this type of fishing effort throughout the country and the actual level of threat to reef fish is hard to be assessed (Floeter et al. 2006).

Invertebrate grazers are also being collected at an increasingly rapid pace, mostly to control algal growth in home aquaria, but, as they play a corresponding role in the wild, their removal may strongly impact their native reefs (Rhyne et al. 2009). On healthy reefs, for instance, both the establishment and the survival of corals depend on high rates of herbivory to suppress macroalgae and reduce competition with cnidarians (Bonaldo & Hay, 2014).

Another interspecific association, the cleaning activity, may be negatively affected by continuous harvesting of fish and shrimps, intensified by the high turnover in ornamental trade, since specialized cleaners generally have a short life in aquariums due to their distinctive feeding habits (Gasparini et al. 2005). Hence, since the influence of the species abundance on cleaning interactions is modulated by the trophic habits and social behavior of the interacting species, the removal of a single cleaner species from a reef will deeply affect the ecosystem functioning, as there seems to be little redundancy on this role when pairs of species are concerned (Floeter et al. 2007).

Not only Brazilian coral reefs but also estuaries (Nottingham et al., 2005b) and sponge reefs (Rocha et al., 2000; Andréa et al., 2007) may be affected by uncontrolled ornamental fisheries. Additionally, large endangered vertebrates can also be harmed by indiscriminate collection of invertebrates and depletion of banks of either macroalgae or macrophytes, e.g. marine turtles (*Eretmochelys imbricata* (Linnaeus, 1766) and *Chelonia mydas* (Linnaeus, 1758)), that feed on a wide variety of invertebrates or graze the substratum (Stampar et al., 2007; Goatley et al., 2012), and the Brazilian marine manatee, *Trichechus manatus* Linnaeus, 1758, whose diet is composed of seaweed and sea grass species identified here (Borges et al., 2008).

Hence, in the face of such concerning scenario, marine aquarium consumers have an important role requiring species from regulated fisheries and shipped in accordance with well-established guidelines (eco-labeled products) and Brazilian authorities must seek environment friendly measures (e.g. implementation of eco-fees to support research on marine ornamental fisheries and mariculture (Leal et al. 2015)).

Aquaculture initiatives must be incentivated, since they might considerably reduce collecting pressure over populations of targeted species (Calado et al. 2003, Pomeroy et al. 2006, Olivotto et al. 2011, Murray & Watson 2014), specially because almost the totality of the native marine aquarium organisms exploited in Brazil are wild-caught and captive breeding of native marine ornamentals is restricted to a few species (e.g. *Elacatinus figaro* and *Hippocampus reidi*) (Meirelles 2008, Hora & Joyeux 2009, Ibama 2009, Côrtes & Tsuzuki 2010). However, captive breeding shall not entirely substitute wild-caught species, because many people depend on the harvesting of aquarium species to survive (Rhyne et al. 2014).

Another way of preventing or reducing overexploitation, would be through ecosystem-based management initiatives (Tissot et al. 2010, Rhyne et al. 2014), as the creation of new marine reserves and the adequate management of the existing ones, in order to promote recovery of stocks of heavily exploited species by the aquarium trade (Friedlander 2001, Tissot et al. 2004, Tissot et al. 2009, Stevenson & Tissot 2013). Such initiatives, instead of preserving a particular species, aim not only the protection of the whole ecosystem but also assure the continuity of inter and intra-specific associations, including the safety of important spawning aggregation sites that are crucial for the survival of some aquarium traded species (Friedlander 2001, Gerhardinger et al. 2009, Comeros-Raynal et al. 2012, Feitosa et al. 2015).

In addition, IBAMA must intensify inspections driven to aquarium trade; IN Ibama 202/08 and decree MMA 445/14 must be reviewed by specialists to identify prohibited species; and educational campaigns explaining the dangers of overexploitation of marine life, involving aquarium stores, importers, wholesalers, retailers and aquarium hobbyists should be carried out.

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## Author Contributions

Lívio Moreira de Gurjão: conceived the work, obtained and analyzed the data and wrote the manuscript;

Tito Monteiro da Cruz Lotufo: contributed to analysis and interpretation and also wrote the manuscript.

## Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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