



Echinoderm harvesting in Todos-os-Santos Bay, Bahia State, Brazil: the aquarium trade

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Abstract – The ornamental marine trade has increased on a worldwide scale. Although Brazil is amongst the major exporters, data about this activity are underestimated. Therefore, the profile and consequences of such activity to the wild populations are not fully understood. In spite of being basically supported by fish collection, charismatic invertebrates also figure in this trade and virtually nothing is known about the echinoderms harvested in Brazil. Since baseline data are scarce, this study aims to provide an initial assessment on the marine aquarium echinoderm trade in Bahia State, northeastern Brazil, evaluating the landing of these animals during a ten-year period. Echinoderm landing was monitored and the trade profile was investigated from January 1996 to December 2005. The trade involved five economic segments and supplied not only the local market but other Brazilian states and countries such as Argentina. Fifteen species were commercialized and, amongst them, threatened echinoderms included in the National Red List. Fishermen usually captured them by hand but destructive methods were also used. For these reasons, studies on the dynamics of harvested populations and the development of public policies are urgently needed in order to allow the sustainability of this trade.

Additional key words: conservation, echinodermata, fisheries, Northeast Brazil.

Resumo (Coleta de equinodermos na Baía de Todos os Santos, estado da Bahia: o comércio aquariofilista) – O comércio ornamental marinho tem crescido em escala mundial. Apesar do Brasil estar entre os maiores exportadores, dados sobre esta atividade são subestimados e, portanto, seu perfil e consequências às populações não são totalmente entendidos. Ainda que seja sustentado pela coleta de peixes, invertebrados carismáticos também figuram neste comércio e praticamente não há informações sobre os equinodermos coletados no Brasil. Dada a escassez de dados, este estudo teve como objetivo prover uma avaliação inicial do comércio de equinodermos pra o aquariofilismo marinho no estado da Bahia, Nordeste do Brasil. O desembarque de equinodermos foi monitorado e o perfil do comércio investigado de Janeiro de 1996 a Dezembro de 2005. A atividade envolveu cinco segmentos econômicos e abasteceu não apenas o comércio local, mas outros estados brasileiros e países, a exemplo da Argentina. Quinze espécies foram comercializadas, entre elas, equinodermos incluídos na Lista Vermelha Nacional de organismos ameaçados. Pescadores normalmente os coletavam manualmente, no entanto, métodos destrutivos também eram utilizados. Assim, estudos sobre a dinâmica das populações coletadas e o desenvolvimento de políticas públicas que regulem esta atividade são urgentes, a fim de permitir a sustentabilidade deste comércio.

Palavras-chave adicionais: conservação, echinodermata, pesca, Nordeste.

During the last decades, the marine aquarium trade has increased in popularity and volume (Chan & Sadovy 1998; Best 2002) mostly because of the development of new technologies that allowed the rapid growth of public and domestic aquaria (Delbeek 2001), involving millions of dollars every year (Wood 2001a). In contrast to the freshwater aquarium industry, that can breed most of the ornamental species in farms, the vast majority of marine organisms sold in the aquarium trade are collected from their natural habitats (Wilson et al. 2001). Therefore, data on the capture of these species are important in elucidating possible risks and benefits of this activity (Tlustý 2002;

Micael et al. 2009).

As mentioned by Shuman et al. (2004), a successful management strategy can be designed only through detailed scientific studies on the collection area for extended periods of time. In spite of this, our concern is that this business is relatively new in Brazil and, although there are some data, they might be underestimated (Gasparini et al. 2005; Rosa et al. 2006), making difficult a possible implementation of conservation plans in the country. According to Rosa et al. (2002), this activity is not regulated or monitored systematically in northeastern Brazil and Monteiro-Neto et al. (2003) warned that conservation steps are ineffective due to the lack of baseline data.

Usually the aquarium industry is supported by fish harvesting; however, the growth of invertebrate animal collection is particularly evident (Adams et al. 2001). For

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Communicating editor: Freddy Bravo

Submitted in: 29 June 2011; online publication: 13 June 2012

instance, Echinodermata have been largely cited as target animals for the aquarium trade during the last decade (e.g., Adams et al. 2001; Shimek 2004; Gasparini et al. 2005; Calado 2006; Micael et al. 2009). This phylum is composed of five classes, three of them having different economic importance: sea cucumbers and sea urchins are cultured in aquaculture (Sloan 1985) and largely eaten worldwide, while starfish are documented as important items in the local 'zoo' craft (Alves et al. 2006) and used in 'candomblé' rituals – an Afro-Brazilian religion (Alves & Cerqueira 2000).

