PROCEEDINGS OF THE INTERNATIONAL WORKSHOP ON THE TRADE IN STONY CORALS: Development of Sustainable Management Guidelines

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U.S. Department of Commerce
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PREFACE

The International Coral Trade Workshop sessions consisted of a series of background presentations on the trade, individual country reports, and a discussion of factors that need to be considered for a country developing a sustainable management approach for the stony coral trade. The first session included presentations on 1) the global trends in the stony coral trade; 2) environmental concerns and information needs; 3) import controls and port inspection processes in the U.S. ; 5) mariculture alternatives; and 6) certification for best practices proposed by the Marine Aquarium Council. This was followed by country reports, where workshop participants discussed the status of the industry in their country, existing management mechanisms, information gaps and the types of technical and financial assistance they need to develop a science-based management plan. This was followed by presentations on factors that need to be included in a management plan for the coral fishery, best collection practices, and types of monitoring information needed to determine a sustainable quota , to make a non-detriment finding as required by the Convention on International Trade in Endangered Species (CITES), and to assess impacts associated with harvest.

Because Indonesia is the world's largest coral exporter, much time was devoted to presentations on the coral trade in Indonesia. The workshop opened on April 9 against the backdrop of the Indonesian Minister of Environment's recent announcement that he might consider banning the coral trade in Indonesia as a less costly alternative to the development of legislation and regulations for sustainable management. A keynote speech by the Honorable Sarwono Kusumaatmadja (the Minister of the Ministry of Marine Affairs and Fisheries) emphasized the importance of the coral trade for local economies, the need for better management and enforcement to eliminate destructive practices and other threats to coral reefs, and the difficulties that Indonesia would have to overcome to achieve this. Suharsono (a coral reef scientist that works for the CITES Scientific Authority of Indonesia) explained how he developed a quota system for the harvest of stony corals. He recognized many of the difficulties in coming up with a species by species quota, discussing the lack of information available on the biology, distribution and abundance of many of the species in trade. He asked for assistance in improving their ability to assign a quota to each species to ensure that the harvest is sustainable. A local NGO presented information on the importance of the coral trade for local communities, some of the health and safety issues, user conflicts, and illegal trade concerns.

The Indonesian Coral, Shell and Ornamental Fish Association (AKKII, Asosiasi Koral, Kerang dan Ikan Hias Indonesia) was well represented at this meeting. AKKII is responsible for allocating the quota to their members that is established by the CITES Management and Scientific Authorities of Indonesia, and also serves as a liaison between the government and the exporters. AKKII says it is committed to developing the industry in a manner that ensures its future viability , and is working to develop mariculture techniques to supplement wild harvest. AKKII demonstrated its willingness to work with the international community by assisting in all aspects of this workshop. Also, its commitment and contributions to our follow-up field surveys demonstrated the eagerness of members to work with scientists and the government to obtain monitoring information on the status of the resource to ensure that the established quota is based on sustainable use.

Keynote presentations from areas with coral fisheries, including Australia, Fiji, Solomon Islands, Vanuatu and Vietnam illustrated the degree to which coral resources are harvested, locations of harvest, fishery participants, existing and proposed management strategies, and difficulties government agencies have in managing, monitoring and enforcing the coral fishery. The coral fishery in Australia in primarily for domestice use, and has been well managed for over 70 years. The main difficulty that has occurred in this

fishery has been associated with a shift in the types of coral collected, from a dominance by shallow water branching species for curios to an increase in other types of corals for the live coral market. In Fiji, the market for curio corals began in about 1984, and during the 1990s was expanded to include live rock and live coral exports. Reefs are currently managed under a marine tenure system, which has meant that local communities have established partnerships with industry. One concern has been a rapid growth in exports over the last five years, along with a major loss in coral resources as a result of a bleaching event in 2000/ 2001. In the Solomon Islands reefs are also managed under a customary marine tenure system. Coral has been harvested since 1984, but few records have been kept regarding locations of harvest and volume of export.The Solomon Islands currently lacks a management plan and the number of collectors are unknown. The trade in corals from Tonga began in 1988, and has been characterized by a relatively small number of operators that harvested coral for a few years before stopping operation, followed by new operators coming onto the scene. The government currenlty allows a maximum of 5 aquarium operators per year. The Ministry of Fisheries has developed a code of practice for collectionthat include quantities and locations of harvest regulated through permits. In Vanuatu the trade in corals began in 2000, and is primarily focussed on live rock with some live corals.There is no management plan, but exporters must obtain a license and export permit for each shipment. In Vietnam corals have been traditionally harvested for lime production and only within the last five years has an export market developed for live corals and curio corals. The fishery is notcurrently managed, and collection and export statistics are not compiled.

In the Proceedings, I include background information on the trade, an abstract for each presentation, country reports, and the Working Group reports. I also include the results of the field survey conducted in conjunction with this workshop, illustrating a possible technique to monitor the resource and estimate a sustainable quota. The Proceedings end with an article that compiles the recommendations made by the working group members into guidelines for a sustainable stony coral fishery, which will appear in a book on the ornamental trade later this year. I am grateful to all of the participants, and look forward to working with each of you to implement these recommendations. Together we can ensure that stony coral fisheries are sustainable, and can provide important revenue for dependent communities far into the future.

Andy Bruckner, September, 2002.

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Executive Summary

There is a general belief that the trade in corals and other ornamental coral reef species is contributing to the world-wide degradation of coral reefs, and there is the need for the development of strategies to mitigate negative impacts associated with the trade and ensure sustainable collection. As one step in this process, the United States supported a regional workshop in Indonesia to develop sustainable management principles for stony corals. This included an approach for ensuring ecologically sustainable resource use, best collection practices, and techniques to assess and monitor coral resources. The workshop was attended by 127 participants, including key stakeholders (government, academia, industry and NGOs) from major coral exporting nations (Indonesia, Fiji, Solomon Islands, Tonga, Vietnam, and Vanuatu), other countries that extract coral for ornamental purposes (Australia), and importing nations (The U.S. and European Union). The focus of the workshop involved an examination of the status of stony coral fisheries and trade, perceived problems associated with the trade, current management guidelines, and differences in management mechanisms and experiences among countries that harvest coral. Following a series of presentations by participants, three concurrent Working Groups made up of experts from each country developed guidelines for coral harvest, management and monitoring. The Working Groups compiled recommendations for a sustainable coral fishery based on existing management strategies, best practices proposed by stakeholders and scientists, and local expertise of the working group participants. In addition, NMFS provided training in coral identification for 40 Indonesian law enforcement personnel. At the end of the workshop, twelve participants performed surveys in coral collection areas off of South Sulawesi (Spermonde Islands) to test a pilot survey technique, and to collect information on specific taxa in trade from Indonesia that are currently under trade suspension in the EU.

The management WG recommended that a holistic (ecosystem management) approach is optimal, with consideration of 1) target species, their role in the ecosystem and sustainability issues arising from collection activities in areas impacted by other factors; 2) other species and interactions with the ecosystem; and 3) other natural or anthropogenic stressors causing reef degradation. Zoning is necessary to spatially or temporally separate uses and user groups; this can minimize conflicts, while having a beneficial effect on exploited and unexploited organisms and the preservation of biodiversity. Managers should limit the amount of coral that can be collected in each area, based on the ecological carrying capacity and social objectives for the collection area and the community. If a quota is used as the primary management restriction, this must be set at the level of a geographically defined collection area for each target species, in accordance with ecologically sustainable limits with regards to the abundance, population dynamics and life history characteristics of that species. Overall, the objectives of a management plan for a coral fishery must ensure that exploitation of corals for domestic use and international trade is undertaken without detriment to the ecosystem or its component species.The development of a sustainable management plan must be undertaken with participation and consultation of all stakeholders, with equitable distribution of benefits arising from resource utilization.

