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Managing the marine aquarium trade: is eco-certification the answer?

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SUMMARY

Global trade in marine ornamental species includes numerous countries; however, 80% of the trade involves exports from the Philippines and Indonesia to the USA. The worldwide import value of marine ornamentals is estimated at US$ 200–330 million annually. Recent concern regarding sustainability and environmental impacts on coral reefs where collection occurs has spurred debate as to how best to monitor, manage and regulate the industry. A certification programme proposed by the Marine Aquarium Council (MAC) has the potential to manage the trade efficiently by minimizing environmental impacts, thus continuing this important source of income for impoverished coastal villagers. The MAC Ecosystem and Fishery Management (EFM) Standard was established to protect fish stocks from overexploitation and will be the most difficult component of the certification programme to implement. Prerequisites for successful EFM in developing nations are local control over fisheries and accurate records to monitor catch. Collector logs were found to be a useful tool to monitor both catch per unit effort (CPUE) and catch composition from collection areas in the Philippines. Comparison of catch composition in two distinct regions of the Philippines indicated that one site was severely overfished while the other was moderately overfished. The Collection Area Management Plan required by the MAC certification programme, combined with the current legal framework in the Philippines allowing for local jurisdiction of reef resources, has the potential to prevent further overfishing in the latter region. Until sufficient ecological data can be obtained, CPUE can provide an effective means to monitor and manage the fishery within the framework of the MAC certification programme. Despite effective management plans in source nations, legislation in receiving nations may be required to help stimulate a strong market demand for certified ornamentals if the MAC certification programme is to be successful.

Keywords: aquarium trade, catch-per-unit-effort, coral reef conservation, eco-certification, fisheries management, Philippines

INTRODUCTION

Recent improvements in home-aquarium technology have helped to increase the global trade in so-called 'ornamental' fish and other organisms that are caught wild from freshwater and marine ecosystems. The proportion of marine organisms in the world ornamental trade rapidly increased from only 1% in 1975 to 10% of the 350 million aquarium fish traded annually by 1999 (Andrews 1990; Forum Secretariat 1999). The import value has increased from US$ 24–40 million annually in the 1980s (Wood 1985) to US$ 200–330 million in 2001 (Chapman *et al*. 1997; Forum Secretariat 1999; Larkin & Degner 2001) with imports to the USA representing 80% of the trade (Larkin & Degner 2001).

Marine ornamental species are currently collected and sold worldwide. However, an estimated 66–85% of the marine organisms exported to North America, Europe and South-east Asia, the three major destinations for marine ornamentals, are collected from reefs in the Philippines and Indonesia (Forum Secretariat 1999; Wood 2001*a*). Most of the remaining 15–33% is collected from reefs in Pacific island countries, Hawaii, the Caribbean, Florida, the Red Sea, Sri Lanka, Indian Ocean island countries and East Africa (Forum Secretariat 1999; Wood 2001*b*).

Although aquaculture (Kaiser *et al*. 1997) and post-larval capture and rearing (Bell *et al*. 1999; Dufour 2002) are beginning to supply markets with a few species, the majority of marine ornamentals are collected from the wild as juveniles or adults. The coral reefs where marine ornamentals are collected have been suffering from increasing multiple impacts of global warming, El Niño Southern Oscillation events, overfishing for food fish, sedimentation and pollution on a global scale (Hodgson & Liebeler 2002; Wilkinson 2002). Therefore, the effects of the marine aquarium trade on coral reefs have come under increasing scrutiny by government regulators.

There have been few studies designed to quantify the ecological impacts of marine ornamental collection or to

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analyse trends in ornamental fish and invertebrate stocks. Attempts to apply traditional fisheries analytical tools to the ornamental fishery need to consider the unique characteristics of the trade. For example, almost all traditional food fishing activities are carried out 'blindly' and target the largest fish. In contrast, marine ornamental fishers dive underwater to visually track and capture individual fish, and prefer juveniles or small adults (Lieberman & Field 2001; Sadovy & Vincent 2002). In addition, destructive fishing practices, such as the use of cyanide and the breakage of corals to obtain fish that have hidden in the corals, can damage or destroy the reef, reducing the possibility for natural recovery of removed species (Wood 1985; Randall 1987; McAllister 1988; Salia *et al*. 1993; McManus *et al*. 1997).

