

Marine ornamental species from European waters: a valuable overlooked resource or a future threat for the conservation of marine ecosystems?

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SUMMARY: The worldwide growth of the marine aquarium market has contributed to the degradation of coral reef ecosystems. Enforcing the legislation on importing ornamental species has led some European traders to concentrate on local species. Portugal is used as a case study of marine ornamental fish and invertebrate collection in European waters. One hundred and seventy two species occurring in Portuguese waters (mainland, the Azores and Madeira archipelagos) were considered as potential targets for the marine aquarium industry, some of which are already traded on a regular basis (e.g. *Clibanarius erythropus*, *Lysmata seticaudata*, *Cerithium vulgatum*, *Hinia reticulata* and *Ophioderma longicauda*). To ensure appropriate management and conservation of these resources, the following options have been evaluated: banning the harvest and trade of all marine ornamental species from European waters; creating sanctuaries and “no take zones”; issuing collection permits; creating certified wholesalers; implementing the use of suitable gear and collecting methods; setting minimum and maximum size limits; establishing species-based quotas; protecting rare, or “key stone” species and organisms with poor survivability in captivity; establishing closed seasons; culturing ornamental organisms; and creating an “eco-fee” to support research and management. Establishing this sustainable alternative fishery may help minimise the economical and social impacts caused by the crash of important food fisheries in Portugal and other European and West African countries.

Keywords: marine ornamentals, aquarium trade, marine conservation, marine resources, management, alternative fisheries.

RESUMEN: ESPECIES MARINAS ORNAMENTALES DE AGUAS EUROPEAS: ¿UN RECURSO VALIOSO PASADO POR ALTO O UNA AMENAZA FUTURA PARA LA CONSERVACIÓN DE ECOSISTEMAS MARINOS? – El crecimiento a nivel mundial del comercio para acuarios marinos ha contribuido a la degradación de ecosistemas de arrecifes de coral. La aplicación de la legislación referente a importaciones de especies ornamentales ha inducido a algunos comerciantes europeos a concentrarse en especies locales. Portugal se utiliza como caso específico para la recolección de peces e invertebrados marinos en aguas europeas. Un total de 172 especies presentes en aguas portuguesas (península, Azores y Madeira) se consideran objetivos potenciales para la industria de acuarios marinos, siendo algunas de ellas ya el objeto de un comercio regular (p.e. *Clibanarius erythropus*, *Lysmata seticaudata*, *Cerithium vulgatum*, *Hinia reticulata* y *Ophioderma longicauda*). A fin de asegurar la correcta gestión y conservación de estos recursos, las siguientes opciones fueron evaluadas: prohibición de la recolección y comercio de todas las especies marinas ornamentales de aguas europeas; creación de santuarios y zonas de veda; emisión de permisos de recolección; provisión de certificados acreditados a mayoristas; implementación del uso de artes y métodos de recolección adecuados; establecimiento de límites de tallas máximas y mínimas; establecimiento de cuotas para cada especie; protección de especies raras, especies claves y de organismos con débil supervivencia en cautividad; establecimiento de vedas estacionales; cultivo de organismos ornamentales; y creación de una eco-tasa para potenciar la investigación y la gestión. El establecimiento de esta alternativa pesquera sostenible puede ayudar a minimizar el impacto social y económico causado por el colapso de importantes pesquerías en Portugal y otros países europeos y de África occidental.

Palabras clave: especies marinas ornamentales, conservación marina, recursos marinos, gestión, pesquerías alternativas.

INTRODUCTION

The increase in coastal development in reef areas, the practice of coral dredging for construction purposes, dynamite fishing, global environmental changes and other impacts have led coral reefs to crisis state (Bryant *et al.*, 1998). These complex and fragile ecosystems have been the main suppliers of tropical marine ornamentals for a long time (Wood, 1985; Wabnitz *et al.*, 2003). Unfortunately, the worldwide growth in the trade of these highly priced species for the aquarium market has also contributed to the degradation of these habitats. As usually happens when any natural resource is exploited, countries involved in this billion-dollar industry are now facing several problems (Olivier, 2003). Some of the most concerning are the over-harvesting of ornamental species, the ecological changes induced by ornamental collection, and a general degradation of reefs due to the use of unsuitable collection gears and poisoning by cyanide (Wood, 2001; Wabnitz *et al.*, 2003). The increasing global awareness of the negative impacts of collecting ornamental species has led collectors, traders, researchers and hobbyists to evaluate sustainable solutions for these important fisheries. Certainly, one of the solutions would be to ban the collection of ornamental species completely. However, collecting these species is an important income source for most exporting countries (e.g. Daw *et al.*, 2001), and the economical and social impacts of complete banning would certainly be disastrous. Nevertheless, creating protective reserve areas where ornamental collection is prohibited has proven to be a highly effective strategy for managing these resources (Friedlander, 2001). Using acceptable collecting methods and gears has also ensured minimal damage both to stock and habitat and reduced post-harvest losses. In addition to these measures, establishing size limits for certain species and species-based quotas, protecting “key-stone” species, introducing closed seasons and limiting the number of collectors have also proven to be appropriate management strategies (Wood, 2001). An alternative approach to using wild reef organisms is the aquaculture of ornamental species. However, with only about 5 to 10% of the marine species available in the aquarium market produced in captivity, this approach is still far from ensuring that the increasing demand for marine ornamental organisms can be exclusively fulfilled with specimens raised in captivity (Chapman *et al.*, 1997; Tlusty, 2002).

