Tracking the trade in ornamental coral reef organisms: The importance of CITES and its limitations

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ABSTRACT

The extraction of coral reef organisms for the aquarium and curio trade is reported to be contributing to coral reef degradation. The total international trade and associated impacts are unknown, because data are collected only for organisms listed on Appendix II of CITES, which include stony corals, antipatharians and giant clams. CITES data indicate that trade in live stony coral and reef substrate ('live rock') increased by 15–30% each year during the 1990s, with most exports since 1992 from Indonesia and Fiji. Overall, 19% of all stony coral traded (by item) from 1985 to 1997 was live; 71% of this was traded between 1993 and 1997 (52% of total trade). Although tracking trade using information from the CITES Trade Database provides limited information (e.g., coral is reported to genus, and volume is reported by item or weight), the CITES mechanism promotes the development of strategies to protect resources. In response to CITES requirements, Indonesia developed a management plan for sustainable harvest of corals, but not for non-CITES listed species such as soft corals and fishes. Trade in hard and soft coral provides revenue for developing countries; however, in order to be of lasting value the industry must be developed with a conservation ethic. This requires support for international programs such as CITES, management plans for sustainable harvest, and improved enforcement.

INTRODUCTION

Coral reefs are in a worldwide state of crisis, experiencing widespread declines in the abundance of corals, fishes and other organisms. The 1998 World Resources Institute *Reefs at Risk* report (Bryant *et al.,* 1998) estimated that 58% of the world's coral reefs are threatened by human activities such as coastal development, destructive fishing, overexploitation of marine resources, marine pollution, and terrestrial runoff. These impacts are intensifying the effects of natural events such as coral reef diseases, crown-of-thorns (*Acanthaster planci*) sea star outbreaks and tropical cyclones (Global Coral Reef Monitoring Network, 1998). In 1998, coral reefs suffered the most extensive and severe coral bleaching episode in modern record, with subsequent mortality affecting 70–80% of all shallow-water corals on many Indo-Pacific reefs (Wilkinson, 1998). Recently, scientists have raised serious concern that the collection of corals, reef rock and coral reef fishes to supply the aquarium and curio trade may be unsustainable, and destructive techniques such as cyanide fishing used in their collection are contributing to the accelerated deterioration of coral reef ecosystems (Barber and Pratt, 1998; Bryant *et al.,* 1998; Clark and Gulko, 1998; Moss and Van Der Wal, 1998).

Coral reefs, renowned for their high diversity and productivity, are facing increased pressure to supply the world's growing demand for food, ornamental

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organisms and traditional medicines. Fishing, including coral harvest, is the most widespread exploitative human activity on tropical reefs, and can lead to a reduction in the abundance, biomass and mean size of targeted species, as well as a shift in species composition (Jennings and Polunin, 1996). Intense fishing pressure may cause large-scale ecosystem shifts such as a population explosion of a non-targeted species or the replacement of a thriving, coral-dominated system with a low-productivity algal reef (Hughes, 1994; McClanahan, 1995). Collection of coral reef fishes for the aquarium trade is a small portion of the total finfisheries catch, although it has continued to grow in order to keep pace with increasing demand (Vallejo, 1997; Lathrop and Hourigan, 1998; Tissot, 1999). Aquarium fish collection occurs on reefs worldwide, including U.S. reefs, and it involves a high diversity of fishes including juveniles of food fish as well as non-food fish species (Johannes and Riepen, 1995).

In the major source countries of the Indo-Pacific, one of the most common methods to capture reef fish for the live food and aquarium trade involves the use of poisons including cyanide, chlorine bleach, and plant extracts. Live reef food fish (LRFF) include grouper, Napolean wrasse, coral trout and other large predatory fish that may be threatened or endangered throughout their range (Johannes and Riepen, 1995). Hong Kong is the largest consumer of LRFF, importing from 25,000 to 35,000 metric tons per year with an estimated retail value of over $1 billion (Barber and Pratt, 1998; Bryant *et al.,* 1998; Lau and Jones, 1999). While the LRFF trade extracts primarily the more fecund larger individuals, the most popular marine aquarium fishes are smaller; aquarium fishes include herbivores, juveniles of species (e.g., Kole, *Ctenochaetus strigosus*) that are also caught as adults for food by subsistence fishers, and other ornamental species such as butterflyfish and angelfish (Clark and Gulko, 1998; Tissot and Hallacher, 1999). Marine aquarium fishes with the highest retail value are those that are the rarest and hardest to find in the wild, which may create economic incentives adverse to the survival of those species.

