



Brazilian environmental legislation as tool to conserve marine ornamental fish



Flavia Duarte Ferraz Sampaio*, Antonio Ostrensky

Integrated Group for Aquaculture and Environmental Studies (Grupo Integrado de Aquicultura e Estudos Ambientais—GIA), Federal University of Paraná (Universidade Federal do Paraná—UFPR), Paraná, Brazil

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ABSTRACT

Legislation is considered an effective means to regulate the fishing and trade of marine ornamental fish (MOF), which is an industry with a wide range of environmental and social impacts worldwide. This study analyses Brazilian MOF legislation as a tool for conservation. Brazil's legal framework includes participation in international agreements, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), as well as administrative measures that regulate the capture of certain species in Brazil. However, compared with the laws that pertain to terrestrial fauna, Brazil's MOF legislation remains limited and possibly lacks the necessary technical and scientific foundation. There is a trend to prohibit the capture of organisms according to the criterion of "rarity". The legislation also includes the use of "positive lists", which identify which species may be caught and establish maximum individual capture and trade quotas. Nevertheless, the criteria used to determine the quotas are not established *a priori* and apparently defined without scientific rigour. In this context, it is impossible to affirm that Brazilian MOF legislation fulfils its function as an instrument for the conservation of MOF stocks.

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1. Introduction

As with other natural resources, the harvest of marine ornamental fish (MOF) for commercial purposes reflects the circumstances described as the "tragedy of the commons"; MOF are a shared renewable resource that can eventually be depleted [1]. In addition, the relatively low operating costs of MOF harvest and the outdated but still frequently held view that marine resources are inexhaustible exacerbate the situation [2,3].

The global trade in MOF is based on extractive fishing and concentrated mainly in tropical regions, particularly in countries such as Indonesia, the Philippines, Brazil, the Maldives, Vietnam, Sri Lanka and the U.S. state of Hawaii. The primary consumer markets for MOF are the U.S., Europe and Japan [4].

Most of the fish caught for ornamental purposes inhabit reefs, and their capture and trade are related to a number of environmental impacts: the decrease in the population of target species or changes in the ecological processes of natural environments [4], the introduction of exotic species [4,5], the local extinction of organisms [6] and the use of toxic substances, such as cyanide, which can cause irreversible damage to organisms and ecosystems [4,7–9].

To reconcile the market demand for MOF with the necessary minimisation of problems caused by MOF extraction, the use of

* Corresponding author. Postal address: Marechal Mallet Street, Number 400/12, Ahú, Curitiba, Paraná 80540-230, Brazil. Tel.: +55 41 32059608 (home); mobile: +55 41 92386246.

E-mail addresses: fdfsampaio@hotmail.com, flavia.sampaio@ifpr.edu.br (F. Duarte Ferraz Sampaio).

environmental management tools to manage fisheries resources is required [10–15]. Currently, the management of marine resources faces the challenge of balancing conservation with development activities in the context of uncertainty common to natural systems and the political and social pressures of civil society [16].

According to McClanahan [17], a substantial number of scientific publications claim that banning coral reef fishing would solve the environmental problems of such ecosystems because fishing is the primary cause of such problems. The author notes that the alternatives that represent less extreme forms of management are the least studied.

One attempt to minimise the impact of fishing for ornamental organisms in coral reef areas involves leasing such areas to local artisanal fishermen. This approach prevents destructive fishing, enables the management and the conservation of natural stocks and hinders the exploitation of the area by individuals who do not belong to the local community [18].

Recently, ornamental aquaculture has begun to emerge as an alternative to restrictions on the capture of wild animals and a means to reduce the impact of uncontrolled fishing on coral reefs [18–25]. However, according to Pomeroy et al. [26], the discussion on the development of aquaculture for coral reef fish species should encompass not only the environmental but also the social and economic aspects of aquaculture.

The development of aquaculture remains limited by a lack of investment throughout this new production chain. Moreover, high production costs make the activity risky for aquaculture entrepreneurs [8]. Furthermore, even if aquaculture becomes a source of MOF,

there are no guarantees that this development will contribute to the reduction of catches in natural environments [13,14] because aquaculture and fishing are fundamentally different activities.

In this context, legislation can aid the management process, and many studies describe legislation as a useful instrument for the conservation, management and trading of MOF. However, virtually no studies assess legislation's effect on the conservation of natural MOF stocks.