An important step for protecting reef habitats is tighter control of importation of ornamental species by some of the major importing countries – the USA and EU countries. Although in EU countries this control has been mainly focused on CITES listed species (namely stony corals and giant clams) (Bruckner, 2001), the increased enforcement of the legislation on importing ornamental species has led some traders to reconsider their market policies. In Portugal, the main consequence of this law enforcement has been an attempt by marine ornamental traders to concentrate on local species. It is already common to find the hermit crab *Clibanarius erythropus* (Latreille, 1818), the Monaco shrimp *Lysmata seticaudata* (Risso, 1816), the cerith snail *Cerithium vulgatum* Bruguiere, 1789, the nassa snail *Hinia reticulata* (Linnaeus, 1758) and the serpent star *Ophioderma longicauda* (Retzius, 1805) for sale in Portuguese aquarium stores.

The main criteria marine species from warm temperate and subtropical waters should fulfil to achieve “ornamental” status is the ability to tolerate tropical aquarium temperatures (ranging from 26 to 30°C), be “hardy”, display a striking coloration and be “reef-safe” (not harming other inhabitants of the reef aquarium) (Calado *et al.*, 2003a). However, if a certain species only lacks the coloration requirement but displays a unique appearance (such as mimetic species), or performs a specific function in the reef aquarium (such as eating algae or “nuisance organisms”) it may also be reasonably targeted by the ornamental industry.

Despite the existence of strict European legislation on food fisheries, the capture and trade of ornamental species in European waters has never been addressed. This lack of legislation, associated with the high market prices marine ornamental species can attain, may lead to unsustainable use of these new and valuable resources, further impairing the conservation of marine habitats.

The objective of this work is to use the Portuguese situation as a case study, by presenting a list of invertebrate and fish species occurring in Portuguese waters that may be potential target species for the marine ornamental industry and suggesting management and conservation measures.

MATERIALS AND METHODS

The members of genera or families of the most heavily traded invertebrate groups and fishes

described by Fosså and Nielsen (2000), Michael (2001) and Sprung (2001) occurring in Portuguese waters (Portugal mainland, the Azores and Madeira archipelagos) were evaluated as potential target species for the marine aquarium trade industry. The majority of organisms unable to stand the temperatures of tropical marine aquariums (Calado, unpublished data) were excluded from this preliminary list. However, some of the organisms unable to tolerate the warmer temperatures of reef aquariums, but superbly coloured and appealing were included in the present list. To evaluate the potential economic profitability of marine ornamental collection in Portuguese waters, average commercial values are presented based on year round surveys of the main Portuguese aquarium retail stores. Highly priced species and species inhabiting the intertidal

region, where large numbers of specimens can be easily collected, were considered to be more vulnerable to the marine ornamental trade, and the ones that should have their collection and trade most readily regulated.

RESULTS

One hundred and seventy two species occurring in Portuguese waters were considered as potential target species for the marine ornamental trade industry (Fig. 1). The 109 invertebrate species are listed in Tables 1, 2 and 3 and are mainly represented by decapod crustaceans (32 species) and molluscs (29 species). The 63 marine fish species are listed in Table 4 and are mainly represented by the families

TABLE 1. – Potential marine ornamental sponge, cnidarians and segmented worm species from Portuguese waters (A, Azores; M, Madeira; P, Portugal mainland).