Unlike other forms of destructive fishing such as blast fishing and muro-ami that are utilized largely for subsistence fisheries, cyanide fishing is driven entirely by the international trade in live coral reef fishes. Aquarium fish collectors typically use one or two 20 g sodium cyanide tablets in a one liter squirt bottle, while food-fish fishers use 3–5 cyanide tablets per liter (Rubec *et al.,* 2000). Fishers squirt cyanide into coral formations to stun and collect their prey, using a crowbar to pry apart the coral heads to reach the fish that retreat into crevices (Barber and Pratt, 1998). Cyanide kills many non-target fish along with corals and other reef invertebrates, and a large percentage of the fish that are captured die in transit (Rubec, 1988). Despite the fact that cyanide fishing has been banned in most countries, the high value of live reef fish drives the continued use of cyanide (Bryant *et al.,* 1998). The spread of cyanide fishing into remote locations is of particular concern, as these areas have been minimally impacted by other human threats (Johannes and Riepen, 1995).

Coral is harvested for building materials, curios, jewelry and aquarium organisms. The mining of reef rock and live corals for building materials can devastate coral reefs (Brown and Dunne, 1988), however this is primarily for domestic markets. Coral extracted for the curio trade consists of a small number of taxa, primarily large, adult colonies of branching (*Acropora* spp. and *Pocillopora* spp.) and fungiid (*Fungia* spp.) corals (Green and Shirley, 1999). Corals harvested for the aquarium trade are mostly massive species, or species with large fleshy polyps and prominent tentacles; small polyp corals have become increasingly popular aquarium organisms in recent years, and *Acropora* spp. is now one of the top five corals in international trade (Bruckner, unpublished data). Millions of kilograms of reef substrate ('live rock') are also extracted each year to supply the aquarium trade.

The collection of corals and live rock for international trade may be a small issue in global terms, but in recent years it has increased significantly and can accelerate reef degradation, particularly on reefs threatened by other human activities. Corals, the major reef-builders in tropical environments, provide physical and topographic complexity and habitat for fish and motile invertebrates. Corals are an important source of primary productivity, and once they die, their skeletons are cemented together to form the reef structure. Harvest of 'live rock' (dead coral and other limestone reef rock with attached invertebrates, microorganisms and coralline algae) results in the net loss of substrate that requires decades to centuries or longer to replace, and may be considered consumption of a non-renewable resource. Live rock provides a site for the attachment of reef-building corals and other organisms crucial for continued reef growth. In addition, many commensal (symbiotic), sessile organisms essential for the health of the reef are removed along with the rock (Maragos, 1992). Ironically, the U.S., the main importer of coral, has legislation banning the collection of stony coral and live rock from many of its own reefs.

The harvest of coral reef organisms has potential long-lasting effects on the structure and function of coral reef ecosystems, due to their vulnerability to overexploitation. Unfortunately, the total volume of organisms harvested from coral reefs for international markets, and the effect of their removal on the ecology and geology of the reefs are poorly understood. This paper summarizes the available trade statistics for stony corals and coral reef fishes that supply the aquarium and curio trade, including the volumes in trade and major exporting and importing countries. The value of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II listing for stony corals as a means to regulate the trade and prevent overexploitation of coral reef species is examined. The information presented here allows an identification of the complex problems associated with the trade in coral reef organisms, and the benefits and limitations of CITES Appendix II. To highlight the importance of CITES, current conservation efforts in Indonesia for stony coral are compared with non-CITES listed coral reef fishes.

MATERIALS AND METHODS

Coral reef fishes

There are few data available on international trade in marine fishes. Information on tropical aquarium fishes was obtained from the U.S. Fish and Wildlife Service database. Additional statistics were obtained from Traffic USA, other published reports (e.g., Miyasaka, 1994; Vallejo, 1997; Lathrop and Hourigan, 1998; Tissot and Hallacher, 1999), and FishBase (Froese and Pauly, 2000).