The Collection Working Group (CWG) examined five main issues: 1) collection techniques that minimize collateral damage to non-target organisms and the surrounding reef environment; 2) optimal locations of collection; 3) preferred target species; 4) proper handling techniques to maximize survivorship; and 5) obligations of coral fishers. The CWG proposed a maximum size limit for corals, depending on their growth form and life history. Collectors should preferentially target species with high local abundance, fast growth rate, and high rates of reproductive replenishment, as well as species that survive well in captivity. Collection should occur, where possible, in areas of dense coral growth or where competition threatens the existence of a given target species. The number of corals collected from any one area should be low

enough to ensure the potential for replacement and regeneration. Specific collection and handling techniques are necessary for target species to minimize stress and to maximize their health and survival. This includes limiting the distance between the collection site and the holding facility, minimizing exposure to direct sunlight, and ensuring sufficient water changes to maintain ambient temperature and salinity and prevent the build-up of toxic metabolites. The CWG identified a number of species that experience high rate of mortality resulting from collection and/or transport and a low survival in home aquaria, or that may be particularly vulnerable to overexploitation based on their abundance or biology. The CWG suggested that further investigation of these species is necessary to ascertain the nature of the problems, and that a limitation or prohibition on the take of particularly vulnerable taxa may be necessary in the future. The CWG also noted that collection should be prohibited or limited for species that are known to be rare or vulnerable to overcollection in one area, but that species could be collected in other areas or countries if it is more abundant and can be sustainably harvested.

The Monitoring Working Group (MWG) was tasked with identifying an approach to monitor coral reef resources that could address management needs, and also assess ecosystem impacts associated with coral harvest. Effective monitoring requires a tiered approach conducted at different spatial and temporal scales. It should include 1) a baseline assessment of the abundance and size frequency of target stocks and the extent (aerial coverage) of their habitats, as well as that portion of the total habitat where collection occurs; 2) periodic monitoring to detect changes in the resource associated with collection or other impacts; and 3) a combined evaluation and analysis of fisheries data, trade statistics, and field survey information to verify compliance with management measures and ensure that the proposed management guidelines achieve their intended goals. The ultimate goals of a monitoring approach for the stony coral trade are to determine the total allowable catch that a particular management area can sustain without detriment, and to provide feedback that allows a refinement of the quota in response to natural or anthropogenic changes, thereby ensuring that the resource can continue to be utilized without detriment to the target species, associated species or the ecosystem.

Summary of Resolutions from the Management Working Group

1. Coral fishery management should occur at all levels (ecosystem, collector/fisher, middleman, and exporter) to achieve conservative management approaches that can be validated and enforced. This will provide a variety of management mechanisms to ensure that corals and the ecosystem on which they depend are being adequately protected and sustainably utilized.

2. The coral collection fisheries including associated fish and invertebrate species need to be managed in a holistic manner, recognising that it may be difficult to monitor ecosystem impacts. Arrangements need to be flexible and able to take into account other impacts to coral reefs.

3. The preferred management strategy would be to identify defined coral collection areas on a broad reef scale, (or smaller reef scale), and restrict coral collection activities to those areas only.

4. Each country should keep a watching brief on the development of coral culturing technology and evaluate how it might compliment the wildstock management arrangements in place in accordance with the management objectives of that country.

5. Objectives of coral fishery management must ensure that the exploitation of corals for both international and domestic markets is undertaken without detriment to the ecosystem or its component species. Management must enable the participation of all stakeholders and enable the equitable distribution of benefits.

6. Consultation with relevant stakeholders, appropriate to the level of the issue, needs to be undertaken when developing a management plan for the coral fishery. Consultation needs to be transparent, well-organised and well-planned.

7. Some form of limitation to the number of coral collectors and the amount of coral that can be collected should occur. This needs to be appropriate to the ecological carrying capacity and social objectives for the coral collection area and the community. A precautionary approach must be considered if definitive information is not available on the ecological carrying capacity of the area.

8. If a quota is to be used as the primary management restriction, then the quota must be set at the geographically defined collection area in accordance with ecologically sustainable limits and with regard to species-specific sustainability issues. In the absence of sufficient specific information a precautionary approach must be adopted.

Summary of Resolutions from the Coral Collection Working Group

1. The preservation of coral reef framework and non-target benthic invertebrates is essential in all collection activities. Collectors must avoid breaking apart larger colonies or dislodging or damaging corals or other invertebrates located in close proximity to the target coral.

2. Collection can occur in all habitat types, including reef flats, reef slope, fore reef and back reef environments, grassbeds, lagoons, and deeper soft bottom communities, with collectors targeting areas of dense coral growth and avoiding isolated coral colonies. Within a collection area, specific sites should be established for coral collection with certain areas being off limits to collection to serve as refuges, brood stock and to minimize user conflicts. Sites that are closed to collection should include a portion of all representative habitat types in each collection area and contain all target species. Collectors can use snorkel, SCUBA, or hookah diving, provided that the collectors follow dive safety guidelines. Collection should be limited to 25 m depth, as deeper depths will be difficult to monitor, assess collection impacts, or determine sustainable harvest levels.

3. Species targeted for collection should be considered so as to maximize their continued presence and reproductive capacities in any collected area. All species of corals may be harvested, provided that the coral is common enough in the collection site so that its removal will not cause localized extirpations. In some cases particular species should not be collected in certain countries if they are known or thought to be uncommon, until monitoring information demonstrates that they occur at a level that can support limited harvest. These same species may be obtained from other countries where they are more abundant.Collectors should target species with high local abundance, fast growth rates, and high rates of reproductive replenishment, and avoid collecting species with low survivability. A maximum size is established based on the growth rate of the coral, its abundance and its recruitment potential.

4. Fragmentation to obtain small specimens from an adult colony is preferable over removing the entire colony, for species that exhibit high survival of fragments, with no more than 20% of the colony removed or 20% of the cover of a particular species in each collection site. Additional fragments should not be taken from those colonies until they demonstrate complete regrowth.

5. A limit on the number of boats or the number of collectors may be necessary, based on the ecological carrying capacity of the resource and the interests of the community, but additional information is necessary before these limitations can be established.

6. Collectors should avoid damaging other organisms when removing a specimen. However, if breakage occurs, the branches, fragments, or portions of the benthic invertebrate should be secured near the mother colony or used for mariculture and other reef restoration projects.

7. Curio collection needs to be evaluated to ensure sustainability, as the trade targets branching species that are susceptible to mortality from bleaching, predation, storms and other disturbances and the colonies are removed at a much larger size. Corals should only be removed from dense areas, prefrably with a minimum of 50% cover. In addition, the group recommends limiting the size of specimens to the same adopted for live corals, with a maximum allowable size of 25 cm.

8. Both unconsolidated and cemented reef material can be collected as live rock, with unconsolidated material preferable, when available. Collection can occur throughout all reef environments, but removal must not compromise the structure of the reef, it must not convert reef habitats into rubble fields or sand flats, and it must not lead to altered water transport patterns. The working group does not recommend limiting the size or weight of live rock material removed, until further information is available on the potential impacts; however, resource area will determine the total allowable harvest.

9. All collectors, middlemen, exporters and others that handle corals should ensure the highest standards to maximize coral survival. This includes (but is not limited to) minimizing transport time, limited handling (avoid touching polypar surfaces), individual packaging of specimens, frequent water changes, and limited exposure to sunlight.

10. All collectors should be licensed and required to maintain logbooks, ensure that SCUBA gear is in proper working order and divers follow safe diving practices, and participate in training courses.

Summary of Resolutions from the Monitoring Working Group

1. Both fishery-dependent and fishery independent monitoring is necessary to ensure sustainable coral harvest. Fishery-dependent data would be obtained through mandatory logbooks submitted by each coral fisher that include information on the species, size, number of specimens, location and depth of collection, search time and other pertinent information. Fishery-independent monitoring needs to be conducted using a tiered approach, with a flexible design that may change with time, that is undertaken in the context of serving management needs.