Tissot et al. [27] emphasise that the management and the regulation of species captured for the marine ornamental trade are insufficiently developed in most countries of origin, particularly those countries that are major suppliers, such as Indonesia and the Philippines. The authors also claim that improved law enforcement in combination with the market demand for responsible fishing practices can create incentives to improve the MOF management in the countries of origin and reduce the ecological impact of the extraction.

According to Reynoso et al. [8], despite the economic potential observed in the worldwide trade of ornamental marine organisms, another factor related to legislation is that the exporting countries typically have an inaccurate and inefficient control of the captured species and their populations. Furthermore, a lack of technical knowledge in the public employees charged with controlling the MOF fishery is common, which results in the misidentification of specimens and undue authorisations to exploit endangered species.

Chong et al. [10] assessed the risk of the extinction of fish in Malaysia and concluded that legal measures, such as the zoning of the fishing areas, controlling the mesh size of fishing nets and limiting the number of fishing licences, can help minimise the impact of overfishing.

In Palawan, a province in the Philippines, rules were created to regulate the resources that are caught alive in coral reefs, including MOF. However, researchers who evaluated the fisheries policy in the area note that the major challenge is to effectively implement the law [9,28].

Brazil has emerged as an important supplier of MOF in the world market [4], particularly fish from the Pomacanthidae family, which account for most of the MOF captured and traded [6,29]. Recently, the trade of these animals has increased in the Brazilian domestic market. However, there are no reliable data on the trade of MOF or a systematic control of MOF commercialisation in Brazil [6,29], which prevents a more accurate assessment of market size and trade volumes. Additionally, there is little information on how these animals are caught and the impact of bycatch on specific stocks, such as seahorses. Furthermore, the knowledge of traditional fishermen is not exploited in the attempts to manage these resources [30].

Floeter et al. [11] claim that there is a high biodiversity of reef organisms on the Brazilian coast; the estimated percentage of endemism among fish species ranges from 15% to 20%. According to these authors, capture pressure has had a significant negative effect on the abundance and the size of several species. Furthermore, recent discoveries of ornamental marine species [31–33] and the realisation that there are few studies in Brazil focused on the assessment of the biodiversity and the bio-ecology of endemic MOF invite us to conclude that the effects of overfishing on such resources may be severe.

The goal of the present study is to analyse Brazilian MOF legislation as a conservation tool and based on a comparative analysis with the laws of other countries to determine whether and how the legislation can be made more effective.

2. The Brazilian legal system and the role of legislation applicable to MOF

The Brazilian environmental legal system is based on the Federal Constitution (FC) and the laws that establish general

environmental norms. The system also includes administrative documents, such as the Normative Instructions (NI) and other documents, particularly those issued by the Brazilian Institute of the Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis –IBAMA) and the Ministry of Fisheries and Aquaculture (Ministério da Pesca e Aquicultura–MPA). These documents address the main topics included in the FC and the laws.

Through the General Coordination of Fisheries Resource Management, IBAMA is responsible for coordinating, supervising, regulating and guiding the execution and implementation of actions and activities related to the management of fisheries resources [34]. The MPA's duties include the organisation and maintenance of the general registry of fishing activity, the control of fishing and aquaculture health, the supervision of fishing and aquaculture activities and the granting of licences, permits and authorisations to fish for ornamental specimens [35].

The FC allows the creation of laws and environmental administrative documents at the federal, state and municipal levels with the condition that lower-ranked legislation must be more restrictive than higher-ranked regulations. The systematic analysis of how MOF are addressed by Brazilian legal experts in environmental law indicates that the fish are generally treated indirectly in chapters on fauna protection. There is a more explicit and direct concern with terrestrial than with aquatic animals [36–40].

Regarding federal laws, the Environmental Crimes Law (Law no. 9.605/98) contains articles that relate to MOF. It is prohibited to fish species that must be preserved or that are smaller than permitted, to fish using certain equipment and to fish using toxic substances (a common practice in several countries) [4,7–9]. Because of the structure of the Brazilian legal system, there are no specific federal laws that regulate MOF exploitation. The topic is addressed only in NIs.