Stony corals

A global assessment of the legal international trade in stony corals was performed using CITES annual reports for 1985–1997 (provided by the World Conservation Monitoring Centre). The CITES annual reports for corals include information on the taxa (reported as 'Scleractinia' or as genus), quantity (weight or items), country of origin, importing country, description of coral (live, raw, carvings) and source (wild or captive-bred). The data presented here represent minimum trade volumes, and do not include illegal, confiscated coral shipments, or quantities reported as an unusual unit (e.g., bag or box). Although coral sand is listed as Scleractinia, it is assigned a separate code and this material was excluded from data presented. All data are presented by the origin of the coral (original exporter) or the destination (final importer). Export and import data contained in the CITES Trade Database may differ because some countries report exports as the total number of specimens for which permits are issued, instead of the actual quantity traded. This is further complicated by the fact that not all countries are CITES members, and non-parties may not report the trade. For this analysis, a comparison of exports, imports and re-exports was first made, to determine shipments not reported by either country and to ensure that data were not recorded twice. Records were divided by year into coral listed only as 'Scleractinia', and coral reported to genus, and each group was further subdivided by unit (item or kilogram). The total trade (live and dead coral pooled) was calculated by combining import records with data of exports destined for those countries that did not report coral imports. Finally, records were analyzed by types of coral (live specimen or dead skeleton) to determine recent trends; comparisons between live and dead coral were only made using import data, as exporting countries often listed all coral as 'dead', including live specimens. All data are presented in the original units by item or weight, and different units were not combined (using a conversion factor).

RESULTS

Trade in coral reef fishes

The international trade in ornamental fishes is a large industry involving highly selective harvest from reefs worldwide. Recent estimates suggest that

15–20 million coral reef fishes are collected annually to supply public and private aquaria worldwide (Wood, 2001). Over 1200 species from 45 countries are commercially available to hobbyists, of which only about 1% are captive bred (Froese and Pauly, 2000). In the U.S., coral reef fishes are commercially harvested for the aquarium trade primarily from Hawaii, Florida, Puerto Rico and Guam; the fishery is largest in Hawaii, where approximately 430,000 fishes were collected in 1994 (Miyasaka, 1994). There is concern that these fishes have a high potential for overexploitation, and their removal may induce shifts in community composition. Exporters have expressed concern over a perceived decrease in the catch of valuable species, and a potential loss of variety (Vallejo, 1997). Studies have only begun to document the extent and potential impact of collection of coral reef fishes for the marine aquarium trade, however (Tissot and Hallacher, 1999).

Specific data on individual species or source countries are largely unavailable since only limited recording is done by importing or exporting countries. In exporting countries, fisheries data are often aggregated by weight, making it difficult to determine the quantity of a given species brought to a particular collection point, or the volume of exports in any one year. In the U.S., where reporting of catch data is voluntary (e.g., Hawaii), there is no way to verify the accuracy of reports; catch data from Hawaii appear to be under-reported, but coral reef fishes are reported to the species level (Clark and Gulko, 1998).

Between 200 and 250 million ornamental fish are imported into the U.S. per year (The U.S. Fish and Wildlife Service database). An example of the type of import data collected by the U.S. government is shown in Figure 1. Because freshwater and marine species are combined in U.S. trade data for ornamental fishes, it is difficult to estimate the proportion of coral reef fishes. An analysis of export statistics from the major suppliers of aquarium fishes reveals that marine fish imported into the U.S. account for 10–20% of the total ornamental fish trade, with about 80–90% of these originating in Indonesia and the Philippines (Vallejo, 1997; Lathrop and

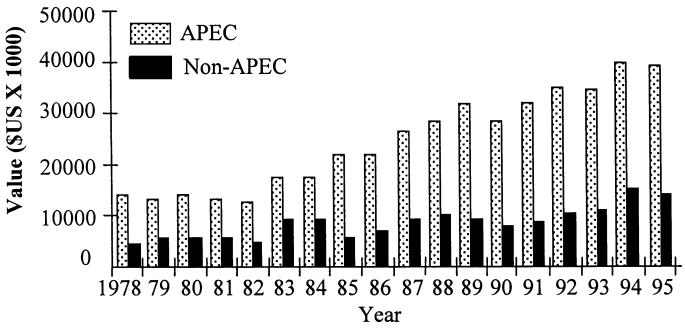

Figure 1. The estimated U.S. customs value (in thousands of dollars) of ornamental fish imported into the U.S. between 1978 and 1995. Solid bars refer to the portion from non-Asia Pacific Economies (non-APEC), and open bars are imports from Asia-Pacific Economies (APEC). Figure adapted from Lathrop and Hourigan (1998).

Hourigan, 1998). A rapid increase in the harvest of marine species for home aquaria occurred in the 1980s (Andrews, 1990) and exports have continued to increase in the 1990s (Vallejo, 1997). Available trade data of U.S. imports do not allow an analysis of the volume for individual taxa.