2. Fishery-independent monitoring should be conducted at varying temporal and spatial scales, including 1) initial (one-time) country–wide scales to map the total aerial extent of various habitat types occupied by corals; 2) localized assessments at a short-to medium time frame to determine the extent and type of habitats targeted by collectors and their condition; and 3) detailed, periodic monitoring of individual sites to determine the density, cover, size frequency distribution, diversity and other biological parameters of target corals, and also assess impacts associated with the fishery and other disturbances.

3. A monitoring protocol should provide sufficient information to demarcate individual collection sites and to assess the status and trends of the resource, including the distribution and abundance, cover, size frequency distribution, rates of recruitment, and condition of target corals within collection sites, with comparable data obtained for no-collection sites.

4. To determine a sustainable harvest quota for a chosen species, resource managers need to set a range of percentages that coral fishers could take of standing stock, based on the biology of that species or a closely related species and surrounding conditions in the collection site. They then would make a conservative estimate of the population dynamics of the species of interest within a collection site based on monitoring or existing data; set a percentage that can be collected from that site; monitor CPUE over time; and conduct periodic surveys within the collection area to assess resource status.

5. Exporting countries should make use of the best available information for evaluating the impact of potential coral exports on wild populations as per the requirements of CITES. If there are insufficient data to determine the impact of a given harvest, then exports cannot and should not be authorized under the terms of the treaty. However, precautionary management measures can be implemented by using basic information on the species' biology or the population dynamics of similar species. As time and resources permit, more data can be collected through more intensive monitoring programs which in turn allow adjustments to fishery and export controls.

6. All stony corals should be identified at minimum to the level of genus, with identification to species for those taxa indicated by CITES as readily identifiable, as well as any other corals that can easily be identified to the species level. In addition, all corals recorded along transects should be identified (at least to genus) during baseline surveys and during detailed follow-up monitoring to allow appropriate management decisions, as monitoring of only a small group of "notable" species will not be sufficient to ensure sustainable harvest (see below).

7. A detailed baseline assessment evaluating every stony coral taxon should be conducted in each collection site to provide information for the development of a science-based management plan. Detailed monitoring should be repeated one year after the management plan is implemented to ensure that the adopted management measures are sufficient to ensure sustainable harvest. Provided that no changes (or disturbances) are noted within a collection site, the detailed monitoring could then be conducted once every five years. However, rapid assessments using the MAC Monitoring Protocol should be conducted once each year, during periods when the detailed monitoring is not undertaken.

8. Monitoring should be conducted by unbiased parties, including students, scientists, NGOs, and fisheries agencies, with assistance by coral collectors. The cost of monitoring should be divided among the industry, consumers and the fisheries agencies, with financial assistance from developed countries that are the major importers of these resources.

9. In order better understand the impacts of removal of live rock and to develop sustainable harvest guidelines, basic research and monitoring needs to be conducted to determine the rate of deposition of live rock, tthe potential quantity of the resource and the scale over which harvest occurs, time required for replacement of harvested material, the impact of removal on associated flora and fauna and the ecosystem, and effects of removal of rubble versus cemented reef substrate.

10. There is a need for increased collaboration among scientists, resource managers, coral fishers and hobbyists to improve our understanding of the biology of stony corals including growth, recruitment, and effects of habitat, environmental processes, and disturbance on their life history, combined with a greater emphasis on field monitoring to determine sustainable levels of harvest of individual species and in specific areas, and to quantify and mitigate potential harvest impacts.

INTRODUCTION

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Coral reefs, renowned for their high diversity and productivity, are facing increased pressure to supply the world's growing demand for food, ornamental organisms and traditional medicines. Fishing, including coral harvest, is the most widespread exploitative human activity on tropical reefs that 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; Ross, 1984). 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 are the major reef framework constructors in tropical environments. Most reef-building corals exhibit relatively slow rates of growth, but they have the potential to live for centuries and can achieve immense sizes. Corals provide topographic complexity and critical habitat for fish and motile invertebrates and are an important source of primary productivity. The removal of live coral may reduce live coral cover and rugosity, which may translate into a reduced abundance and diversity of fish, including species utilized in artisanal and export fisheries (Dulvy et al., 1995).

Once a coral dies, it's skeleton is colonized by algae and encrusting invertebrates and it becomes cemented to the reef, forming part of the reef structure. Harvest of this material (e.g., "live rock" results in the net loss of substrate that may require decades to centuries or longer to replace, and is considered in some countries as 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. Also, commensal (symbiotic), sessile organisms essential for the health of the reef are removed along with the rock (Maragos, 1992).

Although overharvesting of stony corals can contribute to large-scale changes in species composition and health of the exploited reef community, it is possible to develop a coral fishery in a manner that minimizes destruction to the habitat and does not negatively impact the survivorship and persistence of the targeted species. In many countries regulations have been implemented or are being developed to manage the harvest and trade in corals. At one extreme, this involves a complete prohibition on take and export, such as that implemented in the Philippines and Mozambique in response to catastrophic losses of live coral associated with anthropogenic impacts (e.g., destructive fishing) or natural events (e.g., the 1998 bleaching event). At the other end of the spectrum, countries have developed management plans that allow sustainable harvest, and have proven successful over several decades of harvest (e.g., Australia). Management measures for the harvest of stony corals may include the zoning of reefs for various uses with a provision for areas that are off-limits to take, an annual quota, size limits, and licensing of collectors.

A. Types of coral that are commercially harvested

Corals of commercial value can be divided into five groups: hard corals, semi-precious corals (e.g., black coral), precious corals (e.g., pink, gold and bamboo corals) shallow-water gorgonians (e.g., sea fans) and alcyonarians (e.g., soft corals). This workshop focused on hard or stony corals, including Anthozoans in the orders Scleractinia (all taxa), Stolonifera (organ pipe coral *Tubipora musica*) and Coenothecalia (blue coral *Heliopora coerulea*), and the hydrozoan orders Milleporina (fire corals) and Stylasterina (lace corals *Stylaster* spp. and *Distichopora* spp.). All of the species under consideration are listed on Appendix II of the Convention on the Trade in Endangered Species of Fauna and Flora (CITES).

i. Domestic use

Hard corals are mined for use in construction of roads, jetties and seawalls, as building materials, for production of lime for cement and the betel nut industry, and also for other industrial purposes. Coral is mined primarily from shallow reef flats using iron bars to detach robust branching and massive corals. Preferred taxa include *Porites*, *Goniastrea*, *Platygyra*, *Acropora* and *Favia*. Coral may be used as whole colonies, or it is cut into blocks, crushed for use as aggregate, or burned for production of lime. Coral mining occurs in Sri Lanka, the Philippines, Malaysia, Indonesia, Maldives, India, Fiji and many other countries, and is known to result in large shifts in species composition and abundance, and has caused major changes in fish community structure (Brown and Dunne, 1988). Several countries are establishing strict regulations to minimize this industry, including complete bans on harvest in some areas. Efforts are also underway to provide communities with alternative building materials and more efficient kilns for lime production (Dulvy et al., 1995). As it is highly unlikely that coral mining can be sustainable, this activity should be prohibited.

ii. International trade

Corals are harvested for international trade to supply souvenir and curio markets, and for aquarium displays, jewelry and carvings, human bone graft operations, traditional medicines, and biomedical purposes. A small component of the trade is also used in scientific studies and supplies brood stock for captive-breeding facilities.