Bahia State is one of the major suppliers of ornamental marine organisms in Brazil (Sampaio & Rosa 2003; Rosa et al. 2006) and Todos-os-Santos Bay, the second-largest Brazilian bay (Cirano & Lessa 2007), represents an important collection area (Gasparini et al. 2005; Rosa et al. 2006). In this regard, this study aims to provide an initial assessment on the marine aquarium echinoderm trade in Bahia State, northeastern Brazil, by: 1- describing the profile of the fishermen, their collecting sites and methods; 2- providing information on segments of the trade; 3- identifying the targeted species and quantifying the amount of specimens collected during a ten-year period.

MATERIAL AND METHODS

Records of daily landings of ornamental echinoderms (January/1996–December/2005) were obtained from the middlemen of ornamental marine organisms in Bahia State, NE Brazil. Sixty-one fishermen were monitored: 24 collected during ten years and 37 collected sporadically. However, since the middlemen established the amount of collected specimens depending on the market demand, the number of fishermen had no influence over the amount of collected specimens. The monitoring was constant throughout the sampled period.

After landing the biological material, the common names of collected species were registered on field sheets and the animals were quantified as well as the amount paid by the middlemen for each specimen. For correct identification of species, echinoderms were photographed during the first visits to make a reference collection with their scientific and common names. The identification was based on Smith (2005), Clark & Downey (1992), and Hendler et al. (1995).

In order to outline the socio-economic situation of the fishermen involved and trade profile, free interviews (Appendix 1) were performed with the 24 fishermen who collected during the whole period, the main middleman and owners of aquarium shops between February 2001 and October 2002. During this period, prices of specimens sold worldwide were acquired from nine online pet shops. Three criteria were applied to select them: having at least one of the targeted species for sale, providing its scientific name and a picture. The publication of these data was allowed, provided that the anonymity of those involved was preserved.

RESULTS

Habitats identified as collecting areas by the fishermen were chosen because of their richness and abundance of species. These areas comprised coastal reefs located in Todos-os-Santos Bay (Figure 1; for more details see Dutra et al. 2006 and Cruz et al. 2009), including: 1- Ilha de Maré reef; and 2- Boa Viagem reef were the main fishery grounds, followed by; 3- Salvador rocky reefs and; 4- Pinaúnas reefs. Depths of collecting sites ranged from 0.5 to 25 m.

The echinoderm trade in Bahia State is composed of five segments: fisherman, middleman, importer, hobbyist, and retailer. This trade comprises different routes (Figure 2) and supplies mainly an internal market in which the collected animals are delivered to the middlemen and then sold directly to the hobbyists or to local aquarium shops. Moreover, there is a strong commerce with other Brazilian states, especially Rio de Janeiro, São Paulo, Ceará and, to a lesser extent, Espírito Santo, and Pernambuco. The trade also supplies other countries such as Argentina, Italy, and Germany, the latter in reduced amounts. Because of the difficulty in acquiring this type of data, detailed information, such as the amount of exported specimens, was unavailable.

The questionnaires applied to the fishermen involved on this trade showed that most of them are men between 18 and



Figure 1. Map of Todos-os-Santos Bay showing the harvesting sites (shaded areas in the ocean): 1- coral reefs near Ilha dos Frades; 2- Mangueiras reef and Pedras Alvas reef; 3- coral reefs near Farol and Porto da Barra; and 4- Pinaúnas reef.