Wood (2001*a*) provided a review of the management options available to curb environmental impacts and noted that differing strategies will be needed in different countries based on the structure of the trade and level of government control. Reefs within the regulatory boundaries of the USA and Australia are more regulated and monitored than those in most developing nations (Wood 2001*a*). For example, in the USA state of Hawaii, approximately 35% of the west coast of Hawaii is protected from aquarium fishing (Tissot 1999; Tissot & Hallacher 1999; Tissot *et al*. 2002). However, traditional marine tenure (ownership) can be equally strict in developing nations. Fijian reefs generally fall under a customary marine tenure system where local families or villages control the fishing rights on their local reefs (Medley *et al*. 1993; Wood 2001*a*). Although this system of management may occasionally be circumvented and require government assistance, this system may facilitate local people being stewards of their own resources (Hardin 1968). Indonesia, however, lies at the opposite end of the spectrum. Free access laws make local protection schemes difficult (CCIF [Conservation and Community Investment Forum] 2001) and a lack of resources limits the ability of the central government to enforce existing regulations (Erdmann 2001).

Noting the possibility for overexploitation and habitat damage resulting from an unregulated trade, Wood (1992) recommended the introduction of licensing and improved management and monitoring of the trade at all stages along the 'chain of custody'. Although moderately successful in selected regions, no single government or other entity has been able to work with the wide range of stakeholders to cover the international aspect of this marine conservation issue (Forum Secretariat 1999). One way to implement such a licensing scheme would be through an independently (third party) monitored certification programme. A management scheme based on certification, however, must have sufficient flexibility to operate and be adapted to varying regulatory, political and socioeconomic frameworks in different countries.

This paper critically evaluates the certification scheme proposed by the Marine Aquarium Council (MAC) and discusses the pros and cons of eco-certification as an effective tool to sustainably manage the marine aquarium trade. A case study is presented to explore the challenges associated with the implementation of the ecosystem and fishery management requirement for MAC certification within the social, economic and political structure of the Philippines. The role of international government is also assessed to determine how national and international policies can stimulate ecological sustainability within the marine ornamental trade.

ECO-CERTIFICATION: BACKGROUND AND CHALLENGES

A recent trend in 'green consumerism' has involved consumers seeking out companies and products that minimize environmental impacts (Wynne 1994). Eco-certification programmes empower consumers to assist in the reduction of environmental impacts by selectively purchasing products that are produced and distributed in an environmentally friendly manner (Teisl *et al*. 2002). Eco-certification, eco-labels, eco-logos and other similar standards are issued by independent organizations and are voluntarily displayed by manufacturers who have passed a set of criteria dictated by the issuing organization.

The effectiveness of eco-labels depends on a variety of factors that can be grouped in two classes, namely consumer awareness of the label and consumer acceptance of the label (Wessells *et al*. 1999). While the details of these factors will differ for varying industries and product types, consumer acceptance can be described as consumers' (1) confidence in the credibility of the agency providing a label for certification; (2) understanding of the link between product choices and environmental impact; and (3) clear understanding of the meaning of the certification (Wessells *et al*. 1999).

Eco-certification of marine ornamental species

The Marine Aquarium Council was formed in 1998 to bring marine aquarium animal collectors, exporters, importers and retailers together with aquarium keepers, public aquariums, conservation organizations and government agencies to minimize ecological impacts and ensure sustainability within the trade. MAC's mission is to conserve coral reefs and other marine ecosystems by creating standards and educating and certifying those engaged in the collection and care of ornamental marine life.

MAC has produced a series of core standards for the marine aquarium trade (MAC 2001*a*, *b*, *c*) and three best-practice guidance documents that set the baseline for MAC certification (MAC 2001*d*, *e*, *f*). These standards, released in November 2001, cover three areas: (1) ecosystem and fishery management (EFM) practices, (2) collection and fishing practices, and (3) handling and transportation practices. The EFM component will be one of the most challenging, partially because of the lack of scientific knowledge regarding the reproductive biology and life history characteristics of most target species. In addition, there are many difficulties inherent in the design and implementation of management

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and monitoring programmes on varying reef types scattered throughout the tropical world.