Trade in stony corals: CITES Appendix II listing

There are several global declarations and international treaties established to protect coral reef ecosystems, such as the International Coral Reef Initiative (ICRI). Only one treaty, CITES, provides a mechanism for regulating international trade in coral reef species (Armstrong and Crawford, 1997). CITES is an intergovernmental treaty that came into force on July 1, 1975 and now has 151 member parties. The overriding goal of the convention is to ensure that international trade in specimens of wildlife does not affect the survival of species. CITES also seeks to demonstrate that effective management of resources may be beneficial to the conservation of species and ecosystems, and to the development of local communities. The convention classifies species in three categories. Appendix I includes species that are threatened with extinction and in which commercial trade is prohibited. Appendix II contains species not necessarily in danger of extinction, but which may become threatened if trade is unregulated. Appendix III are species that are protected by the countries or states that list them and for which they seek the cooperation of other parties in ensuring that illegal trade does not occur. All species of black coral (Antipatharia) and hard coral in the orders Coenothecalia (*Heliopora coerulata* – blue coral), Milleporina (hydrozoan fire corals), Scleractinia (stony corals), Stolonifera (*Tubipora musica* – organ-pipe coral) and Stylasterina (lace corals) are listed in Appendix II. Anemones and false corals (Subclass Zoantharia), soft corals (Order Alcyonaria) as well as sea fans, sea plumes and deep- water precious corals (red, pink, gold and bamboo corals) in the Order Gorgonacea are not currently listed in CITES.

Since 1985, CITES has provided the only effective mechanism to regulate international trade in stony corals and to protect these resources from overexploitation. To trade in these species, shipments must be accompanied by an export permit that has been issued by the CITES Management Authority in the country of export. Before issuing the permit, the countries CITES Management Authority and Scientific Authority must make a finding that the specimen was acquired legally, and trade in that particular species is not detrimental to its survival in the wild. CITES annual records provide information on the type of coral in trade, the volume (reported by item or weight), whether it is live or dead, and the major exporting and importing country.

Coral commodities and volume of trade

Stony coral enters the international trade as cured coral skeletons (dead coral or raw coral, bleached and cleaned), carvings, or live specimens. Cured coral may be in a raw form for use as ornaments or decoration, or in a manufactured form as

carvings, jewelry, furniture or artwork. A small amount of dead (recently killed) *Porites* spp. and *Goniopora* spp. coral is also traded for surgical use in bone graft (Hodgson, 1989). Large quantities of reef substrate (e.g., 'live rock' – any hard, calcareous substrate such as long-dead coral skeletons or limestone reef rock that supports an assemblage of living marine organisms, including attached invertebrates, microorganisms and coralline algae) are traded for use in home aquaria.

CITES annual records can be divided into two components, coral listed as 'Scleractinia' and coral reported to the level of genus. Scleractinia was first added to the CITES database in 1986, with over 1.2 million exports reported from the Philippines. As this was the first full year of the CITES Appendix II listing for corals, it is presumed that records of Scleractinia consisted primarily of unidentified coral skeletons; at this time the Philippines were the world's primary supplier of coral, and yet they reported very few exports to genus. Over the next several years, permits listing Scleractinia may have included reef rock (dead coral substrate of unrecognizable taxa, also known as base rock or live rock), mixed shipments of coral, sand and shells, or corals that could be identified to genus but were lumped as Scleractinia (Shoup and Gaski, 1995). Reporting procedures improved in the 1990s, and most records for Scleractinia now consist of live rock, long-dead coral, or reef substrate with attached soft corals. According to a resolution prepared at CITES COP 11 (Draft Resolution of the Conference of the Parties, Com. 11.9, April 2000), Scleractinia can only include specimens that are readily recognizable as coral rock, whereas the genus cannot be readily determined; coral fragments between 2 and 30 mm in diameter and coral sand are no longer regulated within CITES.

The total volume of coral in trade reported as Scleractinia has grown substantially between 1990 and 1997, with 750,000 kg and 625,000 items traded in 1997 (Figure 2). With the exception of over 800,000 kg of Scleractinia traded between China and Hong Kong in 1991 and 1992, over 90% of all Scleractinia was imported by the U.S. Quantities of Scleractinia reported by weight do not describe the same physical specimens as those reported by item (piece); the bulk of the wild-harvested Scleractinia reported by item originates primarily from Indonesia, and that reported by weight is from Fiji.