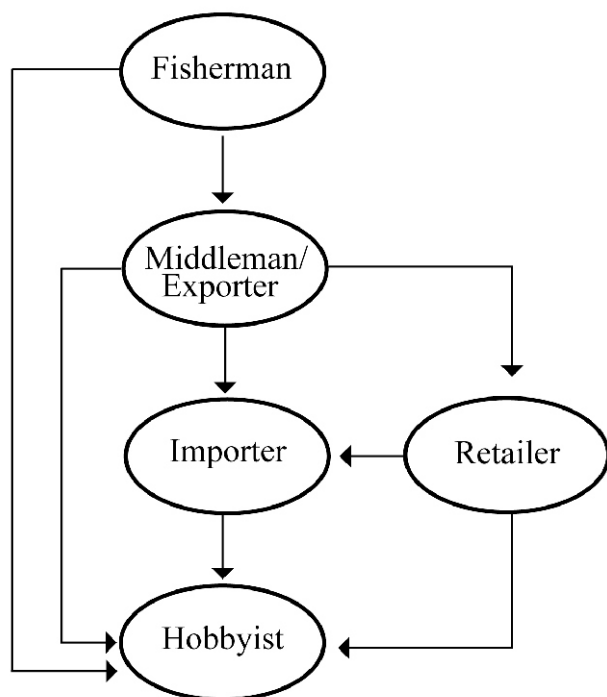


Figure 2. Diagrammatic representation of the trade routes of echinoderms collected for aquarium trade in Salvador, Bahia State, northeastern Brazil.

44 years old; only two women were registered. In addition, the most frequent education level was “Some school”; nevertheless, three undergraduate students (two of Biology and one of Fisheries Engineering) were part of the group. All interviewees affirmed that the money earned from fishery corresponded to 100% of their monthly family income. The collecting was performed by free diving (snorkeling) or using hookah gear, which is very common among fishermen, although harmful to human health. They always used diving mask, fins and weight belt, but rarely used proper safety clothing or gear such as wetsuit, gloves and knives. During the dives, they did not make any decompression stops and only few fishermen demonstrated to have some knowledge about this issue. Instead of

cyanide, the fishermen usually used “bicheiros”, which is a small, thin and flexible type of stick with a fishhook tied on the tip, in order to catch some animals fixed in the substratum or inside crevices. When captured, animals were put in plastic bags and sea water was constantly renewed during dives.

The number of organisms and species captured depended on the orders given by the middlemen. Collecting activities were performed almost every day and the only limiting factor was the weather condition. After collecting, animals were delivered to the middlemen and maintained in aquaria under very poor conditions and without food, which usually resulted in high mortality rates. According to the main middleman, animals are not fed because their faeces would worsen the water quality. After receiving the animals, middlemen would distribute them directly to hobbyists (to a limited extent), to a retailer or export them (Table 1).

A total of 37,066 specimens of 15 different species were commercialized during the analyzed period (Table 1). The most collected classes were Asteroidea and Ophiuroidea, and *Echinaster* spp. and *Ophioderma* spp. corresponded to 33.99% and 37.66% of the total collected species, respectively. *Echinaster (Othilia) echinophorus* and *Echinaster (Othilia) guyanensis* were considered herein as *Echinaster* spp. once fishermen could not distinguish these two species taxonomically, naming both as red or orange starfish. The same occurred with *Ophioderma* spp., since both *Ophioderma cinerea* and *Ophioderma appressa* are species registered for Salvador coast (Magalhães et al. 2005).

The number of collected specimens of the most representative species of the ornamental trade is represented in Figure 3. Variations in this number may be related to the demand of the ornamental trade and not necessarily to population reduction.

Free interviews showed that approximately 80% of the hobbyists were worried about the origin of the organisms they buy, and they would be willing to pay more if a conservation measure, such as a certification program, was implemented. Most interviewees think that a program like

Table 1. Species collected between January 1996 and December 2005, their respective common names in Brazil, the total number of organisms gathered with their relative abundance, prices (in US\$) paid to the fisherman by middlemen, to the middleman by retailers, to the middleman by hobbyists and prices charged by retailers and online pet shops worldwide. * Online retailers (source: pet shops).