Families	Species	Common name	Occurrence
Sponges			
Aplisinidae	<i>Aplysina aerophoba</i>	Golden sponge	M, P
Axinellidae	<i>Acanthella acuta</i>	Spiny sponge	P
	<i>Axinella polypoides</i>	Finger sponge	P
	<i>Axinella verrucosa</i>	Finger sponge	P
	<i>Haliclona oculata</i>	Tube sponge	P
Clathrinidae	<i>Clathrina clathrus</i>	White clathrina	P
	<i>Clathrina coriacea</i>	Yellow clathrina	M
Hymeniacionidae	<i>Hemimycale columella</i>	Crater sponge	M, P
Irciniidae	<i>Ircinia fasciculata</i>	Stinking sponge	P
	<i>Ircinia muscarum</i>	Dark stinking sponge	P
Spongiidae	<i>Spongia agaricina</i>	Elephant ear	P
Cnidarians			
Actiniidae	<i>Anemonia sulcata</i>	Snakelocks anemone	M, P
Aiptasiidae	<i>Aiptasia mutabilis</i>	Trumpet anemone	M, P
Alcyonidae	<i>Alcyonium acaule</i>	Broccoli coral	P
	<i>Alcyonium coralloides</i>	Broccoli coral	P
	<i>Alcyonium glomeratum</i>	Broccoli coral	P
	<i>Alcyonium palmatum</i>	Broccoli coral	M
Anthipatidae	<i>Antipathes subpinnata</i>	Black coral	A, M, P
Cerianthidae	<i>Cerianthus membranaceus</i>	Tube dwelling anemone	M, P
Corallimorphidae	<i>Corynactis viridis</i>	Jewel anemone	A, M, P
Dendrophylliidae	<i>Dendrophyllia ramea</i>	Tree coral	M
	<i>Leptosammia pruvoti</i>	Yellow solitary coral	P
Gerardiidae	<i>Gerardia savaglia</i>	Encrusting anemone	M
Gorgoniidae	<i>Leptogorgia ruberrima</i>	Red sea fan	P
	<i>Lophogorgia sarmentosa</i>	Yellow sea fan	M
	<i>Lophogorgia viminalis</i>	Red sea fan	M
Isophelliidae	<i>Telmatactis cricoides</i>	Club tipped anemone	M
Parazoanthidae	<i>Parazoanthus axinellae</i>	Sponge zoanthid	P
Sagartidae	<i>Actinothoe sphyrodeta</i>	Daisy anemone	M, P
Zoanthidae	<i>Palythoa canariense</i>	Canarian sea mat	M
Segmented worms			
Sabbelidae	<i>Sabella pavonina</i>	Spiral feather duster	A, M, P
	<i>Sabella spallanzanii</i>	Peacock feather duster	A, M, P
	<i>Bispira volutacornis</i>	Cluster feather duster	M
Serpulidae	<i>Filigrana</i> sp.	Hard tube duster	P
	<i>Protula tubularia</i>	Hard tube cluster duster	P
	<i>Serpula vermicularis</i>	Variable tube worm	A, M, P
Terebelidae	<i>Eupolymnia nebulosa</i>	Spaghetti worm	M, P

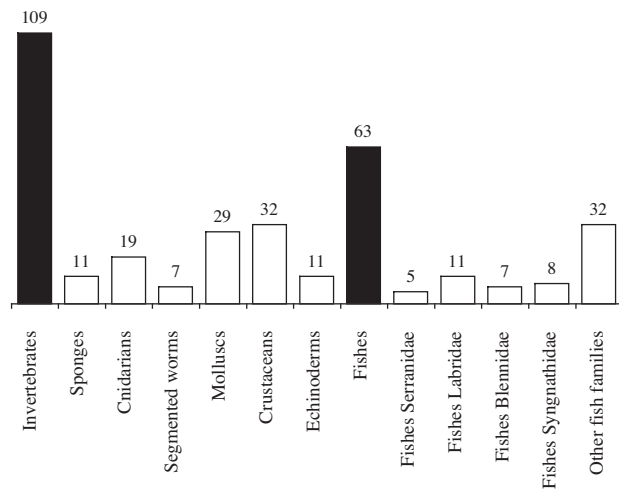


FIG. 1 – Potential marine ornamental invertebrate and fish species from Portuguese waters (Azores, Madeira and Portugal mainland).

Labridae (11 species), Syngnathidae (8 species), Blennidae (7 species) and Serranidae (5 species). Certain species, such as the members of the families Nassariidae, Cerithiidae, Columbelloidae, Fissurellidae, the crustaceans *Percnon gibbesi*, *Clibanarius erythropus* and *C. aequeabilis*, the serpent star *Ophioderma longicauda* and the blennies *Coryphoblennius galerita* and *Parablennius parvi-*

cornis, are also listed in Tables 1, 2, 3 and 4 not due to any attractive feature, but rather because they are popular members of “reef aquarium cleaning crews” (see Sprung, 2001), responsible for eating algae or “nuisance organisms” or scavenging on detritus. The estimated commercial values of selected highly priced ornamental invertebrates and fish are listed in Table 5 and 6 respectively. The species labelled as “cleaning crew” members are also listed in Tables 5 and 6 because they are generally purchased in considerable numbers by the majority of hobbyists. The invertebrate and fish species considered as most vulnerable to the ornamental trade are also summarised in Table 5 and 6 respectively. Again, “cleaning crew” members were listed because of their popularity and due to the fact that they can be easily captured in considerable numbers, either by traders or hobbyists, in intertidal regions or shallow water that is accessible with snorkelling gear.