An analysis of CITES records allows the determination of the major exporters, and whether the trade is shifting from one region to another. CITES trade records for the period from 1985 to 1997 indicate that over 900,000 kg and 16 million items of coral reported to the genus level were exported from 66 countries; this does not include the coral reported as Scleractinia, described above. Throughout the 1970s and 1980s the vast majority of all coral in trade originated in the Philippines (Mulliken and Nash, 1993). Due to a ban on Philippine coral exports (Philippines Presidential Decrees 1219 and 1698; first implemented in 1977, but not enforced until the late 1980s), Indonesia emerged as the world's largest coral exporter in 1990 (Bentley, 1998). Over the last five years, the volume of stony coral and live rock from Fiji has doubled or tripled each year, and today they are the second largest exporter of these items. Eight Indo-Pacific nations exported 90% of all stony coral listed in CITES annual records (Table 1).

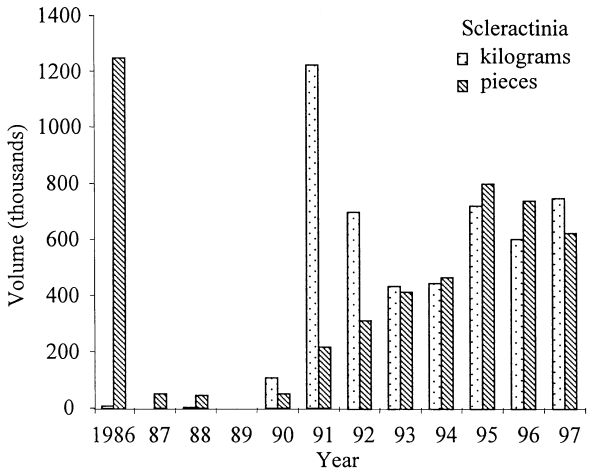

Figure 2. Total volume of coral reported as Scleractinia in trade between 1985 and 1997. Data are reported by thousands of kilograms (stippled bars) or by thousands of pieces (cross-hatched bars).

Table 1. The primary sources of stony coral (reported to genus) exports, according to the CITES annual records

Country	1985–1990	1991	1992	1993	1994	1995	1996	1997	Total
*Data reported as thousands of items**									
Philippines	2474	9	4477	2.5	1	1	3	12	6979
Indonesia	1662	570	371	729	645	634	635	763	6011
Taiwan	706	49	188	70	0	0	4	3	1021
Fiji	180	71	57	19	34	65	77	168	670
Mozambique	0	0	0	0	0	75	293	159	527
Solomon Islands	4	5	8	5	15	45	43	31	154
*Excludes coral reported by weight.									
*Data reported as thousands of kilograms***									
China	12	21	85	114	45	40	18	0	334
Taiwan	262	39	4	0	<1	<1	0	0	268
Mozambique	0	15	0	0	0	41	75	0	131
Philippines	63	1	17	0	0	0	0	0	78
New Caledonia	22	18	1	0	0	<1	0	0	41
Fiji	0	<1	25	0	2	<1	<1	1	28
Indonesia	1	<1	3	<1	0	<1	3	14	20
**Excludes coral reported by item.									

Overall, 98 genera of Indo-Pacific reef-building corals are listed in CITES annual reports, with 20 dominating the trade today. The top three corals in trade between 1985 and 1997 were *Pocillopora* spp. (23% of the total, 3.6 million items), *Fungia* spp. (19%, over 3 million items) and *Acropora* spp. (16%, 2.6 million items).

A further 23% (3.6 million items) of the trade consisted of eight other genera, and all other corals accounted for approximately 9% of the total trade (import data plus records of exports not reported by importing countries are pooled). Most stony coral traded internationally prior to 1990 consisted of skeletons, carvings and manufactured products. Since 1993, the amount of dead coral in trade has remained fairly constant, but the amount of live coral for the aquarium trade has increased by 30–50% per year, exceeding the volume of dead coral for the first time in 1996. Overall, only 19% of all coral traded (by item) since 1985 was live coral; however, 71% of all live coral was traded between 1993 and 1997 and this represents 52% of total trade for that period (Table 2). Data presented in Table 2 may represent an underestimate of the total volume in trade, as only import records were used and non-CITES parties that import coral are not required to report their trade. Export data were not used because exports from some countries (e.g., Indonesia) may not represent the actual volume in trade, but the number of corals of each species listed on CITES permits (Shoup and Gaski, 1995), and these were frequently reported as dead coral (even if colonies were live).