Corals for curios and souvenirs are collected when alive, primarily from shallow water, by snorkeling, wading and diving, and may be removed with hammers, chisels and iron bars. Specimens are bleached, cleaned and dried prior to export, and some may be dyed; they are sold intact as "raw coral" or manufactured into carvings, jewelry, inlays for furniture and picture frames, or other items. A relatively small number of taxa are preferred for curio markets; this includes branching scleractinians such as *Acropora*, *Pocillopora* and *Stylophora*, solitary mushroom corals (*Fungia* spp.), and two octocorals, *Heliopora* and *Tubipora*. Colonies harvested as curios vary widely in size, but may be up to one meter or more in diameter, are generally reproductively mature, and can be a decade or more in age. Another concern is that the preferred taxa utilized in the curio trade are those corals that are most frequently damaged during storms, are most susceptible to bleaching, and are often the preferred foods of corallivores such as *Acanthaster* sea stars and *Drupella* gastropods. Corals harvested for curios are a non-perishable product that can be taken from remote locations and transported to export facilities at leisure.

Coral in trade as live specimens (primarily for aquarium displays) consist of a high diversity of taxa and include branching, massive and plating species. The five most common taxa in the live trade are: *Euphyllia*, *Goniopora*, *Trachyphyllia*, *Catalaphyllia*, and *Acropora*, respectively (Bruckner, 2000). The preferred colonies are small in size, and in many cases may not yet be reproductively mature; depending on the taxa, colonies can be from six months to about five years in age. Collection in most countries is carried out by local fishers who free dive or use surface-supplied air; a small number of species can also be collected on reef flats by wading. Because only certain sizes and colors are preferred, fishers often cover large of reef to obtain the desired species; thus harvest is relatively selective. Colonies must be removed carefully to avoid injuring tissue and are held in water with minimal contact with other corals; they must be transported to the holding facility and airport relatively soon after collection. Areas of collection are generally limited to those located relatively near to airports with international flights to minimize rates of mortality.

Another component of the trade consists of material reported on permits as "Scleractinia" which includes live rock, reef substrate, coral gravel and coral sand. Live rock is any hard reef substrate (limestone skeletal material of algal or coral origin) that supports an assemblage of living marine organisms, including coralline algae. Live rock is used to create "living reefs" in home aquarium. Live rock serves as a natural filter; the living microrganisms remove organic wastes and stabilize the pH and alkalinity of the water. Live rock also provides habitat for motile organisms and substrate for attachment of benthic organisms such as stony corals. Live rock may be chipped from the reef substrate in shallow water, or it may consist of loose pieces of coral rubble. The product may be exported with minimal preparation and cleaning, or it may be transported to a holding facility and cured through several washes to remove unsuitable organisms. Live rock is typically exported out of water, wrapped in moist newspaper. Reef substrate consists of small (generally up to 5-10 cm diameter) pieces of reef rock with a single attached soft coral, a colonial anemone or other benthic organism. The organisms of value are the attached invertebrates, but the underlying reef substrate must be removed to minimize damage to the targeted species. Coral sand and coral gravel are also a minor component of the trade reported as Scleractinia, but will not be considered in this workshop.

B. Potential threats associated with overexploitation of stony coral

Corals and relict reef substrate are important natural resources that provide valuable habitat for a large number of associated organisms. This includes sites for the attachment of algae and sessile invertebrates, and structural relief that shelters coral reef fishes and motile invertebrates. Corals also contribute to reef growth and they are an important source of productivity. The harvest of stony corals has potential long-lasting effects on the structure and function of coral reef ecosystems due to their vulnerability to overexploitation, slow rates of growth and irregular recruitment. While other anthropogenic and natural factors may result in much more significant losses of corals and coral reefs, extraction of corals may affect the population structure of corals of interest, and may compound the effects of other stressors. Overall, **unregulated, unsustainable collection of stony corals may** 1) lead to overexploitation, localized extinctions, and reduced coral diversity; 2) result in reduced recruitment potential of that species; 3) cause loss or destruction habitat for fish and other reef animals; 4) lead to increased erosion of the reefs and nearshore environments; 5) negatively affect associated organisms such as commercially important finfish and shellfish; and 6) contribute to user conflict between tourism, fisheries and conservation groups.

BACKGROUND

NOAA/NMFS Office of Protected Resources conducted an analysis of the international trade in stony corals that prompted the U.S. Coral Reef Task Force to identify trade in coral reef species as a major concern to the health of coral reefs, especially in the IndoPacific. We found that in 1997 the U.S. imported about 80% of all live coral, over 95% of the live rock and over 50% of the dead coral skeletons traded internationally, and the trade is increasing by 15-30% each year. While this trade has the potential to be sustainable, these activities are currently contributing to the decline and degradation of coral reefs, primarily through damage associated with coral removal and overharvesting of uncommon species. Based on these findings, the U.S. developed a broad-based strategy to discourage the use of destructive and unsustainable collection practices that includes 1) consultation and capacity building in exporting countries; 2) increased consumer awareness; 3) improved domestic law enforcement of illegal trade; 4) active participation in the international arena to highlight coral trade issues; and 5) the development of measures to reduce unsustainable collection of CITES-listed species, reduce destructive fishing practices, and reduce mortality rates of animals during transport and handling.

NOAA continues to work domestically and internationally to address problems associated with the trade. We are working to improve the ability of customs officials to properly identify corals in trade through training in coral identification. Towards this goal, we developed a coral identification module for IndoPacific corals in international trade. This booklet includes photos, descriptions and a key to corals in trade for use by wildlife enforcement agents, and has been adopted as the standard identification guide for CITES parties. Concurrently, we are developing guidelines for the sustainable harvest of corals in U.S. waters, including recommendations that could be adopted by major exporting countries. We convened this workshop in Indonesia during April, 2001 to assist Indonesia, Fiji, Vietnam and other coral exporting countries in the development of a sustainable management approach for the harvest of stony corals and guidance for best collection practices. The implementation of the recommendations proposed in these proceedings should help promote conservation of coral resources, and ensure that the trade can continue to provide benefits for future generations.

PURPOSE

The purpose of the ***International Workshop on the Trade in Stony Corals*** was to bring together fishers, exporters, importers, government officials, scientists, environmental organizations and the Marine Aquarium Council to develop recommendations for the sustainable management of stony coral resources, best harvest practices, and methods to monitor the resource and impacts associated with the coral harvest.

The workshop included a session where keynote speakers presented talks on 1) the magnitude of the trade; 2) CITES regulations and obligations, reporting requirements and the non-detriment finding for stony corals; 3) environmental and social concerns, including information on the taxa of corals that cannot be exported to the EU and the justification for these suspensions; 4) the proposed MAC certification program; 5) country reports on the extent of coral harvesting (how much coral is exported, how many collectors are involved, where the collection takes place, how it is collected), condition of coral resources, management measures for stony corals, and major problems and needs identified in each exporting country; 6) existing management plans and best collection practices for coral harvest and biological, physical and ecological parameters that should be included in the development of a sustainable approach to coral resource management; and 7) information needed to monitor the resource, determine an appropriate quota, or verify an established quota.

Based on the information presented and the background documents in the workshop manual, smaller working groups developed three guiding documents that can be utilized in exporting nations as a basis for the development and promotion of sustainable resource use, for meeting international obligations (CITES requirements) and for achieving MAC certification requirements. The working group tasks included the development of 1) recommendations and revisions to existing management plans to ensure sustainable harvest of corals; 2) guidance for best collection practices; and 3) monitoring strategies for collection and no collection areas. A training session in coral identification, including distribution of the NMFS coral identification manual, was provided for law enforcement officials from Indonesia. A group of seven certified divers (primarily from Indonesia and including a coral expert from Fiji and the United States, a U.S. hobbyist, and an E.U. NGO representative) also tested the pilot monitoring strategy in one provinces in Indonesia where coral collection occurs (two collection sites), and began collecting information on the population dynamics of the dominant corals in the trade from Indonesia, with an emphasis on those taxa that were subject to trade suspensions in the EU.