DISCUSSION

The large number of potential target species for the marine ornamental industry occurring in

TABLE 2. – Potential marine ornamental mollusc species from Portuguese waters (A, Azores; M, Madeira; P, Portugal mainland). * See text for explanation.

Families	Species	Common name	Occurrence
Molluscs			
Cerithiidae	<i>Cerithium rupestre</i> *	Common cerith	P
	<i>Cerithium vulgatum</i> *	Cerith	M, P
Columbellidae	<i>Columbella rustica</i> *	Dove shell	A, M, P
	<i>Mitrella gervillei</i> *	Dove shell	P
	<i>Mitrella scripta</i> *	Dove shell	M, P
Cypraeidae	<i>Erosaria spurca</i>	Cowries	A, M, P
	<i>Luria lurida</i>	Cowries	M, P
	<i>Schilderia achatidea</i>	Cowries	M, P
	<i>Zonaria pyrum</i>	Cowries	P
Fissurellidae	<i>Diodora gibberula</i> *	Keyhole limpet	P
	<i>Diodora graeca</i> *	Keyhole limpet	M, P
	<i>Diodora italica</i> *	Keyhole limpet	P
Limidae	<i>Lima exilis</i>	File shell	A, P
	<i>Lima hians</i>	Hian's file shell	A, M, P
	<i>Lima lima</i>	Greater file shell	M, P
Nassariidae	<i>Hima incrassatus</i> *	Nassa snail	P
	<i>Hinia reticulata</i> *	Nassa snail	M, P
	<i>Nassarius elatus</i> *	Nassa snail	P
	<i>Nassarius nitidus</i> *	Nassa snail	M, P
	<i>Niotha denticulatus</i> *	Nassa snail	M, P
	<i>Uzita lima</i> *	Nassa snail	M, P
Octopodidae	<i>Octopus macropus</i>	White spotted octopus	A, M, P
Patellidae	<i>Helcion pellucidum</i>	Translucid limpet	P
Pinnidae	<i>Atrina pectinata</i>	Smaller pen shell	P
	<i>Pinna nobilis</i>	Greater pen shell	P
	<i>Pinna rudis</i>	Pen shell	A, M
Spondylidae	<i>Spondylus gaederopus</i>	Thorny oyster	A, M, P
Turbinidae	<i>Bolma rugosa</i> *	Star snail	A, M, P
Vermetidae	<i>Serpulorbis arenaria</i>	Worm shell	P

TABLE 3. – Potential marine ornamental crustacean and echinoderm species from Portuguese waters (A, Azores; M, Madeira; P, Portugal mainland). * See text for explanation.

Families	Species	Common name	Occurrence
Crustaceans			
Alpheidae	<i>Alpheus macrocheles</i>	Red pistol shrimp	A, P
	<i>Alpheus glaber</i>	Large pistol shrimp	P
Diogenidae	<i>Calcinus tubularis</i>	Sedentary hermit crab	A, M
	<i>Clibanarius erythropus</i> *	Hermit crab	A, P
	<i>Clibanarius aequabilis</i> *	Hermit crab	M
	<i>Paguristes eremita</i>	Hermit crab	P
Dromiidae	<i>Dromia marmorea</i>	Marble sponge crab	A, M
	<i>Dromia personata</i>	Linnaeus's sponge crab	A, P
Enoplometopodidae	<i>Enoplometopus antillensis</i>	Dwarf reef lobster	M
Galatheidae	<i>Galathea strigosa</i>	Blue striped squat lobster	A, M, P
Hippolytidae	<i>Lysmata grabhami</i>	Lady cleaner shrimp	M
	<i>Lysmata seticaudata</i>	Monaco shrimp	A, M, P
	<i>Hippolyte inermis</i>	Seagrass shrimp	P
	<i>Hippolyte varians</i>	Variable seagrass shrimp	A, M, P
	<i>Thor amboinensis</i>	Humpbacked shrimp	M
Palaemonidae	<i>Periclimenes sagittifer</i>	Partner shrimp	M, P
	<i>Tuleariocaris neglecta</i>	Sea urchin shrimp	M
Pandalidae	<i>Plesionika narval</i>	Unicorn shrimp	A, M
Rhynchocinetidae	<i>Cinetorhynchus rigens</i>	Atlantic dancing shrimp	A, M
Stenopodidae	<i>Stenopus spinosus</i>	Mediterranean boxer shrimp	A, M, P
Gnathophyllidae	<i>Gnathophyllum elegans</i>	Spotted bumblebee shrimp	A, M
	<i>Gnathophyllum americanum</i>	Striped bumblebee shrimp	A, M
Inachidae	<i>Inachus phalangium</i>	Anemone spider crab	A, M, P
	<i>Inachus dorsettensis</i>	Decorator spider crab	P
	<i>Macropodia rostrata</i>	Spider crab	P
	<i>Stenorhynchus lanceolatus</i>	Arrow crab	M
Pisidae	<i>Pisa armata</i>	Decorator crab	A, P
	<i>Lissa chiragra</i>	Decorator crab	P
Paguridae	<i>Pagurus prideaux</i>	Prideaux's hermit crab	M, P
Plagusidae	<i>Percnon gibbesi</i> *	Sally lightfoot	A, M
Xanthidae	<i>Platypodiella sp.</i>	Gaudy clown crab	M
	<i>Euryozius bouvieri</i>	Strawberry crab	A, M
Echinoderms			
Antedonidae	<i>Anthedon bifida</i>	Atlantic feather star	M
Arbaciidae	<i>Arbaciella elegans</i>	Elegant sea urchin	M
Brissidae	<i>Brissus unicolor</i>	Big white heart urchin	M
Cidaridae	<i>Cidaris cidaris</i>	Pencil urchin	P
Diadematidae	<i>Centrostephanus longispinus</i>	Needle spined urchin	M
	<i>Diadema antillarum</i>	Long spined sea urchin	M
Echinasteridae	<i>Echinaster sepositus</i>	Spiny seastar	M, P
Loveniidae	<i>Echinocardium cordatum</i>	Small white heart urchin	M, P
Ophidiasteridae	<i>Ophidiaster ophidianus</i>	Purple seastar	M, P
Ophiodermatidae	<i>Ophioderma longicauda</i> *	Serpent star	P
Spatangidae	<i>Spatangus purpureus</i>	Violet heart urchin	P