Table 2. The 20 dominant stony coral genera in trade between 1985 and 1997 listed in order of abundance*

Genus	Dead coral			Live coral	
	Kilograms	Items		Items	
	1985–1997	1993–1997	1985–1997	1993–1997	1985–1997
Pocillopora	181,106	132,878	3,486,470	36,348	81,678
Fungia	7645	12,751	2,993,087	21,849	34,274
Acropora	161,006	426,348	2,210,380	171,057	226,660
Heliopora	10,953	118,139	711,565	18,732	49,237
Euphyllia	171	62,375	92,192	255,081	407,023
Tubipora	22,526	31,279	341,035	138,114	156,993
Goniopora	74	61,521	79,493	215,370	300,666
Stylophora	5187	72,900	283,433	13,161	20,698
Catalaphyllia	0	36,539	47,479	185,485	250,006
Pavona	16,223	76,534	253,103	9630	21,828
Seriatopora	137,880	46,518	253,503	5163	19,121
Porites	27,285	17,682	150,572	54,375	85,793
Plerogyra	9	36,746	52,489	111,116	161,126
Platygyra	161,406	527	185,932	1328	22,321
Trachyphyllia	0	24,827	26,169	72,449	156,993
Heliofungia	0	23,735	30,171	84,433	124,749
Favia	1931	14,524	112,817	21,126	28,869
Lobophyllia	18,478	17,048	57,078	55,459	66,331
Tubastraea	14	12,953	40,232	58,090	62,428
Pectinia	96	36,746	91,675	7013	8204
Other	17,499	153,844	376,737	301,019	341,480

*Data are from annual CITES import records obtained from the World Conservation Monitoring Centre.

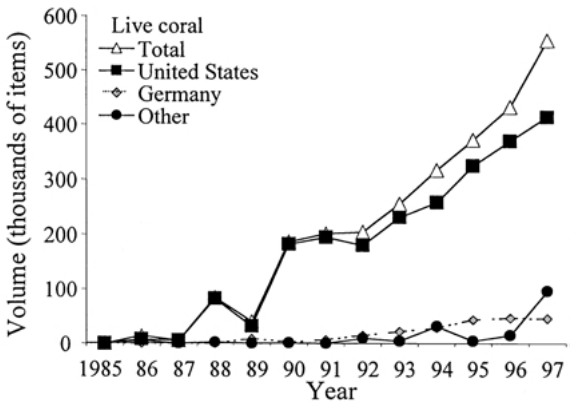

Figure 3. Volume of live coral in trade between 1985 and 1997. Open triangles are the total volume imported by all countries, black squares are the portion imported into the U.S., diamonds are imports into Germany, and black circles are imports into all other countries.

Live coral in international trade is imported primarily by the U.S., Europe, Japan and Canada. The U.S. has consistently imported 70–80% of all live coral, with approximately 10% destined for Germany and 10% going to all other countries (Figure 3). There has been a notable increase in imports of live coral in Japan, amounting to approximately 10% of the worldwide trade in live coral for 1997.

With the increase in the volume of live coral in trade, there has been a major shift in the types of corals traded. Most corals traded as dead specimens were shallow water branching species. These types of corals are the most abundant on reefs in the Indo-Pacific, and they exhibit the greatest rates of growth and highest level of sexual recruitment; however, specimens traded as skeletons are significantly larger than corals traded live, and a single item may be up to 1 m in diameter. It is important to note that 'dead' coral is harvested while alive, and therefore this trade does have some impact on living reefs. Nine of the 10 most common species traded live are massive corals or coral with very large, colorful polyps and prominent tentacles. These types of coral are relatively slow growing, exhibit low rates of sexual recruitment, and in many cases include uncommon species. The taxa of live coral most readily available to the hobbyist are *Goniopora* spp., *Euphyllia* spp., *Acropora* spp., *Trachyphyllia geoffroyi*, *Heliofungia actiniformis* and *Catalaphyllia jardinei*; with the exception of *Acropora* spp., all of these corals were much less common in trade prior to 1990.

DISCUSSION

Non-CITES organisms

Ornamental coral reef species that are not listed on CITES include, *inter alia*, aquarium fishes, crustaceans, molluscs (other than giant clams), polychaetes, soft

corals, and certain precious corals. Although significant increases in trade have been reported for most aquarium organisms, reef fishes appear to make up the bulk of the trade in numbers and value. Information available on trade in coral reef fishes does not allow an analysis of the volume for individual taxa, making it difficult to determine whether certain fish are being traded unsustainably. However, at one site in Hawaii the top 10 aquarium fish species declined by 59% over 20 years, indicating that the concern for overexploitation may be justified (Clark and Gulko, 1998).