Regarding MOF, there are three NIs [34,41,42], which were written by IBAMA between 2004 and 2008. The goal of NI 05/04 was to recognise species of fish and aquatic invertebrates that were endangered, overexploited or threatened by overexploitation. This NI was written to meet Brazil's commitments with respect to the Convention on Biological Diversity (CBD) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The document recognised the following species as endangered: *Elacatinus figaro*, *Gramma brasiliensis*, *Bodianus insularis* and *Stegastes sanctipauli*. In addition, the following species were recognised as overexploited or at risk of overexploitation: *Hippocampus erectus* and *H. reidi*. According to this NI, recovery plans should be developed for endangered species and management plans should be developed for overexploited species or those at risk of overexploitation. These plans should be coordinated by IBAMA in collaboration with the state environmental agencies, the scientific community and civil society and should be implemented within 5 years [41]. There are no other IBAMA documents that address the topic, and there are no records on the implementation of such plans to date.

NI 14/04 and NI 202/08 address essentially the same topic and list species that may be caught and the permissible quantity of captured specimens for each species. The last NI, which is still in force and which revoked the first, includes lists of species that may be imported or whose import is prohibited.

According to NI 202/08, it is possible to collect specimens from 136 MOF species native to Brazil using diving equipment, e.g., a weight belt, fins, a mask and underwater breathing equipment such as valves, cylinders and air compressors.

IBAMA displays a preference to work with positive lists (lists of species that can be caught rather than species whose capture is prohibited) because such lists prevent the capture and commercialisation of unidentified fish [43]. Nonetheless, these NIs do not

Table 1

Species of Brazilian MOF with vulnerability characteristics, NI capture prohibition status and annual harvest quotas.

Species name	Vulnerability aspect	NI 14	NI 05	NI 202	Annual quota (number of individuals)
<i>Abudeodus saxatilis</i>	a				1000
<i>Anisotremus moricandi</i>	d	X		X	
<i>Antennarius multiocellatus</i>	a; b	X		X	
<i>Antennarius striatus</i>	a; b				1000
<i>Apogon americanus</i>	d				1000
<i>Apogon planifrons</i>	a	X		X	
<i>Apogon pseudomaculatus</i>	a				1000
<i>Balistes vetula</i>	a	X		X	
<i>Bodianus pulchellus</i>	a				1000
<i>Bodianus rufus</i>	a				1000
<i>Cantherines macrocerus</i>	a				1000
<i>Cantherines pullus</i>	a				1000
<i>Canthigaster fagineiroi</i>	a; d				1000
<i>Centropyge aurontonotus</i>	a; d				1500
<i>Chaetodon ocellatus</i>	a				1000
<i>Chaetodon sedentarius</i>	a				1000
<i>Chaetodon striatus</i>	a				1000
<i>Chromis flavicauda</i>	a; d	X		X	
<i>Chromis jubauna</i>	a; d	X		X	
<i>Chromis multilineata</i>	a				1000
<i>Cyclichthys spinosus</i>	d				1000
<i>Elacatinus figaro</i>	a; d		X	X	2,000 ^a
<i>Epinephelus itajara</i>	a; b; c	X		X	
<i>Equetus lanceolatus</i>	c	X		X	
<i>Ginglymostoma cirratum</i>	a; b	X		X	
<i>Gramma brasiliensis</i>	a; d		X	X	2,000 ^a
<i>Halichoeres aff. cyanocephalus</i>	a; d				1000
<i>Halichoeres aff. maculipinna</i>	a; d				1000
<i>Halichoeres bivittatus</i>	a				1000
<i>Halichoeres brasiliensis</i>	a; d				1000
<i>Halichoeres poeyi</i>	a				1000
<i>Hippocampus aff. erectus</i>	a; b; d				250
<i>Hippocampus aff. reidi</i>	a; b; d				250
<i>Holacanthus ciliaris</i>	a				3500
<i>Holacanthus tricolor</i>	a				2000
<i>Labrisomus cricotata</i>	a; d	X		X	
<i>Labrisomus nuchipinnis</i>	a				1000
<i>Liopropoma carmabi</i>	c	X		X	
<i>Malacoctenus sp.</i>	a; d	X		X	
<i>Microphis eigenmanni</i>	a; b; d	X		X	
<i>Microspathodon chrysurus</i>	a	X		X	
<i>Narcina brasiliensis</i>	a	X		X	
<i>Ophioblennius trinitatis</i>	a; d				1000
<i>Opistognathus longurus</i>	a	X		X	
<i>Opistognathus sp. n.</i>	a; d	X		X	
<i>Parablennius marmoreus</i>	a				1000
<i>Phaeoptyx pigmentaria</i>	a				1000
<i>Pomacanthus arcuatus</i>	a				2500
<i>Pomacanthus paru</i>	a				2500
<i>Prognathodes brasiliensis</i>	d	X		X	
<i>Prognathodes guyanensis</i>	d	X		X	
<i>Prognathodes obliquus</i>	c; d	X		X	
<i>Ptereleotris randalli</i>	a; d	X		X	
<i>Rhinobatus spp.</i>	a	X		X	
<i>Scartella cf. cristata</i>	a; d	X			1000
<i>Scarus zelindae</i>	a; d				1000
<i>Sparisoma tuiupiranga</i>	a; d	X			1000
<i>Stegastes fuscus</i>	a; d				1000
<i>Stegastes pictus</i>	a; d				1000
<i>Stegastes variabilis</i>	a				1000
<i>Stygnobrotula latebricola</i>	a; c				1000
<i>Thalassoma noronhanum</i>	a; d				1000
<i>Yirrichtys novacula</i>	a				1000
<i>Zapteryx brevirostris</i>	a	X		X	