Portuguese waters that have a high commercial value, along with the growing restrictions on tropical marine ornamental collection and trade (Wood, 2001), seem to indicate that there is an increasing risk of these resources being heavily harvested. The lack of legislation regulating the capture of most species listed in the present work could be a major problem that could threaten the sustainable use of these marine resources.

To prevent the unsustainable use of these resources urgent regulating measures must be implemented that minimise the risk of jeopardising the conservation efforts of marine ecosystems currently being developed. To ensure that marine ornamental

resources and their habitats are properly conserved and managed the following options (modified from Wood, 2001) should be evaluated:

– Banning the harvest and trade of all marine ornamental species present in Portuguese waters. Although tempting, this is always the most difficult approach to implement. One of the drawbacks associated with this approach may be the risk of involuntarily increasing the commercial value of species in high demand by reducing their supply. This measure can only be implemented if there is suitable surveillance of both collection areas and retail stores.

– Establishing sanctuary and no take zones. This is a method used for managing commercial marine

TABLE 4. – Potential marine ornamental fish species from Portuguese waters (A, Azores; M, Madeira; P, Portugal mainland). * See text for explanation.

Families	Species	Common name	Occurrence
Antennariidae	<i>Antennarius nummifer</i>	Spotfin frogfish	A, M
	<i>Antennarius senegalensis</i>	Senegal frogfish	M
	<i>Histrio histrio</i>	Sargassum frogfish	A
Apogonidae	<i>Apogon imberbis</i>	Flame cardinal	A, M, P
Ballistidae	<i>Balistes punctatus</i>	Spotted triggerfish	M
	<i>Balistes vetula</i>	Queen triggerfish	A
Blennidae	<i>Coryphoblennius galerita</i> *	Montagu's blenny	A, M, P
	<i>Lipophrys canevae</i>	Reticulated blenny	P
	<i>Ophioblennius atlanticus</i>	Redlip blenny	A, M
	<i>Parablennius rouxi</i>	Stripped blenny	P
	<i>Parablennius parvicornis</i> *	Morocco blenny	A, M
	<i>Parablennius ruber</i>	Red blenny	A, M, P
	<i>Salaria pavo</i>	Peacock blenny	P
Callionymidae	<i>Callionymus lyra</i>	European dragonet	A, P
	<i>Callionymus pusillus</i>	Festive-robe dragonet	P
Carangidae	<i>Selene dorsalis</i>	Lookdown	M, P
Cottidae	<i>Taurulus bubalis</i>	Sea scorpion	P
Dactylopteridae	<i>Dactylopterus volitans</i>	Flying gurnard	A, M, P
Diodontidae	<i>Chilomyxus atringia</i>	Spiny puffer	M, P
	<i>Diodon hystrix</i>	Porcupine fish	A, M, P
Gobiidae	<i>Gobius auratus</i>	Golden goby	M, P
	<i>Gobius xanthocephalus</i>	Red spotted goby	M, P
	<i>Thorogobius ephippiatus</i>	Leopard spotted goby	M, P
Labridae	<i>Bodianus scrofa</i>	Red hogfish	A, M
	<i>Centrolabrus truta</i>	Atlantic wrasse	A, M
	<i>Coris julis</i>	Rainbow wrasse	A, M, P
	<i>Ctenolabrus rupestris</i>	Goldsinny wrasse	P
	<i>Xyrichthys novacula</i>	Cleaver wrasse	A, M, P
	<i>Labrus bimaculatus</i>	Cuckoo wrasse	A, M, P
	<i>Labrus bergylta</i>	Ballan wrasse	A, M, P
	<i>Symphodus bailloni</i>	Baillon's wrasse	P
	<i>Symphodus mediterraneus</i>	Axillary wrasse	M, P
	<i>Symphodus melops</i>	Corkwing wrasse	A, P
	<i>Thalassoma pavo</i>	Turkish wrasse	A, M, P