In order to obtain more accurate information on the trade in ornamental fishes and the impacts of this fishery, exporting countries must establish data gathering and monitoring systems. Asia-Pacific Economic Cooperation (APEC) economies likewise recommended implementing mechanisms to track the volume, value and species of LRFF in order to better address trade-driven cyanide fishing (Asia-Pacific Economic Cooperation Marine Resources Conservation Working Group, 1998). For ornamental fishes, data should also include, at minimum, specific information on location of harvest, monthly reports of the volume of exports and species in trade, and the numbers of fishers involved in the harvest (Sadovy, 1992). Collection of trade data is critical for coral reef monitoring. Monitoring programs for coral reef fishes need to collect census data on the distribution and abundance of the targeted species, and combine this with information on the life history parameters and changes in population dynamics over time for targeted species, both in collection and no-collection areas (Tissot and Hallacher, 1999). Importing countries need to establish a database that contains information for each species on the number of live fish imported and the country of origin. These statistics should be shared with exporting countries to allow these countries to verify their trade data.

Limitations of the CITES Appendix II listing for corals

With respect to corals, there are several limitations of the CITES Appendix II listing. The largest, perhaps, is the taxonomic level at which data are collected; there is little taxonomic specificity in trade reports, as corals are not required to be reported to species on CITES permits. Within one genus the abundance of different species varies widely and each species may be affected differentially by varying threats; by only reporting trade to genus, there is the potential to extirpate an uncommon species by over collection. Nonetheless, although the CITES reporting procedures for corals are currently under revision, it would be impractical to report coral to the level of species for all taxa. There are over 500 species of reef-building corals in the Indo-Pacific and some genera, such as *Acropora* spp., consist of up to 110 species, many of which are similar in appearance. Because taxonomic distinctions are extremely difficult, even among trained scientists, it would be impractical to require law enforcement officials to identify every coral to species.

Under current CITES reporting procedures, an accurate estimate of the quantity of coral in trade is not possible. The majority of live coral in trade is reported by item; the dead coral is reported by total weight (per shipment) for each taxa in

some cases, and reported by item in others. Since there is no indication of size or weight of individual corals, there is no reliable means of converting these units to a measure that is useful for coral reef management.

Coral reported as 'Scleractinia' may include unidentified taxa of stony corals, live rock, or reef substrate with attached (non-listed) soft corals. Material reported as Scleractinia in the past often included coral skeletons that could be identified to genus but were lumped together because the exporter or customs official could not properly identify them (Shoup and Gaski, 1995). According to current CITES reporting guidelines, coral reported as Scleractinia is only supposed to include long-dead coral skeletons or other limestone substrate that is not readily recognizable to a higher taxonomic specificity. Today, Scleractinia primarily includes reef substrate, live rock and coral gravel; international trade in coral sand and coral gravel less than 3 mm in diameter no longer requires CITES permits. There are other problems with the CITES trade database yet to be resolved. Specifically, Scleractinia originating in Indonesia consists of coral substrate (e.g., small pieces of reef substrate with one attached soft coral or colonial anemone; 1999 quota is 675,000 items) and coral base rock (e.g., live rock; 1999 quota is 135,000 items) (CITES Management Authority, Indonesia; CITES Notification No. 1999/047). Even though these commodities differ (in size and possibly, type of material), they are currently lumped into one category in the CITES Trade Database.

Most exporting countries claim that coral is being harvested in a manner that is not detrimental to its survival, and collection has a minimal impact on the reef. CITES export permits must include a no-detriment finding; unfortunately, there is very little scientific information to back these claims, and the CITES mechanism does not provide a way to verify this finding in the short term (significant trade review within the Animals Committee of CITES enables some investigation over longer periods). Very few reefs have been surveyed, and there are no recent published data regarding the impact of coral extraction on coral reefs. Several countries that have recently developed management plans for coral harvest, have not developed these in collaboration with an analysis of collection sites to quantify the population dynamics of the taxa in trade and the impacts associated with collection, or to verify whether these reefs have declined over time.