The marine ornamental industry represents an ideal market for a cohesive certification programme. The market for marine ornamentals represents a generally unified and well-informed segment of society. A survey by the American Marinelife Dealers Association (1997) found that 82% of the hobbyists surveyed thought dealers should only stock sustainably caught fish, while 100% agreed that dealers should be able to provide information about the country of origin, time in holding and feeding behaviour of any specimen sold. The understanding of environmental issues exhibited by the majority of consumers in the ornamental market will make it easy for them to understand the link between the certification programme and associated environmental benefits. In addition to environmental benefits, the consumer may receive financial benefits through the purchase of organisms that are in better condition and may live longer in their tanks (Hall & Bellwood 1995). With relatively few retail outlets in any city where hobbyists can purchase ornamentals, there is a potential to reach consumers with educational programmes. An informal survey of 77 aquarium hobbyists revealed that the majority of hobbyists were 'very interested' in the source and collection methods of the organisms they purchased and would be willing to pay more for a certified organisms caught in an environmentally responsible manner (Spruill & Dropkin 2001). In addition, an intensive survey of retailers indicated that 75% of retailers felt that MAC certification was a 'very good' idea (Edge Research 2001). At present, there are no competing certification schemes and most of the major exporters and importers have been involved in the development and implementation process of MAC certification.

MAC ecosystem and fishery management (EFM) certification

The purpose of the EFM certification is to: 'verify that the collection area is managed according to the principles of ecosystem management in order to ensure ecosystem integrity and the sustainable use of the marine aquarium fishery' (MAC 2001*b*). The major component of the EFM certification requirement is the design and implementation of a Collection Area Management Plan (CAMP, Appendix 1; URL http://www.ncl.ac.uk/icef/EC_supplement.htm). Each collection area will have a unique CAMP reflecting the specific ecological characteristics of that area. Very little is known about the ecological effects of collecting for the aquarium trade and little research has focused on the design and implementation of appropriate management plans (Edwards & Shepherd 1992; Tissot & Hallacher 1999; Wood 2001*a*; Bolker *et al*. 2002; Tissot *et al*. 2002).

Under the MAC scheme, third party certifiers are faced with the difficult task of determining whether each CAMP has been developed and is being implemented in compliance with MAC Standards. The CAMPs have been designed to achieve the conservation and sustainable use of the resources involved using an adaptive management approach. This approach will become evident as the monitoring of the resources takes place, and the CAMPs are subsequently revised to minimize negative impacts of harvesting activities (P. Holthus, personal communication 2003). Only through detailed scientific study of the collection area for extended periods of time can a successful management strategy be designed. The fact that over 50% of the world's food fish stocks been allowed to become overfished (Food and Agriculture Organization of the United Nations Fisheries Department 2002) indicates the difficulty of scientifically assessing and managing them. Despite the tremendous advantage of being able to visually count and even census reef fish stocks, natural variation in recruitment limits the ability to predict future stock sizes (Smith 1993; Die & Caddy 1997).

CASE STUDY: OLANGO AND NEW BUSUANGA COLLECTION AREAS, PHILIPPINES

The Philippines encompasses 8% of the world's coral reefs and, along with Indonesia, lies at the centre of global marine biodiversity. These attributes, along with inexpensive experienced labour, have made the country a valuable source of aquarium organisms (Lubbock & Polunin 1975; Albaladejo & Corpuz 1981). Available records indicate that exports began in 1957 and peaked in 1988 at about US$ 8 million (Wood 2001*b*). The cause of the decline is not known, but could be because of increasing competition from other countries and/or decreased exports of high-value species as the reefs have been overfished. Recently, there were an estimated 2500 collectors in the Philippines (Pajaro 1993) supplying as many as six million fish, representing nearly 400 different species, to 45 exporting companies (Barber & Pratt 1997; Wood 2001*b*).

Historically, fish from the Philippines were considered of low quality as a result of the widespread use of sodium cyanide in collection (Albaladejo & Corpuz 1981). The negative effects of cyanide on both targeted fish and reef corals have been documented (Hall & Bellwood 1995; Barber & Pratt 1997, 1998; Jones & Steven 1997; Hanawa *et al*. 1998; Jones & Hoegh-Guldberg 1999; Jones *et al*. 1999; Mous *et al*. 2000; Rubec *et al*. 2001*a*); however, no study has documented cyanide damage on a large scale as a consequence of the normal practice of cyanide fishing. Cyanide was first employed in the Philippines by fishers from Olango Island near the island of Cebu in 1962 (Robinson 1985; Rubec *et al*. 2001*a*) and has since spread throughout much of the Philippines and South-east Asia. Although cyanide fishing is illegal, an estimated 150–300 tonnes of sodium cyanide are squirted into Philippine waters annually for ornamental fish collection (McAllister 1988; Rubec *et al*. 2001*a*). In addition, the health effects on fishers and their families have not been adequately studied and may be the most significant environmental impact. Although there is no direct quantitative evidence, local managers indicate that the use of cyanide is decreasing in some areas in