WORKSHOP OBJECTIVES

The following is an outline of the objectives for an international meeting on the trade in stony corals that incorporates discussion points generated during meetings of the U.S. Coral Reef Task Force (USCRTF) Coral Trade Working Group since October 1999, and subsequent consultations with stakeholders, including international NGOs, industry, and the Marine Aquarium Council (MAC). The primary focus of this workshop was on capacity building in sustainable management of stony coral and live rock resources harvested for ornamental purposes. It also included the development of a monitoring protocol for stony corals, guidance in best collection practices, assistance on fulfilling CITES requirements and obligations, training in coral identification for enforcement purposes, and possible certification standards for resource protection.

Overall Goal

To bring together a core group of people from the international community involved in the trade in stony corals to 1) discuss the status of the stony coral trade, environmental concerns, and existing mechanisms to regulate the trade and conserve coral resources, and 2) develop guidance on best practices in coral collection, resource management and resource monitoring to ensure sustainable resource use. Participants included government officials (Fishery Management Authorities and CITES Management and Scientific Authorities), international NGOs, industry representatives, coral reef scientists, and a multi-stakeholder international organization developing a certification scheme for marine ornamentals (MAC). Representatives from coral exporting nations (Indonesia, Fiji, Solomon Islands, Tonga, Vietnam and Vanuatu) major importers (the U.S. and E.U.), and countries that harvest coral for domestic use only (Australia) were invited.

A. Develop approaches for sustainable management of stony coral and live rock

Coral fisheries provide a livelihood for many collectors and communities, but they must be managed responsibly to maintain the function and structure of the coral reef ecosystem and to provide environmental services and economic benefits for future generations. Various approaches to coral reef management have been undertaken, and international trade in stony corals is regulated under CITES through an Appendix II listing. The CITES listing for corals includes a requirement that the exporting country make a finding that the trade will not be detrimental to the survival of the species or its role in the ecosystem; however, information needed for the CITES non-detriment finding is often lacking. Also, exporting countries have been unable to incorporate an ecosystem approach to manage the ornamental trade, and guidelines for best practices have not been fully developed or implemented. This workshop provided participants with background information on existing approaches to coral fishery management, beneficial attributes and limitations of these plans, and other approaches to coral management. In a focused working group, participants synthesized available information on coral management strategies, compiled a series of recommendations of possible measures to achieve sustainability in the coral fishery, and developed a draft management plan for a coral fishery that could be implemented in exporting countries. Documents produced during the workshop were sent out for peer-review, modified as appropriate based on expert input, and the final recommendations for coral fishery management plans are presented in this document. The coral fishery management approach will be distributed to all participants and the relevant fishery management authorities.

B. Development of best practices for coral collection

In addition to managing harvest levels to avoid overharvesting, collectors must remove corals in a responsible manner that minimizes collateral damage to the reef. Collectors must ensure that extraction of live rock and removal of living corals does not 1) compromise the structure of the reef, 2) substantially reduce topographical relief or eliminate fisheries habitat, 3) extirpate particular taxa from an area, 4) reduce the viability of coral populations (by removing all the reproductive individuals), or 5) negatively affect their role in the ecosystem. In addition to careful, selective harvesting of corals, corals must be collected and handled such that the likelihood of injuries to tissue or potential infection by bacteria or other pathogens are minimized, and certain taxa may be inappropriate for any collection (due to poor survivability in captivity). With initial guidance from the MACs *Core Collection & Fishing Practices International Performance Standards for the Marine*

Ornamental Trade a small working group developed a series of bestpractice recommendations on 1) how to collect live rock and living corals (i.e. techniques to minimize colony injury and reef damage); 2) where to collect the coral (i.e. site selection, depth, reef zone), 3) what colonies should be collected (i.e. the size of colonies that should be targeted and colonies that should be collected as juveniles versus those that can be fragmented from larger colonies), and 4) specific taxa that should not be collected.

C. Development of a monitoring protocol for stony coral resources in international trade

There has been considerable concern expressed by governments, NGOs and scientists that the harvest and trade in stony corals is contributing to the degradation of coral reefs, and trade in several of the taxa that are in highest demand may not be sustainable at current levels of harvest. However, little information is available to verify these claims, as population dynamics and life history attributes of many of the harvested taxa are poorly known. In addition, few studies have been undertaken to quantify the abundance of these taxa at collection sites, and impacts associated with coral collection for ornamental purposes. The purpose of this portion of the workshop was to develop a protocol that can be used to assess the status of the stony coral resource, provide guidance on estimating the sustainable harvest of particular taxa in trade, and determine the impacts of coral removal on the species and the ecosystem. A focused working group, led by Gregor Hodgson of Reef Check (who has implemented a simple protocol for assessing the affects of human activities on the composition, structure and function of coral reef ecosystems), developed recommendations for the types of information needed in a monitoring protocol that addresses the needs of coral resource managers and coral collectors in quantifying sustainable harvest levels. The workshop coordinator compiled these recommendations into a working group report and a pilot protocol which was tested in Sulawesi, Indonesia. The protocol should provide users with specific guidance on techniques to measure the distribution, abundance, cover and size frequency of the dominant coral taxa in international trade, and techniques to measure impacts associated with the collection of these taxa.

D. Testing the monitoring protocol and assessing coral collection areas

At the end of the workshop, a small group of coral biologists, collectors, government officials and NGO representatives examined coral collection sites and conducted assessments to determine the distribution, abundance and population dynamics of the stony corals within these sites. The intent of this exercise was to determine whether the monitoring protocol is feasible for application in the field, and whether it provides sufficient detail to meet a countries information needs for management and for making a non-detriment finding as required by CITES. Secondarily, this served as a pilot project to assess the condition of coral resources in areas targeted by collectors, and obtain preliminary data on the status of several key coral taxa that form a significant portion of the trade from Indonesia, but are thought to be uncommon and in trade at unsustainable levels. These surveys provide realistic information on the numbers and size of colonies that can be sustainably collected, while preventing overharvesting and minimizing damage to associated reef organisms. The focus of this exercise was to collect data on the abundance of the seven coral taxa that can not currently be exported to Europe due to trade restrictions. Importing countries have expressed concern regarding the quota by Indonesia assigned to these corals, and yet there have been suggestions by local scientists that these corals are much more common than previously reported and they can sustain take at levels provided for in the Indonesian quota.

E. Coral identification

All stony corals are listed on Appendix II of CITES. The CITES listing requires, among other items, that shipments contain an export permit listing the taxa in trade and volume of each taxa. Coral shipments are verified by law enforcement at the point of export and by the importing country. In order to build capacity in coral identification, and reduce the likelihood that a coral shipment is refused at the port of entry because of improper identification and reporting, one component of the workshop involved a brief training session in coral identification. A slide show will be presented on taxonomic features used to differentiate corals, and the use of a CITES identification manual developed in the U.S. that is specific for corals in trade. Participants then visited two coral exporting facilities; they each received the CITES identification manual for corals and had the opportunity to practice their identification skills on live coral specimens using this manual.

Terms of Reference for Working Groups

The participants were divided into three working groups, Management, Collection, and Monitoring, based on their expertise and interest. Each working group had one or two facilitatorsthat were given a series of questions to address regarding the harvest and trade in stony corals. The facilitators led the discussion and compiled a series of recommendations for best practices, relying on information presented by the speakers, background materials included with the workshop booklet, existing or proposed management approaches, and the expertise of the partiicpants. These recommendations were developed into preliminary working group reports that were circulated to all participants after the workshop, and all comments received were incorporated into the final documents by the workshop organizer. The following questions were posed to the working groups:

Management Working Group

1. Who should be regulated by a Coral Fishery Management Plan?

2. Should we manage the coral fishery on an ecosystem, single species or 'corals' basis?

3. What type of information is necessary for the devlopment of a coral fishery management plan?

4. How should a coral collection area be divided (e.g., should the reef be zoned for various consumptive and non-consumptive uses)?