Benefits of the CITES Appendix II listing for corals

Listing on Appendix II allows monitoring of the international trade through a permit system. Despite the limitations outlined above, CITES Appendix II listing has provided a powerful incentive for improving management without discouraging a significant increase in the trade. Using CITES data, it is possible to get an idea of current trends in the trade of a particular listed stony coral as well as relevant information as to whether the trade has shifted. In other words, it is possible to determine whether a country that did not previously export coral is now involved in the trade, and whether different organisms are being traded. It also provides a way to regulate the trade, by preventing the wholesale extraction of a particular

taxon at the expense of the taxon, interdependent organisms, or habitats. Because countries must issue a no-detriment finding in order to trade in a CITES-listed species, CITES promotes projects that assess the status of the resource in trade.

In order to address international concerns associated with their trade in corals, Indonesia has developed a management plan for the sustainable harvest of corals. Indonesia has an association for all coral exporters, the Asosiasi Koral Kerang Dan Ikan Hias Indonesia (AKKII, Indonesian coral, shell and ornamental fish association), which currently includes all 18 licensed exporters; each company employs their own divers (there are no middlemen), and provides training in species identification, coral collection and handling procedures. The management plan for coral harvest includes techniques to minimize collateral damage to the surrounding reef when removing corals, and a 1999 quota of approximately 880,000 live corals (CITES Management Authority, Indonesia). As summarized in a report from the Indonesian government (Ministry of Forestry and Estate Crops of Indonesia, 1998), the quota is divided by species among 10 provinces, and was calculated from available information on rates of growth, recruitment, population distribution and abundance, and the total area of Indonesia's reefs. A maximum size limit of 15 cm for massive corals and 25 cm for branching corals has been imposed, and the trade in recently killed corals is prohibited (as of 1998). The management plan includes a rotational harvest that spreads collection over a large area of reef tract and includes no-take conservation areas. Recommendations for assessment and monitoring within collection areas were also proposed. The strategy of the Indonesian government in marine conservation is to achieve sustainable utilization of marine resources, while protecting critical habitats of commercially important species (Suharsono, 1998).

By providing countries with the opportunity to institute stricter domestic measures, CITES also allows importing parties to effect greater reef conservation. For instance, the European Union (EU) has stipulated that CITES-listed wildlife imports must contain import permits as well as export permits. The EU expressed concern at the CITES Animals Committee meeting in June, 1999 that Indonesia was exporting certain coral taxa at rates that were not sustainable. The EU concluded that trade of seven taxa of corals, at the volumes indicated in the Indonesian management plan, may be harmful to the conservation status of those species based on the principles established in their wildlife trade legislation [Council Regulation (EC) No. 338/97 on the Protection of Species of Wild Fauna and Flora], and EU member states have agreed to suspend imports until a formal review is conducted. These restrictions will be lifted once Indonesia demonstrates that the level of harvest allowed through the quota system is in fact sustainable.

CONCLUSIONS

An analysis of available information on marine ornamentals illustrates the limited understanding of the extent of the trade and the impact of this industry on the coral

reef animals and their habitats. The USFWS plans to separate trade records for ornamental fish into marine and freshwater components in early 2000; however this alone will not provide information on a particular taxa in trade. In addition to an assessment of the vulnerability of coral reef fishes to exploitation, there is a need for the development of a database for coral reef organisms in trade, beginning with fishes, that can be examined by species, country and reef.

The CITES Appendix II listing for corals establishes an international legal framework for the effective regulation of trade and it gives producer and consumer countries a share of the joint responsibility for sustainable trade. It provides for the monitoring of international trade, however limited taxonomic specificity as well as the units of volume recorded on export permits limits the use of this information for management purposes. The CITES reporting procedure for stony corals is currently under review. Proposed changes include improved taxonomic specificity required on permits as well as standardized units of volume, two areas that would clearly improve the usefulness of CITES annual records as tools for conserving coral reefs.

The development of management plans based on sustainable harvest is essential to carry the marine ornamental industry into the 21st century. These plans must include a quantitative analysis of the amount of trade on a species by species basis. Trade statistics must be combined with information on their life history parameters, their distribution and abundance, their role in the ecosystem, the life stage at which they are harvested, their longevity in captivity, and potential threats that affect them and their habitat, including collection methods. It is critical that the total volume of organisms in trade does not exceed the natural rate of replacement, and the methods of collection must be as benign as possible. By improving collection, handling and transport procedures, the amount of mortality throughout the chain of custody will decline. Assuming moderate or no growth in the marine aquarium hobby, improved survivorship in captivity may translate to a reduced demand for wild harvest, thereby diminishing the negative effects of the trade on the threatened coral reef ecosystems of the world.

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