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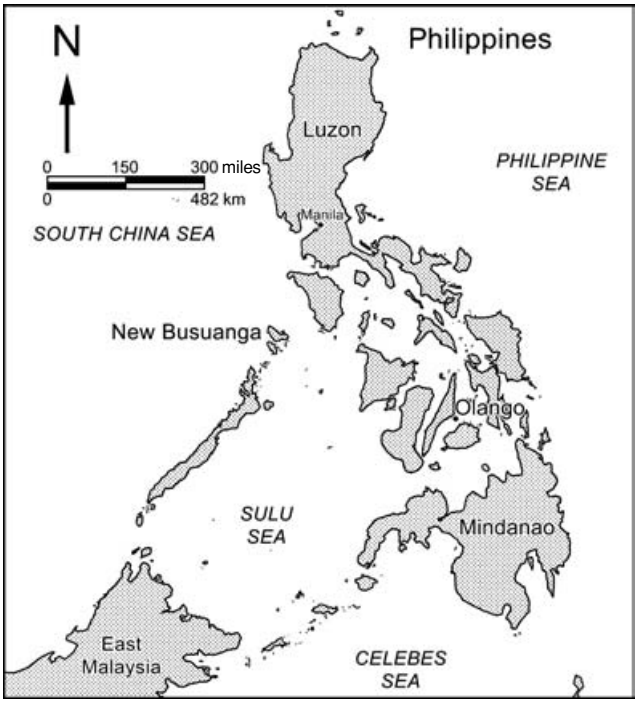


Figure 1 Map of Philippines showing study areas at Olango (a small island in the province of Cebu) and New Busuanga (a municipality on the island of Busuanga in the province of Palawan).

the Philippines because of increased management, awareness and the prospect of certification (T. Menguito, Olango Island, personal communication 2002). In addition, a cooperative effort by the International Marinelife Alliance (IMA), the Bureau of Fisheries and Aquatic Resources and the Haribon Foundation has trained local fishers to catch fish with small barrier nets without the use of cyanide (Barber & Pratt 1997; Rubec *et al.* 2001*a*; Rubec & Cruz 2002). Once trained, most fishers become efficient without cyanide, but a lower CPUE would be expected when catching fish that school or group together.

Olango is home to an estimated 600 aquarium fishers (Sotto *et al.* 2001), but is just one of an estimated 80–200 collection areas in the Philippines. When high-value fish were depleted from nearby reefs, Olango fishers were forced to travel to distant areas such as New Busuanga, Palawan, to find sufficient stocks (Fig. 1). In this way the Olango fishers spread their fishing skills, including the use of cyanide (Robinson 1985), to other areas of the country.

Composition and value of ornamental catch

Fisher's logbooks can be very useful tools to determine catch composition and volume (see Jennings & Polunin 1995). Logbooks were obtained from fishers residing in the Olango/Cebu and New Busuanga/Palawan regions of the Philippines providing catch composition information from September 2001–March 2002. Logbooks described the catch (at species level), price paid for each species (including size classes for select species), and the general area that was fished. Catch estimates were generated from collector logbook records detailing over 1500 man-hours of collecting and yielding a catch of over 34 000 fish and invertebrates. A subset of these records included estimates of time required to harvest the organisms through which CPUE and value per unit effort (VPUE) were calculated. Catch records from the Olango region were separated into two types of collecting, free diving or hookah (compressor). Records from the New Busuanga region contained only free diving records.

Prices paid to fishers for individual species were obtained from a combination of collector records, interviews with collectors and exporter receipts of delivery from collectors. Prices were not available for all species, so the mean of known prices was calculated for each taxonomic family and multiplied by the number of organisms to provide an estimate of the value of the catch of each family. Mean values for the family Gobiidae do not include the eleven occurrences of spikefin goby (*Discordipinna griessingeri*) as this species commands a price as much as 100-fold that of other goby species.

The Olango catch was dominated by low-value pomacentrids (damselfish). The diversity of the catch and catch value, however, increased with the use of the hookah (Table 1). In contrast, the catch from New Busuanga was composed primarily of high-value species. Chaetodontids (butterflyfishes) and pomacanthids (angelfish) comprised approximately 83 and 89% of the total number and value of the catch, respectively, while pomacentrids composed only 8% of the catch and 2% of the catch value. Percentage contributions of fish families from member countries of the Forum Fisheries Agency in the Pacific (Wood 2001*b*) allowed for the assessment of the status of the fisheries in Olango and New Busuanga. The

Table 1 Per cent of catch (fish only) by number and value from Olango obtained by free dive and hookah methods and from New Busuanga obtained from free dive methods. Pacific Fisheries data represent export estimates from member countries of the Forum Fisheries Agency in the Pacific.
*Source: Wood (2001*b*).