Monacanthidae	<i>Stephanolepis hispidus</i>	Filefish	M
Muraenidae	<i>Enchelicore anatina</i>	Fangtooth moray	A, M
	<i>Gymnothorax polygonius</i>	Spotted moray	M
	<i>Muraena augusti</i>	Duke Augustus moray	A, M
Ostraciidae	<i>Acanthostracion notacanthus</i>	Island boxfish	A
Pomacentridae	<i>Abudefduf luridus</i>	Bluefin damsel	A, M
	<i>Chromis chromis</i>	Eastern-Atlantic damsel	P
	<i>Chromis limbata</i>	Eastern-Atlantic damsel	A, M
Priacanthidae	<i>Heteropriacanthus cruentatus</i>	Glasseye	M
	<i>Priacanthus arenatus</i>	Atlantic bigeye	A, M
Serranidae	<i>Anthias anthias</i>	Swallowtail sea perch	A, M, P
	<i>Callanthias ruber</i>	Parrot sea perch	A, M, P
	<i>Mycteroperca fusca</i>	Comb grouper	A, M
	<i>Serranus cabrilla</i>	Comber	A, M, P
	<i>Serranus scriba</i>	Painted comber	A, M, P
Syngnathidae	<i>Enterlurus aequoreus</i>	Snake pipefish	P, A
	<i>Hippocampus hippocampus</i>	Seahorse	A, M, P
	<i>Hippocampus guttulatus</i>	Seahorse	P
	<i>Nerophis lumbriciformis</i>	Green pipefish	P
	<i>Nerophis ophidion</i>	Green spotted pipefish	P
	<i>Syngnathus abaster</i>	Blackstriped pipefish	P
	<i>Syngnathus acus</i>	Great pipefish	A, P
	<i>Syngnathus typhle</i>	Deepsnouted pipefish	P
Scaridae	<i>Sparisoma cretense</i>	Parrotfish	A, M, P
Scorpionidae	<i>Scorpaena maderensis</i>	Madeira scorpion fish	A, M
Tetraodontidae	<i>Canthigaster capistrata</i>	Sharpnose puffer	M
	<i>Lagocephalus lagocephalus</i>	Puffer fish	A, M, P
	<i>Sphoeroides marmoratus</i>	Guinean puffer	A, M
	<i>Sphoeroides spengleri</i>	Bandtail puffer	A, M, P

food-fisheries (see Frank and Brickman, 2001) that may also be applied to ornamental collection. Although such areas already exist in Portugal,

enforcing the existing legislation is already a challenging task, particularly when dealing with illegal collection of specimens using scuba diving gear.

TABLE 5. – Estimated retail value (in euros per specimen) and reason for vulnerability of some highly priced marine ornamental invertebrate organisms present in Portuguese waters. CV, Commercial Value; NAM, Novelty on the Aquarium Market; PIRLD, Present in the Intertidal Region or at Low Depths; UCM, Unsuitable Collection Method. * See text for explanation.

Species	Common name	Commercial value (euros)	Reason for vulnerability
<i>Aplysina aerophoba</i>	Golden sponge	15-30	CV, UCM
<i>Cerianthus membranaceus</i>	Tube dwelling anemone	20-40	CV, UCM
<i>Telmatactis cricoides</i>	Club tipped anemone	30-50	CV, NAM, UCM
<i>Protula tubularia</i>	Hard tube duster	25-30	CV, UCM
<i>Sabella spallanzanii</i>	Spiral feather duster	8-12	CV, PIRLD
<i>Bolma rugosa</i>	Star snail	2-3*	PIRLD
<i>Cerithium vulgatum</i>	Common cerith	1-2*	PIRLD
<i>Hinia reticulata</i>	Nassa snail	1-3*	PIRLD
<i>Cinetorhynchus rigens</i>	Atlantic dancing shrimp	15-20	NAM
<i>Clibanarius erythropus</i>	Hermit crab	5-6*	CV, PIRLD
<i>Enoplometopus antillensis</i>	Dwarf reef lobster	25-40	CV, NAM
<i>Lysmata grabhami</i>	Lady cleaner shrimp	30	CV, NAM
<i>Lysmata seticaudata</i>	Monaco shrimp	20	CV, NAM, PIRLD
<i>Percnon gibbesi</i>	Sally lightfoot	6-8*	CV, NAM, AIRLD
<i>Stenopus spinosus</i>	Mediterranean boxer shrimp	20-30	CV, NAM
<i>Diadema antillarum</i>	Long spined sea urchin	20	CV, PIRLD
<i>Ophioderma longicauda</i>	Serpent star	10-12*	CV, PIRLD