5. What role does coral mariculture, aquaculture and restoration play in management of a coral fishery?

6. What types of ecological, social and economic objectives should a management plan address?

7. Who should be involved in the development of a management plan for a coral fishery?

8. What collection guidelines are needed in a management plan?

9. How many coral fishers should be allowed to collect coral in one area?

10. Is a quota is necessary to regulate coral harvest?

11. How do you establish areas where collection is allowed?

12. How do you measure the effectiveness of a management plan?

Collection Working Group

1. How should stony corals be removed?

2. Where should stony coral collection occur?

3. What species and sizes of stony corals should be authorized for collection?

4. When should collectors remove whole colonies versus portions (fragments) of colonies?

5. How many collectors should operate in one area?

6. What should collectors do if they inadvertantly break non-target corals?

7. What type of collection requirements should be established for corals collected for curios and should this differ from requirements for live aquarium corals?

8. What type of collection requirements should be established for live rock?

9. What guidelines should be established to improve live coral survival post-collection?

10. What handling guidelines are necessary for live rock?

11. What other obligations and reporting requirements should collectors have?

12. What is needed to improve compliance with the proposed collection guidelines?

Monitoring Working Group

1. What type of monitoring should be conducted for the live stony coral fishery?

2. At what scale should fishery-independent monitoring be undertaken?

3. What type of information should a monitoring protocol for an individual collection site provide?

4. What type of monitoring information is necessary to set harvest quotas?

5. What monitoring approaches are needed to meet CITES requirements for export?

6. What level of taxonomic specificity is necessary for field monitoring of collection sites?

7. How often should monitoring occur?

8. Who should be responsible for conducting monitoring and covering costs of monitoring?

9. What type of monitoring should be required for harvest of live rock?

10. What biological information on coral species is currently missing to complete the knowledge that will be gained from the monitoring of commercially harvested reefs?

11. Summarize the steps that should be taken when conducting monitoring, and discuss possible monitoring protocols.

Sustainable Management Approaches for a Stony Coral Fishery

Report of the Management Working Group

Introduction

The major task of the Management Working Group was to discuss many of the issues that would need to be addressed in a formal 'Management Plan' or set of 'management arrangements' for a coral collection fishery in each country. In most cases, Queensland's management arrangements were cited as the model most appropriate to deliver sustainable and conservative management of coral collection fisheries. There were representatives from Indonesia, Vietnam, Philippines, Vanuatu and Australia on the Management Working Group. In all cases, all countries participating in the Working Group discussions were able to agree to a set of resolutions that were reached, and indicate that they were largely achievable in their country.

The following report provides an overview of the resolutions that were reached, the basic questions that were posed and the discussion that took place under each issue prior to formulation of an associated resolution.

1. Who should be regulated by a Coral Fishery Management Plan?

Regulations and restrictions can be placed at any level in the fishery process - from collecting corals to their export. The management tools that can be used at each level differ, and complimentary arrangements can be established that simply and effectively achieve the desired objective of the regulation. The identified levels are described below.

- **Ecosystem level** – includes restrictions on the activities that can occur within an ecosystem, or within defined collection or species-specific areas, that will affect all users (for example: anchoring regulations within an area will affect all users, regardless of the activity they are participating in).

- **Fisher level** – includes restrictions on the activities that can be carried out by the commercial fisher only. This may include a requirement to hold a fishing licence or to comply with size limit or individual quota restrictions. Restrictions such as these would apply to the individual fisher, and all fishers participating in coral collection.

- **'Middleman' or Wholesale level** – includes restrictions that will impact on the person who buys coral from the fisher, and sells it on to the exporter. In some countries this may be also the 'wholesaler' who supplies retail outlets with product. Restrictions that may be used in this level may include a 'buyer's licence', regulated transport requirements, and specific reporting of product.

- **Exporter level** – includes management restrictions that will impact coral exporters. Where CITES listed species are being exported, regulations on the export of coral is required by the convention Restrictions imposed at this level may include requirements to hold an export licence, specific export reporting requirements, holding premises or transport requirements and product audit requirements to enable legal establishment of the chain of custody from collector to exporter. (assuming it exists)

In most countries, regulations at the collector level were not evident. In many cases, the number of participants at the fishing level was not known and possibly consisted of a large number of people at a range of locations across each country. It was felt that Indonesia and Vietnam may have difficulties implementing effective regulations at this level. It was recognised that compliance capability in regional and remote areas in many communities would be low, if present at all.

Marine tenure arrangements in Fiji, Solomon, Vanuatu and Tonga recognises community ownership of marine resources, and local level management in these countries is the responsibility of community leaders and elders. Therefore management in these countries occurs at the fisher level to some extent. The community has an ability to prevent non-community participation and may also have an ability to impose agreed standards or protocols on community members involved in the coral collection fishery. It is probable, in these countries, that the management agency or authority would be different and reflective of these communal arrangements, as opposed to other countries where government would be expected to assume the lead role. In countries where tenure and access has traditionally been administered by the community, it may be the traditionally recognised community structures that are imposing restrictions.

Other countries such as the Philippines and Australia do manage fisheries at the collector level. In addition, Australia manages at the ecosystem level through Great Barrier Reef Marine Park zoning arrangements, and permit and licensing requirements for all reef-based extractive and non-extractive activities.

Resolution: *Coral fishery management should occur at all levels (ecosystem, collector/fisher, 'middleman' and exporter) to achieve conservative management approaches that can be validated and enforced. This will provide a variety of management mechanisms to ensure that corals and the ecosystem on which they depend are being adequately protected and sustainably utilised.*

2. Do we manage on an ecosystem, single species or 'corals' basis?

Management plans or management arrangements can be implemented to protect only single species, a group of species, or a whole ecosystem. Currently, most countries appear to manage those species that are CITES listed (stony corals, or scleractinian corals) so that export approval can be granted that is consistent with CITES requirements. This is a 'minimal' management approach and probably does not satisfy basic protection or sustainability issues associated with the ecosystem requirements of stony coral species. Further, soft corals are not CITES listed, however they make up a significant proportion of the organisms collected to satisfy exports for seawater aquarium markets.

A number of other impacts to coral reef environments were identified that either currently significantly impact on coral reefs, or have a great potential to impact on coral reefs in coral exporting countries. Further, it was identified that in many cases these impacts may be causing far greater negative impacts on coral reef environments than coral harvesting. These impacts include:

- blast fishing;
- cyanide and other chemical fishing;
- coral extraction for building and other uses;
- crown-of-thorns starfish outbreaks;
- bleaching; and
- severe storm, cyclone and other natural episodic damage.

It was questioned (noting that these impacts were already occurring) whether coral collection should be able to continue in already degraded areas, given that the cumulative effect of these impacts far outweighs the expected impacts from coral collection. CITES requires that "export will not be detrimental to the survival of the species" and exports of coral will be limited to maintain them "at a level consistent with its role in the ecosystems in which it occurs". It may be argued then, that allowing coral collection to continue in areas already degraded by other impacts (anthropogenic or natural) is not consistent with CITES management requirements.

Management at an ecosystem level is already occurring to some degree in some coral exporting countries (Vanuatu) and is proposed for Indonesia through their Environment Department. However a systematic and holistic approach to ecosystem management is not being undertaken in most countries.

It was identified that ecosystem management requires a high level of monitoring and may incur greater costs. This may be a disadvantage of an ecosystem management approach. However the short-term costs of adopting ecosystem management may be offset by advantages gained for all stakeholders from a better understanding of the overall ecological health and productivity of reef systems, particularly if all stakeholders share the costs. It was recognised however, that monitoring and research on a single coral species, or group of identified species, is easier in terms of time and costs than ecosystem monitoring.