Classes	Species	Common name	Total collected	% species	Fisherman	Middleman	Retailer	Other Countries *
Asteroidea	<i>Echinaster echinophorus</i> (Lamarck, 1816)	red or orange starfish	13,857	37.38	US\$ 0.05–0.10	US\$ 1.00	US\$ 2.75	US\$ 1.50–2.00
	<i>Echinaster guyanensis</i> A.M. Clark, 1987				US\$ 0.05–0.10	US\$ 1.00	US\$ 2.75	US\$ 1.50–2.00
	<i>Linckia guildingii</i> Gray, 1840	linckia starfish	437	1.18	US\$ 0.05–0.10	US\$ 1.00	US\$ 2.75	US\$ 1.50–2.00
	<i>Oreaster reticulatus</i> (Linnaeus, 1758)	imperial starfish	142	0.38	US\$ 0.15–0.25	-	-	US\$ 10.00
Crinoidea	<i>Tropometra carinata</i> Lamarck, 1816	sea lily	1,708	4.61	US\$ 0.10–0.20	-	US\$ 1.50	-
	<i>Astropyga magnifica</i> A.H. Clark, 1934	king urchin	226	0.61	US\$ 0.50–1.00	-	US\$ 6.00	-
Echinoidea	<i>Echinometra lucunter</i> (Linnaeus, 1758)	black urchin	1,302	3.51	US\$ 0.05–0.10	US\$ 0.75	US\$ 1.00	US\$ 1.75
	<i>Eucidaris tribuloides</i> (Lamarck, 1816)	satellite urchin	441	1.19	US\$ 0.05–0.10	US\$ 0.75	US\$ 1.00	US\$ 1.75
	<i>Lytechinus variegatus</i> (Lamarck, 1816)	green/purple urchin	2,296	6.19	US\$ 0.05–0.10	US\$ 0.75	US\$ 1.00	US\$ 1.75
	<i>Triploneustes ventricosus</i> (Lamarck, 1816)	white urchin	11	0.03	US\$ 0.10–0.25	US\$ 0.75	US\$ 1.75	-
Holothuroidea	<i>Holothuria grisea</i> Selenka, 1867	sea cucumber	1,269	3.42	US\$ 0.05–0.10	-	US\$ 0.75	US\$ 13.99
Ophiuroidea	<i>Ophiocoma echinata</i> (Lamarck, 1816)	furry brittlestar	192	5.18	US\$ 0.05–0.10	US\$ 1.00	US\$ 1.50	US\$ 1.50–2.00
	<i>Ophiocoma wendtii</i> Müller & Troschel, 1842	red brittlestar	183	0.49	US\$ 0.30	US\$ 1.00	US\$ 1.75	US\$ 1.50–2.00
	<i>Ophioderma appressa</i> (Say, 1825)	brittlestar	13,274	35.81	US\$ 0.05–0.10	US\$ 0.60	US\$ 0.60	US\$ 1.50–2.00
	<i>Ophioderma cinerea</i> Müller & Troschel, 1842				US\$ 0.05–0.10	US\$ 0.60	US\$ 0.60	US\$ 1.50–2.00
			37,066	100.00				

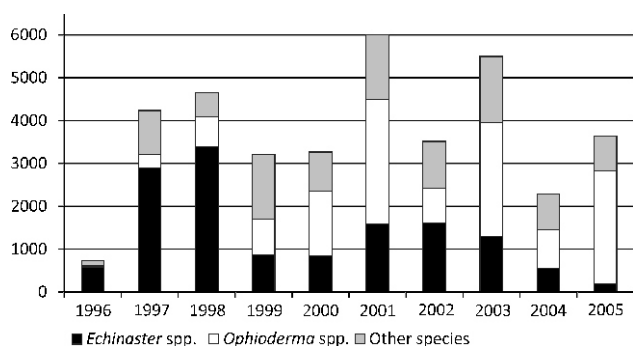


Figure 3. Total number of *Echinaster* sp., *Ophioderma* sp., and other echinoderms collected from January 1996 to December 2005.

that would be interesting, but fear it could be bad managed because of political issues.

DISCUSSION

The reefs presented in the collecting sites were structured by hermatypic corals and shipwrecks (for further details, see Dutra et al. 2006 and Cruz et al. 2009), and are considered as Areas of Environmental Protection. Accordingly, studies have shown that these reefs have been disturbed over the years due to anthropogenic activities (Dutra et al. 2006; Leão et al. 2008; Cruz et al. 2009; Kikuchi et al. 2010), including the over-exploitation of reef organisms, which is amongst the five major environmental impacts on Brazilian coral reefs (Leão et al. 2003). For instance, echinoderms play a major role in coral-reef communities, influencing their structure and function through several trophic levels (Birkeland 1989). Although fishermen in the studied area use typically artisanal material during collecting, Kolm & Berglund (2003) showed that even non-destructive methods can bring negative effects to the organisms. Therefore, the setting up of a more effective monitoring program in the collecting sites is of utmost importance, considering that loss of habitat is the most serious threat to marine biodiversity (Gray 1997).