TABLE 6. – Estimated commercial value (in euros per specimen) and reason for vulnerability of some highly priced marine ornamental fish present in Portuguese waters. CV, Commercial Value; NAM, Novelty on the Aquarium Market; PIRLD, Present in the Intertidal Region or at Low Depths. * See text for explanation.

Species	Common name	Commercial value (euros)	Reason for vulnerability
<i>Apogon imberbis</i>	Flame cardinal	25	CV, NAM
<i>Antennarius nummifer</i>	Spotfin frogfish	30-35	CV
<i>Histrio histrio</i>	Sargassum frogfish	20-35	CV
<i>Balistes punctatus</i>	Spotted triggerfish	30-60	CV
<i>Balistes vetula</i>	Queen triggerfish	30-60	CV
<i>Coryphoblennius galerita</i>	Montagu's blenny	15*	PIRLD
<i>Selene dorsalis</i>	Morocco blenny	15*	PIRLD
<i>Dactylopterus volitans</i>	Lookdown	300	CV
<i>Diodon hystrix</i>	Flying gurnard	60	CV
<i>Chilomycterus atringa</i>	Porcupine fish	25-45	CV
<i>Gobius auratus</i>	Spiny puffer	20-35	CV
<i>Bodianus scrofa</i>	Golden goby	20	CV, NAM
<i>Coris julis</i>	Red hogfish	20-50	CV, NAM
<i>Thalassoma pavo</i>	Rainbow wrasse	15-30	CV, NAM
<i>Stephanolepis hispidus</i>	Turkish wrasse	30-40	CV, NAM
<i>Enchelicore anatina</i>	Filefish	20-25	CV
<i>Muraena augusti</i>	Fangtooth moray	300-350	CV, NAM
<i>Gymnothorax polygonius</i>	Duke Augustus moray	150-200	CV, NAM
<i>Acanthostracion notacanthus</i>	Island boxfish	15-30	CV
<i>Abudefduf luridus</i>	Bluefin damselfish	25	NAM
<i>Heteropriacanthus cruentatus</i>	Glasseye	40-50	CV
<i>Priacanthus arenatus</i>	Atlantic bigeye	50-65	CV
<i>Sparisoma cretense</i>	Parrotfish	40-50	CV, NAM
<i>Scorpaena maderensis</i>	Madeira scorpion fish	15-20	CV
<i>Anthias anthias</i>	Swallowtail sea perch	30-50	CV, NAM
<i>Hippocampus ramulosus</i>	Seahorse	25-30	CV, PIRLD
<i>Canthigaster rostrata</i>	Sharpnose puffer	20-35	CV, NAM

– Issuing collection permits. This measure would ensure that only certified, trained and conscientious collectors would be legally allowed to collect ornamental organisms for trading purposes. To enforce this measure retail stores would have to have a certificate provided by a licensed collector, which would ensure that the organisms for sale were not illegally collected. In addition, licensed

collectors would almost certainly be the first ones to enforce this policy, preventing the action of illegal collectors.

– Creating certified wholesalers. This approach would considerably enhance accurate monitoring of ornamental species collection, since all licensed collectors would have to sell their products to a certified wholesaler. This procedure could play a vital role if

species-specific quotas were established, since all captured organisms would be recorded. These certified wholesalers would be responsible for quarantining and maintaining collected animals before they were sold to retailers, ensuring that only healthy organisms were traded. Official wholesalers would also issue a certificate to retail stores confirming that the organisms for sale had been collected in a sustainable way. This measure could be implemented if hobbyists acted in a conscientious way by only buying certified ornamental organisms and reporting illegal trading to the proper authorities.

- Implementing the use of suitable gear and collecting methods. Although Portuguese law prohibits collecting marine life using scuba gear, for safety reasons licensed collectors should be allowed to operate using it. Therefore, ornamental organisms could be more easily selected and carefully collected. Nevertheless, each collector would be obliged to communicate to the proper authorities when and where they intended to collect the ornamental species. The only collecting gears allowed should be hand nets and small barrier nets (of a certain type and mesh size) for motile species and hand collection for attached or slow moving organisms. Using any kind of “anaesthetic” or destructive collecting method should not be allowed. This measure would not only promote lower post-harvest mortalities but also maximise profitability for collecting effort.