Given the potential effect to coral reefs from natural impacts such as crown-of-thorns, bleaching or cyclone/ storm events, flexible arrangements need to be implemented that are able to take into account these concerns and ensure that timely adaptive management occurs. Management response should take into account the severity of the natural impact and have an ability to assess damage and likely sustainability issues arising from further collection activities.

Resolution: *The coral collection fisheries including associated fish and invertebrate species need to be managed in a holistic manner, recognising that it may be difficult to monitor ecosystem impacts. Arrangements need to be flexible and able to take into account other impacts to coral reefs.*

3. Fishery dependent information

In addition to independent research and monitoring information, it was recognised that fishery dependent information is also required for effective ongoing monitoring and assessment of coral fisheries and their dependent ecosystem components. While the group developed no formal recommendation, various concerns were raised regarding the ability for many countries to promote fishery dependent logbook information. Catch, effort and location information is critical for ongoing fishery assessment, and is recommended as an important source of management information for all countries exporting or collecting coral.

4. Zoning, or spatial coral management

Zoning is used widely to spatially or temporally separate uses, or user groups, in the marine environment. The use of zones and 'protected areas' or sanctuaries assists in minimising conflict issues and has been demonstrated to have beneficial effect on exploited and unexploited species and the preservation of biodiversity.

Many countries exporting coral also rely on tourism as a major source of revenue. Tourism and coral collection activities do not easily coexist and in many places spatial separation of these activities has occurred (eg. in Bali, coral collection for building is prohibited).

Various zoning and 'protected area' arrangements are already implemented in coral exporting countries. These range from small scale protected areas only in 'National Park' areas, to 'protected areas' where small scale collection is authorised to occur. Many of these arrangements are not adequately enforced, as compliance capability in some countries is low, particularly in remote areas, where protected areas often tend to be located.

The protection of areas from coral exploitation was identified as a beneficial management principle. It was recognised as providing refugia for adult spawning corals, enabling them to serve as a source of recruits to exploited areas.

Identified areas specifically set aside for coral collection may provide benefits and promote sustainability of coral fisheries. Benefits of such an approach might include:

- maintenance of biodiversity;
- availability of significant amount of reef as a source of coral replenishment and recruits;
- provision for focused monitoring and research on coral exploitation in the specific locations;
- increased capacity for compliance and enforcement. Resources can be directed into specific locations;
- conflict minimisation between various user groups (particularly tourism).

Flexible arrangements are necessary to alleviate the impacts from natural influences (bleaching, storm damage, crown-of-thorns), and a careful selection process in consultation with fishers, local communities and other stakeholders would be critical in the success of such management initiatives.

Coral areas may be identified for a specific quota and support a number of collectors, or may be on a smaller scale and support collection by one operator only.

Resolution: *The preferred management strategy would be to identify defined coral collection areas on a broad reef scale, (or smaller reef scale), and restrict coral collection activities to those areas only.*

5. Role of coral mariculture, or reseeding coral

It is recognised that the emergence of coral culture and restocking may assist to alleviate the pressure on wildstock resources for some species and may, properly managed, provide sustainable skill-based economic opportunity and foster increased resource stewardship. However, it was also recognised that due to high labour costs it may remain unviable in some countries where there are strict aquaculture regulations or where, for example in Australia, other issues such as maintenance of World Heritage Values take precedence.

While coral culture and reseeding, in appropriate areas and circumstances are activities to be encouraged it needs to be recognised that mariculture, in open systems, does carry with it a level of risk and should not be seen as a substitute for the ineffective management of wildstock coral collection. There are unresolved issues

There are unresolved issues surrounding reseeding, such as genetic translocation, and possible loss of biodiversity and ecosystem resilience. Prudent wildstock management will be required to manage emerging culture activities such as broodstock collection, spat collection, and location of culture sites.

Resolution: *Each country keep a watching brief on the development of coral culturing technology and evaluate how it might compliment the wildstock management arrangements in place in accordance with the management objectives of each nation.*

6. Objectives of management

All plans must have clear objectives that describe the desired outcomes from the implementation of the plan. Each management initiative must go part of the way to delivering a specific objective, and the overall package of management strategies should aim to achieve all the objectives outlined in the plan.

Ideally, the strategies for meeting the objectives should be able to be measured. However, this is often difficult and requires sophisticated monitoring and assessment programs.

The benefits to individuals and the communities relying on coral fisheries are important. Communities must be able to recognise the benefits associated with good management to influence their behaviour, promote a sense of stewardship and generate voluntary compliance with the management plan. Implementation of coral collection best practises using standards developed by the Marine Aquarium Council (MAC) or using other standards that may satisfy Marine Stewardship Council (MSC) certification may reduce wastage, create better market opportunities, and positively influence prices available to both fishers and marketers at export level.

Objectives for the management plan for coral fisheries must address the following:

- Ecological, environmental and habitat issues so as to ensure adequate maintenance and protection of the integrity of coral reef ecosystems.

- Social and human impacts so that benefits available from the coral fishery are optimised and are effective over the long term. Benefits may accrue to individuals associated with the coral fishery, or to the community and associated industries relying on coral fisheries.

- Economic and financial issues associated with the fishery to optimise the economic benefits associated with accessing coral resources.

Resolution: *Objectives of coral fishery management must ensure that the exploitation of corals for both international and domestic markets is undertaken without detriment to the ecosystem or its component species. Management must enable the participation of all stakeholders and enable the equitable distribution of benefits.*

7. Consultation requirements

Consultation with stakeholders on the implementation of appropriate coral fishery management arrangements will provide a number of benefits including:

- promotion of a sense of community ownership over the outcomes and the development of a sense of stewardship;

- incorporation of the best available local information on coral reef environments and local users and impacts;

- better community understanding of the need for coral fishery management arrangements; and

- better understanding and acceptance of the management initiatives within the community and the stakeholders.

It is recognised that end users are important; that they are the persons driving demand and that their active support for appropriate ecologically sustainable management arrangements is both highly desirable and advantageous. This is viewed as a high level objective and, if it is to be achieved, it requires coordinated international action and consumer education

The Working Group identified relevant stakeholders with whom consultation should be carried out when preparing a management plan for the coral fishery. These included:

- Government – fisheries, environment, local, trade, industry, lands, compliance personnel (ie navy, fisheries patrol, rangers etc), legislators, mining, agriculture, public works, education;
- Non-Government Organisations – environmental and business;
- Collectors, fishers (including food fish stakeholders);
- Industry associations;
- Tourism;
- Traditional leaders/indigenous community members;
- Post harvest sector/ processing (middleman);
- Religious leaders;
- Local media;
- Scientists/researchers; and
- Consumers

Resolution: *Consultation with relevant stakeholders, appropriate to the level of the issue, needs to be undertaken when developing a management plan for the coral fishery. Consultation needs to be transparent, well organised and well planned.*

Specific Coral Fishery issues

8. Collection and post harvest methods

Collection of coral should only be undertaken using approved non-destructive methods. Encouragement for industry to develop a 'code of practise' should occur, and relevant government agencies should consider endorsing the code. All countries should work towards a training regime where collectors become licensed or certified. Post-collection handling should be considered as a part of this 'code of practise' to maximise survival of coral and minimise wastage as this will have both economic and environmental benefit.

9. Number of fishery participants

In many countries, the number of people participating in the coral fishery are not identified, licensed or limited in any way. In working towards implementing regulations at all levels, licensing of collectors is paramount in progressing management arrangements to ensure sustainable coral fisheries.

The number of fishery participants can be limited by a number of methods, including:

- limit the number of boats that are permitted to work in a coral collection area;
- limit the number of people that are permitted to work in a coral collection area; or
- limit the individual people who are permitted to work in a coral collection area.