The trade described herein generates income for many families that have the fishery as the only source of livelihood, which, according to Watson & Moreau (2006), is very common in tropical areas where income-earning activities are limited and natural resources are abundant. In addition, the amount paid to fishermen by middlemen in the beginning of this study has suffered no change until 2005, ten years later, showing the subordination of the former.

A considerable difference between the amount received by fishermen and the price retailed in aquarium shops was observed. A fisherman sold a single ophiuroid for about US\$ 0.05–0.10 to the middleman, but the same echinoderm was resold for US\$ 2.00 by retailers (an increase of 2000%). In negotiations involving the imperial starfish the difference was even higher: fishermen received US\$ 0.15, when retailers gained US\$ 10.00 from a hobbyist. Looking for a better profit other trade routes were also available. For instance, an option adopted by some fishermen was to sell directly to hobbyists. Although it was risky because of the

surveillance of the middlemen, they earned more money.

Seven of the ten most collected species in Brazil were observed in the present study: *Echinaster* (*O.*) *echinophorus*, *Echinaster* (*O.*) *guyanensis*, *Oreaster reticulatus*, *Linckia guildingii*, *Echinometra lucunter*, *Eucidaris tribuloides*, and *Tripneustes ventricosus* (see Gasparini et al. 2005 for detailed list). The value attributed to each species depended on its popularity among hobbyists, as well as its abundance in the environment. Thus, the most abundant species had lower value than the rare ones, indicating that the latter were more vulnerable to over-collecting.

Apparently, the targeted echinoderm populations do not present any sign of decline whatsoever. Nevertheless, it is not possible to affirm if the selective fishery could provoke a drastic decrease in their density, since the structure and dynamics of these populations have not yet been studied. Still, there is some concern over the increase of this activity, because four collected species [*Echinaster* (*O.*) spp., *Oreaster reticulatus*, and *Eucidaris tribuloides*] are included in the National Brazilian List of Endangered Aquatic Invertebrates and Fishes (MMA 2009). Records of elderly local fishermen suggest that *Oreaster reticulatus* was abundant in sandy bottoms and reef environments located nearby.

In addition to their importance to the marine ecosystem, species of the genus *Echinaster* are widely used in the local folk medicine (Costa-Neto 1999). Moreover, Micael et al. (2009) highlighted that echinoderm collecting for commercial use have put them under threat, especially because of their restricted distribution, suggesting the compilation of ecological data to better understand the severity of their exploitation, and then prevent them from local extinction (Hawkins et al. 2000).

As we have already mentioned, the economic importance of the phylum Echinodermata is focused on sea cucumbers, sea urchins, and starfish. Although their uses are varied, their collecting for the aquarium industry has not been fairly explored. Sea lilies and ophiuroids (brittle stars), however, are registered herein as having ornamental potential for the first time. For instance, although they do not have attractive features, specimens of *Ophioderma* were the echinoderms most commercialized in this trade. Besides being fairly abundant in the area, they are omnivorous and known as aquarium cleaners, responsible for eating algae and scavenging on detritus (Sprung 2001), playing a major role in marine aquarium maintenance.

As highlighted by Hadel et al. (1999), the use and exploitation of an organism should be the object of a specific legislation, especially if its economic potential is not totally known. Since Bahia State is one of the most important suppliers of marine ornamental organisms in Brazil, it is paramount to study the dynamics of the most collected echinoderm species in order to develop conservative measures to manage them. The national environment agency IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) has some legislations to protect the wild animals (MMA 2009) and also published a book entitled “Livro Vermelho da Fauna

Brasileira Ameaçada de Extinção” (Red Book of the Brazilian Threatened Fauna), which contains all threatened Brazilian organisms classified according to their conservation status (e.g., critically endangered, endangered, threatened, vulnerable). Beyond that, all the ornamental trade practiced in Brazil, including exports, is legal and monitored by IBAMA; however, there is not a policy that manages and controls effectively the collecting. To overcome this issue, meetings involving experts, researchers, traders, and collectors are expected to extend the discussions of the permitted species, number of licenses, and specimens sold per year.