- Setting minimum and maximum size limits. Juvenile specimens, particularly fish, are popular in the aquarium trade. However, if there is relentless harvest pressure on wild juvenile specimens, as there has been in certain food fisheries (e.g. Myers and Quinn, 2002), stocks may be seriously threatened by a reduction in the number of organisms reaching sexual maturation size and a consequent decrease in recruitment may occur. This management measure would require a basic biological knowledge of the life cycle of target species, which unfortunately is still largely inexistent.

- Operating species-based quotas. This is a widely used practice in the food fishery industry as one of the key policies of sustainable marine resource management (e.g. Sutinen, 1999; Whiterell *et al.*, 2000). Since some organisms are more eagerly collected than others, this measure would be highly beneficial. However, establishing a quota does not ensure that a proper conservation measure is being used. To establish appropriate quotas, considerable research effort is required concerning the life cycles

and growth rates of target species, as well as the existence of feasible landing data like that used in food fisheries management (e.g. Koslow *et al.*, 2000; Dunn, 2001). This practice, if properly monitored, can lead to a long lasting sustainable ornamental collection, even allowing an increase in the quotas initially established.

- Protection of rare, “key stone” species, and organisms with poor survivability in captivity. If research studies reveal that a certain species is becoming rare due to collection pressure, or plays a key role in the functioning of the ecosystem, the trade of this species should be banned. For example, some highly priced species present in Portuguese waters are known to play roles in cleaning symbioses (such as the wrasses from the genus *Coris*, *Symphodus*, and *Thalassoma* (Zander *et al.*, 1999) and the shrimp from the genus *Lysmata* (Wirtz, 1995)). Although the actual significance of these associations is still not totally understood (see Spotte, 1998; Losey *et al.*, 1999; Côté, 2000), the ecological impact of removing cleaners from the wild is unpredictable. In addition, species with very demanding captivity requirements make up 80% of post-harvest mortalities (Bunting *et al.*, 2003), either in the wholesale/retail trade or the hobbyists’ aquaria. Collecting and trading these species, such as sea-horses, tube dwelling anemones, pen shells and feather stars should not be encouraged or should even be prohibited.

- Establishing closed seasons. Closure during the breeding season may prove to be a difficult task, since different species breed at different times of the year. However, such measures allow immature organisms to grow and reach maturity, maintaining the balance of wild populations. Again, such measures will only be effective if the biological studies needed to understand the life cycle of the potential target ornamental species are carried out.

- Culturing ornamental organisms. It has been suggested that this is the best approach for minimising the impacts of harvesting wild ornamental organisms, and may even be used to restore depleted ornamental populations (Ziemann, 2001). The current methodologies developed for the larviculture of marine organisms (Calado *et al.*, 2003b; Holt, 2003) may be a precious contribution to the culture of ornamental species (Dhert *et al.*, 1997). Although bottlenecks still impair the commercial culture of the majority of traded ornamental species (Ostrowski and Laidley, 2001), some ornamental

shrimp species from Portuguese waters have already been successfully cultured in captivity on a commercial scale (Calado *et al.*, 2003c). To promote the culture and trade of ornamental species raised in captivity, harvesting these organisms in the wild should be forbidden.

– Creating an ornamental research and management fund. A percentage ranging from 1 to 5% of the commercial value of each traded wild ornamental organism from Portuguese waters should be used to create an ornamental research and management fund. This fund could be used to enforce the application of future legislation, to finance research studies of the biology and culture of ornamental species and to implement monitoring programs to detect as early as possible any negative impact on marine ecosystems associated with harvesting ornamental species. Creating this kind of “eco-fee” would reassure conscientious hobbyists that they were contributing to the conservation and sustainable management of marine resources when buying legally collected organisms.

The suggestions presented here are only tentative guidelines for creating the legislation needed to regulate the collection of ornamental species. Although the present work deals specifically with organisms occurring in Portuguese waters it can be regarded as a case study.

In the near future, ornamental importing countries (other than the USA) may face marine resource management problems that were thought to be exclusive to ornamental exporting countries. The majority of European countries, particularly those in the Mediterranean basin, as well as northern and west African countries may have to rapidly “fill the gaps” in their legislation regarding marine ornamental collection and trade. The lack of legislation addressing this new problem will surely result in unsuitable exploitation of these highly priced organisms. However, if proper management measures are developed to ensure the sustainable harvest of marine ornamentals (see Bolker *et al.*, 2002), an important alternative fishery may be created. Sustainable marine ornamental collection and trade may become an important income source, by creating new fisheries or adding value to several others by using discards or by-catches of existing food fisheries. By shifting the traditional food fisheries’ target species to marine ornamentals, poor communities of fishers may be regenerated. If properly managed, these new fisheries may help to minimise

the economic and social impacts to these communities caused by the crash of important food fisheries.

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