	Olango free dive		*Olango Hookah*		*New Busuanga free dive*		*Forum fisheries**	
	Number	*Value*	*Number*	*Value*	*Number*	*Value*	*Number*	*Value*
Damselfish	89	72	52	20	8	2	29	13
Angelfish	0.3	2	0.2	1	12	40	24	46
Butterflyfish	1	1	1	1	71	49	11	10
Wrasses	3	5	6	4	3	2	7	12
Gobies and blennies	3	10	26	54	0	0	5	3
Other	4	10	15	10	6	7	23	15

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Table 2 Prices paid (US$) to fishers by Olango middlemen and exporters, and proposed prices to be paid for certified fish, as well as prices charged by exporters, wholesalers and retailers for small sized organisms. Species listed are banded coral shrimp (*Stenopus hispidus*), domino damsel (*Dascyllus trimaculatus*), percula clownfish (*Amphiprion percula*), spotted grunt (*Plectorhinchus chaetodontoides*) and chelmon butterfly fish (*Chelmon rostratus*). Source data: *Olango collector records, **anonymous Manila exporter, $anonymous Los Angeles importer and #online retailer www.flyingfishexpress.com.

Species	*Paid to collector*			*Charged by seller*		
	*Middleman**	*Non-certified exporter**	*Certified exporter***	*Exporter***	*Wholesaler*$*	*Retailer*#*
Banded coral shrimp	0.02	0.05	0.05	0.62	NA	7.00
Domino damsel	0.03	0.05	0.05	0.28	1.35	2.00
Percula clown	0.06	0.14	0.23	0.77	7.95	12.00
Spotted grunt	0.06	0.12	0.13	1.50	8.95	15.00
Chelmon butterfly	0.06	0.12	0.18	1.40	8.95	15.00

ornamental fishery of Olango can be characterized as severely overfished. Percentage contributions from high-value species of pomacanthids and chaetodontids are much lower than the trade average.

The ornamental fishery of New Busuanga, on the other hand, can be characterized as moderately overfished. The percentage contribution of pomacanthids, the highest value species, is below the Forum Fisheries average. The percentage contribution of chaetodontids, however, is much higher. Fishers in New Busuanga are concentrating almost exclusively on chaetodontids and are ignoring the relatively lower-value species of Pomacentridae, Labridae (wrasses), Gobiidae (gobies) and Blenniidae (blennies), despite a market demand for these species as demonstrated by the Forum Fisheries records. Without a management plan, the catch composition at New Busuanga would be expected to resemble that of Olango after the abundance of chaetodontids has been reduced and fishers then have to focus on lower-value species.

Ad hoc interviews with fishers in both New Busuanga and Olango provided insights into the socioeconomic and cultural factors that currently affect the ornamental trade. On the economic front, a cycle of debt has developed wherein middlemen provide food, boats, fuel and sometimes cyanide to fishers in return for inexpensive fish (Rubec *et al*. 2001*a*). Fishers get on average half the price for a fish from a middleman than they would get if they went directly through an exporter, although the fishers would have to assume additional costs for transportation and distribution (Table 2). In the Philippines, the high degree of poverty and lack of alternative access to financial resources make it acceptable to borrow money at extortionate rates. This tends to force illiterate subsistence fishers into making poor financial decisions that bind them to selling organisms at a low price to middlemen. For example, it is common for fishers to borrow funds from the middlemen in the event of a personal crisis (death or sickness, for example) or before they depart on a long trip to cover the costs of supporting their family while they are away. The fishers are then financially bound to return with a lucrative catch, providing an incentive for both overexploitation of reef resources and the use of cyanide to increase CPUE. This situation has led to fishers feeling that they must catch every possible organism and employ the use of cyanide to increase their CPUE if they are to provide for their families (Rubec *et al*. 2001*a*). One of the potential advantages of the MAC certification plan is that it may result in a higher pay scale for fishers, thus potentially reducing the incentive for overexploitation and use of destructive fishing practices. The risk, however, is that the more lucrative aquarium fishing becomes, the more attractive it will be and the more fishers will be enticed into the business. Regulating collecting effort by restricting the number of collectors is one way to avoid this problem (Wood 2001*b*).