Several suggestions in order to minimize the impact on the coral reefs and their associated species have been made, such as the maintenance of marine organisms in aquaria and the construction of artificial reefs (Gatenõ et al. 1998; Wilson et al. 2001), the establishment of no take zones and/or closed seasons, the protection of rare and key stone species with poor survivability in captivity (e.g., *Oreaster reticulatus*, *Astropyga magnifica*, and *Tropiometra carinata*), the creation of certified fishermen and wholesalers, and the implementation of the use of suitable gear and collecting methods (Wood 2001b). Popular appeal could also be a good opportunity to raise public awareness about the environmental problems related to this activity (Andrews 1990). In this regard, domestic and public marine aquaria would be very useful for educational purposes (Wabnitz et al. 2003). By allowing people to discover the mysteries and complexities of the oceans, and appreciate the beauty of reefs and animals, the government would bring about their understanding in conserving this environment and have respect and responsibility for it.

Another alternative to reach a better surveillance and control of the trade presented herein could be a program of

certification, which would prevent impacts resulted from harmful collecting and inadequate transportation of the organisms. According to Shuman et al. (2004), many of the certification criteria are simple and should reduce mortality of the organisms, besides reducing or eliminating secondary impacts associated with fishing practices.

However, for a certification program to work in a developing country, it is necessary to take some coordinated actions, such as the development of: 1- an awareness program, which would focus on the importance of the coral reefs and their associated organisms, involving all the segments of the trade; 2- incentive programs to support the basic research, so the ecology of the exploited populations would be understood, and then targets could be set to effectively warranty the sustainability of the trade; and 3- the creation of associations to support the fishermen, providing knowledge on the diving techniques as well as fair payment, which could reflect on their environmental care. Without following these actions and without the commitment of all sectors of this trade, it would be difficult to implement a program and accomplish useful results.

ACKNOWLEDGEMENTS

We are grateful to all people that cooperated with this research and Rafael Moura who edited the map. Special thanks to Drs Angela Zanata and Francisco Barros for helpful suggestions and translation assistance. C.L.S.S. and I.L.R. are grateful for the support provided by the Programa de Pós-graduação em Zoologia – UFPB. Special thanks are due to the fishermen and traders (particularly Samuelle Clerici and Bernardo Linhares) who kindly provided information.

REFERENCES

- Adams, C.M.; Larkin, S.L. & Lee D.J. 2001. Volume and value of marine ornamentals collected in Florida, 1990–98. *Aquarium Science and Conservation* 3: 25–36.
- Alves, M.S.; Silva, M.A.; Melo-Jr, M.; Paranguá, M.N. & Pinto, S.L. 2006. Zooartesanato comercializado em Recife, Pernambuco, Brasil. *Revista Brasileira de Zociências* 8(2): 99–109.
- Alves, O.F.S. & Cerqueira, W.R.P. 2000. Echinodermata das praias de Salvador (Bahia, Brasil). *Revista Brasileira de Zoologia* 17(2): 543–553.
- Andrews, C. 1990. The ornamental fish trade and fish conservation. *Journal of Fish Biology* 37: 53–59.
- Best, B.A. 2002. Coral reef in crisis: trade in coral reef animals and products. *Tropical Coasts* 9(2): 4–11.
- Birkeland, C. 1989. The influence of echinoderms on coral-reef communities. In: B.F. Keegan & B.D.S. O'Connor (eds), *Echinoderm Studies*. Vol. 3. Balkema, Rotterdam, p. 1–79.
- Calado, R. 2006. Marine ornamental species from European waters: a valuable overlooked resource or a future threat for the conservation of marine ecosystems? *Scientia Marina* 70(3): 389–398.
- Chan, T.T.C. & Sadovy, Y. 1998. Profile of the marine aquarium fish trade in Hong Kong. *Aquarium Science and Conservation* 2: 197–213.
- Cirano, M. & Lessa, G.C. 2007. Oceanographic characteristics of Baía de Todos os Santos, Brazil. *Revista Brasileira de Geofísica* 25(4): 363–387.
- Clark, A.M. & Downey, M.E. 1992. *Starfishes of the Atlantic*. Chapman and Hall, London.
- Costa-Neto, E.M. 1999. Healing with animals in Feira de Santana City, Bahia, Brazil. *Journal of Ethnopharmacology* 65: 225–230.
- Cruz, I.C.S.; Kikuchi, R.K.P. & Leão, Z.M.A.N. 2009. Caracterização dos recifes de corais da Unidade de Conservação Baía de Todos os Santos para fins de manejo, Bahia, Brasil. *Gerenciamento Costeiro Integrado* 9: 16–36.
- Delbeek, J.C. 2001. Coral farming: past, present and future trends. *Aquarium Science and Conservation* 3: 171–181.
- Dutra, L.X.C.; Kikuchi, R.K.P. & Leão, Z.M.A.N. 2006. Todos os Santos Bay coral reefs, Eastern Brazil, revisited after 40 years. In: Y. Suzuki, T. Nakamori, M. Hidaka, H. Kayanne, B.E. Casareto, K. Nadaoka, H. Yamano & M. Tsuchiya (eds), *Proceedings of the 10th International Coral Reef Symposium*, Okinawa, p. 1090–1095.
- Gasparini, J.L.; Floeter, S.R.; Ferreira, C.E.L. & Sazima I. 2005. Marine ornamental trade in Brazil. *Biodiversity and Conservation* 14: 2883–2899.
- Gateño, D.; Barki, Y. & Rinkevich, B. 1998. Aquarium