Vulnerability aspects: (a) Reproductive biology associated with increased vulnerability to extinction; (b) estuarine-dependent; (c) rare, defined as recorded in less than 10% of dives or dwelling in depths greater than 40 m in a delimited site (difficult to access by collectors) or ranging in a particular area; (d) endemic to a Brazilian province or the Brazilian coast, in addition to the southern Caribbean coast (adapted from [6]).

^a Refers to the number that was permitted by NI 14/05. However, the capture of this species is currently prohibited.

describe the criteria adopted to permit or prohibit the capture of a particular species.

Gasparini et al. [6] identified the species and vulnerability characteristics of the most collected MOF in Brazil. In Table 1, these

characteristics are compared with the catch permission lists of NI 14/04 and NI 202/08. Of the 64 species that exhibit some of these characteristics of vulnerability, 25 were prohibited by the NIs. NI 202/08 prohibits the harvest of *Elacatinus figaro* and *Gramma*

Table 2

Relationship between the criteria of species vulnerability and permission/prohibition according to NI 202/08.

Criterion of vulnerability	Permitted (%)	Prohibited (%)
Reproductive biology (a)	75	25
Estuarine-dependent (b)	0	0
Rare species (c)	0	100
Endemic species (d)	40	60
Meeting one or more criteria	55.2	44.8

brasiliensis and allows the harvest of *Scartella cristata* and *Sparisoma tuiupiranga*. Table 2 shows that there is a tendency to prohibit species whose vulnerability criterion is “rarity”. However, species that exhibit two or more vulnerability criteria or a single criterion such as “an estuarine-dependent species”, “endemism” and “vulnerability to extinction” did not seem to influence IBAMA catch prohibition.

Regarding exports of native fish from extractive fishing, NI 202/08 establishes annual quotas for each species collected by companies or fishing cooperatives. Of the 136 allowed species, only seven have quotas different from 1000 individuals/year/company. Of these seven species, the harvest of five species is allowed in larger and two species in smaller numbers. *Holacanthus ciliaris* exhibits largest quota: 3500 individuals/year/company. The second largest quota is 2500 individuals/year/company for *Pomacanthus arcuatus* and *Pomacanthus paru*. The *Holacanthus tricolour* and *Centropyge aurantonotus* quotas are 2000 and 1500 individuals/year/company, respectively. The two species with quotas below 1000 are the seahorse species *Hippocampus erectus* and *H. reidi*, which have quotas of 250 individuals/year/company.

The five species with quotas larger than 1000 individuals/year/company are among the most targeted Brazilian MOF [6,29], and the species with quotas of 250 individuals/year/company are classified as overexploited or threatened by overexploitation [41]. In the past, *Elacatinus figaro* and *Gramma brasiliensis* had annual quotas of 2000 individuals/year/company. However, their capture was prohibited in 2005 by NI 05.

NI 14/10, issued by the MPA, also addresses MOF. This NI establishes procedures and describes how to perform the risk analysis for species that are intended for import. Additionally, this document describes the MPA legal procedures with which the countries that export aquatic animals must comply [44].