The current economic structure of the ornamental trade in the Philippines is one that leads to overexploitation and employment of destructive fishing practices. Cyanide use is widespread because it is a very efficient method of fishing, and fishers are paid for the number of organisms caught. Although there has previously been limited testing of ornamental fish for cyanide by the International Marinelife Alliance in conjunction with the Philippine Bureau of Fisheries and Aquatic Resources (Rubec *et al*. 2001*a*), there is a very low probability that an individual fisher would get 'caught' through such a system. Therefore, cyanide fishing persists and there is little incentive, either regulatory or economic, for fishers to use less destructive collection methods. The MAC certification programme would provide a mechanism through which management and monitoring could be achieved at a local level. MAC is currently working on the development of accurate and reliable testing methods for use in both countries of origin and destination to ensure a cyanide-free supply of fish. The chain of custody documentation required by the MAC certification will identify the source of organisms found to be captured using cyanide, which will be crucial to the enforcement of the cyanide prohibition.

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There must be an economic incentive, however, to entice fishers to adopt MAC-approved methods and a monitoring system must be implemented to ensure fishers adhere to MAC standards. Proposed certified prices from an anonymous Manila exporter, non-certified prices and middleman prices, as well as prices charged by exporters, wholesalers and retailers, are shown in Table 2. The incremental increase imposed by certification is a very small percentage of the retail price of the fish. It is likely that this increase could either be absorbed through the chain of custody or passed on to the final consumer where it would have little impact on the final retail price. Detailed economic analyses and a comprehensive survey of consumers' willingness-to-pay for certified organisms need to be evaluated to predict how the additional costs will be supported.

CPUE and VPUE assessment

We compared CPUE derived from the previously described logbook records with direct observations, to assess the accuracy with which collector records could be used to monitor CPUE. Direct observations entailed 30 man-hours of collecting by six different collectors in the Olango region, in which one observer (C. Shuman) recorded the catch and effort of individual fishers. All observations were made during free diving collection activities. CPUE derived from collector logs were separated by collection technique (hookah or free diving). After ensuring that data met assumptions of normality and homogeneity of variances, t-tests were employed to evaluate the degree of similarity or difference between the CPUE estimates. As would be expected, CPUE varied according to collection technique, site and the individual fisher. Collector logbooks yielded a CPUE of 9.4 ± 1.0 organisms hr^{-1} (mean $\pm$ SE, $n = 42$ fishers) for free diving, which was similar to the free diving CPUE of 9.6 ± 1.6 organisms hr^{-1} ($n = 5$ fishers) observed by C. Shuman. Reported hookah collections yielded a CPUE of 7.5 ± 0.9 organisms hr^{-1} ($n = 14$ fishers). The CPUE estimates did not differ significantly from one another ($t = -0.255$, $df = 45$, $p = 0.800$). Assuming that a typical day consists of five hours of collecting, the average daily CPUE in the Olango region was found to be 37.5–48 fish d^{-1}. These CPUE estimates are consistent with those presented by Wood (2001*b*) of 24–36, 20–45 and 30–50 fish d^{-1} in the Cook Islands, Australia and Sri Lanka, respectively.

CPUE based on total number of organisms, however, can be misleading as collectors may spend greater effort catching organisms that command a higher price, thus lowering their CPUE. VPUE data were log transformed to meet assumptions of normality and homogeneity of variances, and the transformed data were subjected to t-tests. Collector logbooks yielded VPUE of 0.33 ± 0.03 US$ hr^{-1} ($n = 42$ fishers) for free diving, which was similar to the free-diving VPUE of 0.27 ± 0.05 US$ hr^{-1} ($n = 5$ fishers) observed by C. Shuman. Reported hookah collections yielded a VPUE of 1.38 ± 0.24 US$ hr^{-1} ($n = 14$ fishers), which was significantly higher ($p \leq 0.01$) than the free-diving VPUE.

The higher VPUE for hookah provides economic justification for the increased costs and, more importantly, for the health risks from extended diving at depth (typically 10–30 m) associated with this collection technique. The similarity between CPUE values obtained from direct observations of collectors and collectors' records lends support to the use of CPUE as a tool to monitor the certified collection area. Care must be taken, however, to assess CPUE for each collector separately, as individual collectors vary in skill level. Although this may be a somewhat crude and a posteriori form of management, there are few options available without time-consuming long-term scientific studies. Even with such studies, there is no a priori guarantee that fish stocks can be protected because of limited knowledge of the mechanisms affecting population sizes of target species and the general coral reef community (Hilborn *et al.* 1995).