- maintenance of reef octocorals raised from field collected larvae. *Aquarium Sciences and Conservation* 2: 227–236.
- Gray, J.S.** 1997. Marine Biodiversity: patterns, threats and conservation needs. *Biodiversity and Conservation* 6: 153–175.
- Hadel, V.F.; Monteiro, A.M.G.; Ditadi, A.S.F.; Tiago, C.G.; Tommasi, L.R.** 1999. Filo Echinodermata. In: A.E. Migotto & C.G. Tiago (eds), *Biodiversidade do Estado de São Paulo, Brasil*. São Paulo, p. 260–271.
- Hawkins, J.P.; Roberts, C.M & Clark, V.** 2000. The threatened status of restricted-range coral reef fish species. *Animal Conservation* 3: 81–88.
- Hendler, G.; Miller, J.E.; Pawson, D.L. & Kier, P.M.** 1995. *Sea Stars, Sea Urchins, and Alliens: echinoderms of Florida and the Caribbean*. Smithsonian Institution Press, Washington DC.
- Kikuchi, R.K.P.; Leão, Z.M.A.N. & Oliveira, M.D.M.** 2010. Conservation status and spatial patterns of AGRRA vitality indices in southwestern Atlantic reefs. *Revista de Biologia Tropical* 58: 1–31.
- Kolm, N. & Berglund, A.** 2003. Wild populations of a reef fish suffer from the “nondestructive” aquarium trade fishery. *Conservation Biology* 17(3): 910–914.
- Leão, Z.M.A.N.; Kikuchi, R.K.P. & Testa, V.** 2003. Corals and coral reefs of Brazil. In: J. Cortés (org.), *Latin American Coral Reefs*. Elsevier Science, Amsterdam, p. 9–52.
- Leão, Z.M.A.N.; Kikuchi, R.K.P. & Oliveira, M.D.M.** 2008. Branqueamento de corais nos recifes da Bahia e sua relação com eventos de anomalias térmicas nas águas superficiais do oceano. *Biota Neotropica* 8: 69–82.
- Magalhães, W.F.; Martins, L.R. & Alves, O.F.S.** 2005. Inventário dos Echinodermata do estado da Bahia. *Brazilian Journal of Aquatic Science and Technology* 9: 59–63.
- Micael, J.; Alves, M.J.; Costa, A.C. & Jones, M.B.** 2009. Exploitation and conservation of echinoderms. *Oceanography and Marine Biology: Annual Review* 47: 191–208.
- MMA** 2009. *Ministério do Meio Ambiente*. Available at <http://www.mma.gov.br/port/sbf/fauna/index.html>; accessed at 5 Oct. 2009.
- Monteiro-Neto, C.; Cunha, F.E.A.; Nottingham, M.C.; Araújo, M.E.; Rosa, I.L. & Barros, G.M.L.** 2003. Analysis of the marine ornamental fish trade at Ceará State, Northeast Brazil. *Biodiversity and Conservation* 12: 1287–1295.
- Rosa, I.L.; Sampaio, C.L.S. & Dias, T.** 2002. Peixes ornamentais marinhos. In: *Revista Eletrônica Aqu@*. Available at <http://www.aqua.brz.com.br>; accessed at 23 Jun. 2004.
- Rosa, I.L.; Sampaio, C.L.S. & Barros, A.T.** 2006. Collaborative monitoring of the ornamental trade of seahorses and pipefishes (Teleostei: Syngnathidae) in Brazil: Bahia State as a case study. *Neotropical Ichthyology* 4(2): 247–252.
- Sampaio, C.L.S. & Rosa, I.L.** 2003. Comércio de peixes ornamentais marinhos na Bahia: passado, presente e futuro. *Boletim da Sociedade Brasileira de Ictiologia* 71: 3–6.
- Shimek, R.L.** 2004. Echinoderms in aquaria. In: *Reefkeeping*. Available at <http://www.reefkeeping.com/issues/2004-12/rs/index.php>; accessed at 27 Feb. 2005.
- Shuman, C.S.; Hodgson, G. & Ambrose, R.F.** 2004. Managing the marine aquarium trade: is eco-certification the answer? *Environmental Conservation* 31: 339–348.
- Sloan, N.A.** 1985. Echinoderm fisheries of the world: a review. In: B.F. Keegan & B.D.S. O'Connor (eds), *Proceedings of the 5th International Echinoderm Conference*, Galway, p. 129–124.
- Smith, A.B.** 2005. *The Echinoid Directory*. Available at <http://www.nhm.ac.uk/research-curation/projects/echinoid-directory/index>; accessed at 5 Oct. 2009
- Sprung, J.** 2001. *Invertebrate: a quick reference guide* (Oceanographic Series). Ricordea Publishing, Miami.
- Thlusty, M.** 2002. The benefits and risks of aquacultural production for the aquarium trade. *Aquaculture* 205: 203–219.
- Wabnitz, C.; Taylor, M.; Green, E. & Razak, T.** 2003. *From Ocean to Aquarium: the global trade in marine ornamental species*. UNEP-WCMC, Cambridge.
- Watson, I. & Moreau, M.-A.** 2006. The ornamental fish trade in support of livelihoods. *OFI Journal* 50: 20–23.
- Wilson, J.; Osenberg, C.W.; Mary, C.M.S.T.; Watson, C.A. & Lindberg, W.J.** 2001. Artificial reefs, the attraction-production issue, and density dependence in marine ornamental fishes. *Aquarium Science and Conservation* 3: 95–105.
- Wood, E.M.** 2001a. *Collection of Coral Reef Fish for Aquaria: global trade, conservation issues and management strategies*. Marine Conservation Society, Ross on Wye.
- Wood, E.M.** 2001b. Global advances in conservation and management of marine ornamental resources. *Aquarium Sciences and Conservation* 3: 65–77.