Another indicator that can be used to evaluate legislation as a tool for conservation emerges from the analysis of the degree of compliance. Article 29 of the Brazilian Law on Environmental Crimes prohibits the harvest of wild animals without a licence or authorisation from the competent authority. An example of how this legislation is overlooked with respect to MOF can be observed in Guarapari City, Espírito Santo State, which is one of the primary commercial MOF fisheries in southeastern Brazil. At Castanheiras Beach, which is located in the city's centre, there is a set of tidal pools that are inhabited by several species of fish and marine invertebrates. Even at high tide, it is possible to access these pools. At this site, small hand nets are sold by street vendors, and children and adults may be commonly observed walking among the pools with their nets hunting for animals that can be captured and which are often removed from their habitat. The harvest of these organisms is a crime under federal Brazilian environmental law. However, here and elsewhere in the country, such harvest occurs freely.

3. International strategies for MOF conservation

Typically, the national MOF legislation is related to local business activities. In the case of importing countries, it is expected that the

legislation can protect the country from the introduction of pathogens and the dissemination of aquatic invasive species. Conversely, if export is the predominant activity, the legislation is expected to function as a means to conserve the natural stocks.

In the attempt to compare Brazilian legislation with the legislation of other countries, scientific papers on the topic were analysed. However, these studies only address the subject tangentially. The legislation is a secondary issue and associated in particular with themes such as trade and MOF conservation.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is one of the main international agreements to encourage the conservation of marine biodiversity [45]. However, CITES's efficacy is limited with respect to the conservation of commercialised organisms. It can issue a warning regarding a threatened organism, but it does not provide any direct mechanism to protect the organism [46,47].

Currently, in Mexico, the international trade of marine ornamental species is regulated by several government agencies. However, the system is unsatisfactory and jeopardises the achievement of measurable practical results. Furthermore, the regulatory activity does not possess an adequate legal framework, and it does not rely on institutional programmes that facilitate the generation of social and economic benefits. Thus, Reynoso et al. [8] conclude that it is necessary to reformulate Mexico's legislation while enforcing the existing rules in a process that would involve the active participation of local and national government, businesses related to the activity, fishermen and the scientific community.

In the case of Sri Lanka, several rules and regulations were designed to conserve aquatic animals and plants, particularly endemic species. National legislation seeks to prevent the introduction of non-native species and pathogens that may affect aquatic organisms. The quarantine process requires the certification of the exporter, and the duration of quarantine varies according to the health status of the fish [25].

The laws of the U.S. and Canadian border states in the Great Lakes region focus on preventing the introduction of non-native species in the region [48]. In the United Kingdom, the control of invasive species is also a matter of concern, and the role of legislation in controlling the problem has been emphasised [49].

Australian legislation imposes strict control on the import of ornamental fish, which includes pre-border health certification and a mandatory quarantine period at the border of one to three weeks [50].

A concern with preventing the introduction of invasive species appears in all of the surveyed areas (Table 3), with different approaches. However, in all areas, a licence is required to import non-native species of ornamental fish.

In Mexico, the regulation of MOF import is included in several articles of the general environmental legislation (the General Law on Environmental Protection and General Law on Ecological Balance) but not further specified. Additionally, the “National Strategy on Invasive Species in Mexico”, a technical document, describes the principles for the prevention, control and eradication of these species. The invasive species with the largest impact in protected natural areas (PNA) is the lionfish (*Pterois volitans* and *P. miles*). The lionfish, which is a popular species among aquarists, has been recorded in eight Mexican PNAs since 2009.

Australia has a list of species that may be imported, which makes it unnecessary to request a permit to import them. Among the list's permitted MOF species is the lionfish. In Brazil, the introduction of exotic species is classified as an environmental crime, and the capture for ornamental and aquarium purposes of any species that is not considered to be native to the national territory is disallowed. Similar to the Australian legislation, the Brazilian legislation allows the importation of three species of the *Pterois* genus (*P. miles*, *P. radiata* and *P. sphex*). However, Brazilian

Table 3

Summary of the primary aspects of MOF trade legislation and information sources.