Prospects of MAC certification

In 1991, local municipalities in the Philippines gained the exclusive rights to license fisheries and other uses of municipal waters within 15 km of the coastline through a system known as territorial use rights fisheries (TURFs; Rubec *et al.* 2001*b*). This law has the potential to eliminate 'open access' by placing control over such areas in the hands of the Fisheries Area Resource Management Council (CCIF 2001; Rubec *et al.* 2001*b*). For example, the New Busuanga Municipal Ordinance (Municipal Basic Fishery Ordinance No. 24) states that all aquarium fishers must be registered with the municipality and are required to adhere to fisheries regulations. The formation of fishing cooperatives within this legislative framework has the potential to stimulate stricter adherence to fishing restrictions including the use of non-destructive collection techniques. Fishing cooperatives will also provide communities with a mechanism to enforce MAC compliance by providing bodies through which violations can be reported.

The first CAMP used to certify a collection area was approved in October 2002 for Batasan Island, Tubigon, Bohol (BTFCA [Batasan Tropical Fish Collectors Association] 2002). In the absence of sufficient long-term data, the CAMP was designed to respond to changes in CPUE. As field data become available to track the local populations of target organisms, the CAMP will be adapted to include the new information. CPUE is commonly used to monitor and manage food fisheries (Russ 1991), but has yet to be employed to monitor marine ornamental fisheries. The Batasan CAMP is based on a 30% reduction in CPUE for any organisms for more than three months. If such a reduction is detected, then this fact shall immediately be brought to the attention of the CAMP committee (generally a working group composed of fishers, managers and community leaders) and all collection of the organism(s) in question stopped (BTFCA 2002). The Batasan Tropical Fish Collectors Association will use the detailed logbooks required by the MAC certification to monitor CPUE within the framework of this management plan.

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This form of management can be misleading and/or ineffective as CPUE can be greatly influenced by market demand and variable recruitment. In addition, the logbooks required by MAC are quite comprehensive and in English (C. S. Shuman, personal observation 2002), which may limit the ability of local fishers to accurately provide the needed information to monitor the fishery with CPUE. Assessment of CPUE from fishers' logs introduces the potential for the fishers to falsify their logbooks further, limiting the efficacy of this type of management. To decrease the ability of fishers to falsify logbooks and to control for differing fishing skills exhibited by different collectors, an independent observer should calculate CPUE on a species, collector and site-specific basis. To enhance the accuracy of the logbooks, MAC should simplify the data entry process and provide copies in local dialects to certified collection cooperatives. Because of the high degree of uncertainty introduced by the use of logbooks and CPUE as a fisheries management tool, we recommend that formal underwater surveys be performed in collection and control areas on a regular basis to track the status of collected stocks. In addition, in collection areas with marked seasonal components, it would be very informative to perform monitoring at the end of both the high- and low-season collection periods.

THE ROLE OF INTERNATIONAL TRADE LAWS

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is the only international legal mechanism with the mandate to protect species from overexploitation as a result of international trade (Lieberman & Field 2001). However, CITES was not designed to be implemented as a comprehensive wildlife management tool (McManus 2001). Although data are collected for species listed under Appendix II of CITES, which include stony corals, giant clams and *Hippocampus* spp. (pipefishes and seahorses), there is currently no international mandate to require records of exports of non-listed species. Consequently, export records vary widely from country to country and there is a general paucity of quantitative data, leading to controversies over the environmental costs and benefits of the trade (Bruckner 2001; Wabnitz *et al*. 2003).

Documentation of imports is equally variable in both the USA and European Union (EU). The trade in Europe is regulated at both EU and country levels; however, there may be large discrepancies between the two sets of regulations (C. Wabnitz, personal communication 2003). Imports of marine ornamentals into the USA are monitored by USA Customs and the USA Fish and Wildlife Service (USFWS); however, data are grouped into broad categories that do not allow these records to be used as a tool to monitor the volume and type of marine ornamentals imported into the USA (Adams *et al*. 2001).

The lack of accurate governmental export and import records is so pronounced that the Global Marine Aquarium Database (GMAD) has turned to records kept by individual exporters and importers to monitor the trade. This database is available freely online (URL http://www.unep-wcmc.org/marine/GMAD/) and represents the first step towards accurately characterizing the volumes of organisms in the ornamental trade.

It has recently been argued that the USA has a critical responsibility not only to address the degradation and loss of coral reef ecosystems worldwide, but also to encourage responsible trade (Moore & Best 2001). Lieberman and Field (2001) recommend that after working with stakeholders, the USA should prohibit the import or export of any coral reef species unless specimens are accompanied by certification that they were not taken through the use of destructive fishing practices. Although a rigorous documentation trail will be needed through the chain of custody to comply with MAC certification standards, it may be necessary for government regulations to monitor and, if necessary, police the import of marine ornamentals into receiving nations. This should be accomplished through a phase-out process to allow the industry to adjust gradually to the stringent criteria required for certification.