Appendix 1. Variables collected from each questionnaire included in our analysis, and details of data classification.

FISHERMEN		
Questions	Description	Data classification
Gender	Male / Female	Categorical
Age	Fishermen's ages	Text
Education level	None / Some school / High School degree/ Some college / Bachelor degree	Categorical
Income	Is the trade the only source of income?	Yes/No
Periodicity of collection	Daily / Weekly / Monthly / Other	Categorical
Type of diving	Snorkelling / Scuba / Hookah gear / Other	Categorical
Diving equipment	Proper diving equipment used.	Text
Safety measures	Any safety measure employed while diving?	Text
Tools/Chemicals	Material used to make easier the collect of specimens.	Text
Target species	How did they choose the target species?	Text
Collecting procedures	Measures taken to keep the specimens alive.	Text
Destination of collection	Middleman / Hobbyist / Store / Other	Categorical
Value of each species	How much did they cost and why?	Text

MIDDLEMEN		
Questions	Description	Data classification
Value of each species	How much did they cost and why?	Text
Target species	How did they choose the target species?	Text
Animal care	In what conditions did they maintain the specimens?	Text
Distribution	Destination of specimens.	Text

RETAILER		
Questions	Description	Data classification
Preferred species	Which species are mostly bought?	Text
Value of each species	How much did they cost?	Text
National sale	Are they sold to other national stores?	Yes/No
Brazilian states involved	Which states are involved on this trade?	Text
International sale	Are they exported?	Yes/No
Countries involved	Which countries are involved on this trade?	Text