Country	Type	Legislation that prevents the introduction of exotic species	Legislation that restricts the species that can be caught	Legislation that requires a quarantine period for importation	Website and access date
Mexico	Federal Legislation	X	X	X	http://www.conabio.gob.mx/ access: 27/09/12
Australia	Federal Legislation	X		X	http://www.environment.gov.au/about/legislation.html ; http://www.aqis.gov.au access: 12/10/12
United States	State Legislation (Florida)	X			http://myfwc.com/ access: 25/09/12
Brazil	Federal Legislation	X	X	X	http://www.ibama.gov.br/ access: 28/09/12 http://www.mpa.gov.br/ access: 14/12/12

law prohibits the import of *Centropyge flavissima*, *Cephalopholis argus* and *Epinephelus merra* because there is a record of invasion by these species in other countries.

The relevant legislation of the U.S. state of Florida includes a clear incentive to eliminate certain specimens from the environment. There, the harvest of lionfish (*Pterois volitans*) is permitted without a licence from the environmental agency and without capture quotas for recreational fishing. Additionally, Florida legislation requires studies to be performed to analyse the risk of introducing marine and estuarine non-native species marketed as pets.

Regarding the restrictions on native species that may be captured, Florida and Australia have lists that regulate the capture of endangered fish. However, no ornamental fish on these lists.

Mexico has a system to classify the risk categories of exploited wild species, including marine ornamental fish. According to this system, the Pr category encompasses species subjected to special protection. Within this category are the following MOF: all of the seahorse species (*Hippocampus* genus), *Chromis limbaughi*, specimens from the Pomacanthidae family (*Chaetodon falcifer*, *Holacanthus clarionensis*, *Holacanthus passer* and *Pomacanthus zonipectus*) and the *Opistognathus rosenblatti* species from the Opistognathidae family.

Australia has a list of native animals that are exempt from export regulations because the animals are products of aquaculture.

According to the Brazilian legislation, it is considered an environmental crime to catch species that should be preserved (Decree no. 6.514/08, art. 35, I). In addition to the list of the native species that may be captured, NI 202/08 dictates that the species that appear in official lists of overexploited species, species threatened by overexploitation, endangered species or species that are cited in Appendix I of CITES should be excluded from the positive list.

The final aspect evaluated concerned legislation to regulate the quarantine period for the import of MOF. In this case, Mexico and Australia have legally adopted such a measure for living aquatic organisms. Australia has a specific government service for inspection and quarantine, and in Mexico, there are rules regarding the certification of organisms that will be exported. However, there is no norm to govern how the quarantine should be performed. In addition, Florida does not have specific legislation regarding MOF quarantine.

Based on the definition adopted by IBAMA, the term "quarantine" in Brazil is used only for terrestrial wild animals. The MPA does not provide the methodological procedures that must be adopted during the import of MOF.

The information presented above confirms that Mexico and Brazil have laws that prevent the introduction of exotic species, restrict the species that can be caught and require quarantine for

import. However, these laws are not as objective and directly applicable as those of Australia and Florida.

4. Conclusion

In Brazil, the expression "dead letter" is used to refer to laws that exist but are not implemented. Brazil's MOF legislation seems to fit this category. The legal framework relating to MOF in the country is relatively wide. The framework encompasses participation in international agreements, such as CITES, requires the adoption of administrative measures to regulate species that can be caught and stipulates risk analyses on species to be imported. However, the application of this framework has been highly limited.

To remedy this situation, several recommendations must be immediately incorporated into the Brazilian legislation, whereas other recommendations must be effectively implemented using the existing rules. The most important recommendations are: (1) The determination of the species prohibited for capture in Brazil and the quotas for capture-permitted species must occur according to clear and well-established criteria that refine the legislation and enable the regular revision of the lists of species whose capture is allowed or prohibited. Such criteria should preferably be based on bio-ecological and commercial characteristics and be sufficiently robust to ensure the maintenance of natural stocks. (2) The recovery and management plans included in NI 05/04 for species that are endangered, overexploited or threatened by overexploitation must be effectively designed and widely announced. (3) Quarantine technical procedures and the procedures used in the risk analysis of the import of ornamental species, which the Brazilian legislation does not clearly explain in terms of operational methods, must be improved. (4) The adoption-of-origin certificate and the establishment of mechanisms to trace commercialised animals must be legally prescribed to identify the fishermen who and the businesses that adopt practices compatible with the conservation of stocks.

If this minimal set of recommendations is not implemented, it is impossible to say that Brazil's environmental legislation fulfils its function as a means to conserve the country's stocks of marine ornamental fish.

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