DISCUSSION

Unsustainable and environmentally harmful practices employed during the collection and transportation of many marine ornamentals reveal the need for additional management measures to ensure a sustainable and environmentally-sound trade in marine ornamentals. Recommendations ranging from modest improvements in record keeping to an outright ban on the import of all marine ornamentals have been proposed to reduce the negative environmental impacts associated with the trade. A national ban on the import of marine ornamentals may actually cause more environmental harm than good by forcing the trade onto the unregulated black market and compelling local fishers to revert to other, less sustainable, sources of livelihood.

The certification programme of the MAC can be an effective way both to monitor and to manage the trade. This will allow the industry to operate, thereby providing income in developing countries and educational opportunities in receiving nations. Although extremely important, many of the certification criteria are relatively straightforward and, if adhered to, should substantially reduce mortality through the chain of custody and reduce or eliminate secondary impacts associated with destructive fishing practices. The certification programme will also provide an accurate record of the quantity and type of species traded on a worldwide scale. The EFM standard, however, will be much more difficult to define, implement and enforce, but is crucial to promote sustainability within the industry.

There are many tools available to help protect ornamental fish stocks and promote the sustainable exploitation of marine ornamentals to be compliant with the MAC Ecosystem and Fishery Management Standard. Recent interests in sustainability within the ornamental trade have led researchers to explore the effectiveness of traditional food fishery

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management options such as marine protected areas (Wood 1985; Randall 1987; Andrews 1990; Friedlander 2001), hatchery releases (Ziemann 2001), closed seasons, species restrictions, size limits and quotas (Wood 2001*a*), as well as non-traditional management options such as artificial reefs (Wilson *et al.* 2001) and post-larvae capture, rearing and redistribution (Bell *et al.* 1999; Dufour 2002). Although several of the above-stated management strategies have been tested in pilot projects, few are currently implemented on a large scale. The passing of Act 306 by the Hawaiian state legislature represents perhaps the largest single management strategy aimed specifically at marine ornamentals. Using 'substantive involvement of the community in resource management decisions', approximately 35% of the west coast of Hawaii were declared as Fish Replenishment Areas where ornamental fishing was prohibited (Tissot *et al.* 2002). In addition to the closure, a series of scientifically rigorous observations have been carried out both within and outside protected areas to determine the efficacy of such management strategies and quantify biological mechanisms responsible for replenishing depleted stocks (Tissot *et al.* 2002).

Implementation of the management tools described above, however, will require funding for expert evaluation, capacity building, enforcement and training. The majority of source nations do not have the resources to fund effective management projects to support the programme. Therefore, funding must be generated through the industry as part of the certification programme to support the establishment, management and monitoring of CAMPs to comply with the EFM certification requirements. Tariffs placed on imported organisms, to be directed back to supply countries, would not only ensure resources for monitoring and management, but also provide additional capital input into the local communities from which the resources were extracted.

The ability of MAC to enforce the certification requirements is critical not only to the success of the certification programme, but also to the preservation of collection areas. At present, MAC does not provide a comprehensive detailed plan for enforcement to ensure compliance. Reliable random cyanide testing of organisms from certified collection areas as well as an emphasis on accurate log books (enforced by the local fishing cooperative or an independent observer) will help to decrease the ability of individuals to 'cheat' the system. In addition, we recommend that MAC introduce a formal requirement of no-take areas, rotation of collection areas and rehabilitation programmes (i.e., larval restocking) to offset the scientific uncertainty surrounding many of the current management programmes. Finally, we recommend that detailed surveys be performed by trained personnel in each collection region before the establishment of a CAMP to determine the baseline of the fishery and aid with the selection of no-take areas. Repeated underwater surveys will be necessary to monitor the effectiveness of the management strategies and assist with modifications to the CAMP to further promote the sustainable extraction of marine ornamentals.

The diversity of both collection practices and local regulations in source countries around the world will make it tremendously challenging to create successful certified fisheries in each collection locale. While promising, the MAC certification programme must overcome many obstacles, especially those pertaining to ensuring ecosystem management, to effectively promote sustainability within the marine aquarium trade. It will take a combination of rigorous scientific research, international cooperation and strong market incentives for the MAC certification process to succeed in creating a sustainable worldwide trade in marine ornamentals.

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