The development or implementation of a quota for a coral collection area and any limitation on the number of collectors needs to be linked with the ecological carrying capacity of the coral collection area. Further, the socio-economic and cultural requirements of collectors and dependent communities needs to be taken into account when deciding the number of people that the coral fishery can sustainably support.

Resolution: *That some form of limitation to the number of coral collectors and the amount of coral that can be collected occurs. This needs to be appropriate to the ecological carrying capacity and social objectives for the coral collection area and the community. A precautionary approach must be considered if definitive information is not available on the ecological carrying capacity of the area.*

10. Coral quota

Quota was used by some countries as the primary management measure for their coral fisheries (Indonesia, Australia). Other countries did not have any quota or limitation in place for collection or export.

Export quotas are not considered to be an appropriate management measure to ensure sustainability of the reef ecosystem. As the Working Group discussed, export quotas do not necessarily limit collection because they do not reflect, and are not inclusive of, the wastage and mortality of coral between collection and export. If quota is to be used as the primary management control, then it is strongly recommended that the quota reflects the actual amount of coral that is collected from the reefs.

11. Location of coral areas

The location of coral collection areas need to be defined in consultation with the local community. In many circumstances, community members will have intimate knowledge of the local environment and other user-groups that utilise reef resources in their locality. The ability to enforce collection areas should also be taken into account and in many instances remote locations will be difficult to enforce.

Geographical range of coral collection areas must support the species being demanded by the coral market. Some coral areas may be developed for certain species only, to ensure that the market is being supplied with the required coral species at an ecologically sustainable level.

The location of coral collection areas should consider sustainability of sites and take into account known anthropogenic impacts and previous or ongoing impacts from storms, bleaching or crown-of-thorns starfish. Ideally, coral reefs suffering from these impacts should be protected from collection to allow recovery to occur. Site rotation may be a viable management option.

12. Reference points, or trigger points

Reference points, or trigger points are used in management planning to measure the objectives of the plan and management effectiveness in maintaining the resource. A management plan for coral fisheries should identify reference points which may indicate that the fishery may be approaching its sustainable limits. A management plan may also identify other reasons to trigger a review such as major bleaching events or storm damage or other non-anthropogenic impacts .

For example, the catch per unit effort (CPUE) may over a period decrease for a particular species, and may hit a predefined 'reference point' which triggers the management agency to investigate the decline. It is important that other information (including fisher anecdotal information) is used to validate the reference point, as sometimes such CPUE decreases will not indicate a decline in the abundance of the species. However if a trigger point is reached agreed actions should be taken. Ideally actions taken should be pre-negotiated. In coming to agreement on reference or trigger points it is important to consider what action will be taken, how it will be taken and most importantly when it will be taken.

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Collection Guidelines for Stony Corals and Live Rock

Report of the Coral Collection Working Group

Introduction

The major task of the Coral Collection Working Group was to develop guidelines for coral collection that 1) can help prevent overexploitation of harvetseted taxa; 2) ensures the viability of coral populations; 3) minimizes damage to the coral reef and associated organisms; and 4) maintains the species at a level consistent with its role in the ecosystem, including the creation of habitat, a potetntial food source, and contribution to reef accretion. These guidelines were developed based on existing collection techniques, current laws and regulations, recommendations of coral reef scientists and environmental groups, proposed requirements of the Marine Aquarium Council's certification scheme, and the expertise of the working group, which included scientists, coral collectors, coral exporters and hobbyists.

The following report provides an overview of the resolutions that were agreed upon, based upon the basic questions that were posed by the workshop coordinator. In several cases, working group consensus could not be reached, partially because of differences in experience and variations in existing regulations within coral collection countries.

1. How should the corals be removed?

The only tools that should be used for collection are ones that are recognized to effectively remove appropriate coral specimens and which produce minimal damage to the target species, associated organisms, and the surrounding coral reef structure. These include pinch bars, small hammers and chisels, and snippers (scissors, etc.).

There will be absolutely no uprooting or breaking apart of large or parent colonies in order to obtain ideal or smaller pieces for sale.

Gloves should not be used for collections as they may abrade the coral. Furthermore, we believe use of gloves to promote the likelihood that unnecessary or overly damaging collecting behavior may result, including uprooting or careless separation of fragments that cause excessive damage to the parent colony.

Resolution: *The preservation of coral reef framework and non-target benthic invertebrates is essential in all collection activities. Collectors must avoid breaking apart larger colonies or dislodging or damaging corals or other invertebrates located in close proximity to the target coral.*

2. Where should coral collection occur?

Corals that are prefered for home aquaria occur in reef environments, as well as grassbeds and soft-bottom habitats. At this time, all sites, habitats, and reef zones are deemed appropriate for collection based on habitat type alone. This ensures a higher diversity of growth forms and species, spreads collection throughout the reef and associated environments, and reduces harvesting pressures in individual locations. The only exception will be that corals shall not be collected from the reef crest, as aquarists cannot feasibly duplicate the wave energy to which these colonies are exposed, and this results in unacceptable levels of mortality for collected specimens. In addition, it is important that specific areas of each habitat type are closed to coral collection.

At this time, it is recommended that collection be made, where possible, in areas of dense coral growth or where competition threatens the existence of a given target species. Collecting from areas of isolated coral growth will be permitted until monitoring can assess that limitation or prohibition is required in such areas, or if other factors listed herein are not met. If information exists that deems such areas are not suitable or feasible for collection, no collection shall be allowed.

Several countries have sugggested to limit coral collection activities to shallow water by allowing only the use of snorkeling gear. For instance, in Tonga collection is currently allowed only in one or two zones. Yet, a number of preferred taxa are found only in deeper depths and this approach concentrates collection in a limited area which may cause gfreater environmental impacts than a collection area that encompasses a broad horizontal and vertical range. At this time, there is no recommendation as to limiting collection for targeted species to snorkeling depths only. However, it is important that collectors follow safe diving practices (see below), and divers limit collection of species to depths of 25 m or less. Deep-water collections (>25 m) should be subject to limitation or prohibition, due to the difficulty of determining sustainable harvets levels or obtaining monitoring data of the status and trends of the resource.

No recommendations are made from this working group regarding closure of a site. It was decided that this is an issue more appropriately determined by management and monitoring working groups. However, it should be the responsibility of the collectors to notify appropriate groups, people, or authorities of the condition of collected areas, especially if the condition of the resource has changed substantially from prior visits, or if impacts or activities are noted which may jeopardize the structure or function of the reef. Also, collectors should refrain from collecting in an area that has been impacted by a recent disturbance.

Resolution: *Collection can occur in all habitat types, including reef flats, reef slope, fore reef and back reef environments, grassbeds, lagoons, and deeper soft bottom communities, with collectors targeting areas of dense coral growth and avoiding isolated coral colonies. Within a collection area, specific sites should be established for coral collection with certain areas being off limits to collection to serve as a refuge,as brood stock, and to minimize user conflicts. Sites that are closed to collection should include a portion of all representative habitat types and include all target species. Collectors can use snorkel, SCUBA, or hookah diving, provided that the collectors follow dive safety guidelines. Collection should be limited to 25 m depth, as deeper depths will be difficult to monitor, assess collection impacts, or determine sustainable harvest levels.*

3. What types and sizes of corals should be collected?

The working group does not recommend a prohibition on the take of any species of coral at this time, however it is recommended that collectors limit the collection of those species that are rare or do not survive well in captivity. Several groups are developing lists of suitable and unsuitable species, and this issue will have to be reevaluated. It may be appropriate, after further investigation , to reduce collection pressure on some species that are currently regularly collected and made available to the general market by being made available only by special order. This may be an effective means of both limiting harvest pressures on rare species or species that have low survivability in captivity, while ensuring availability of specimens for scientific use, in furthering advances in husbandry technique, etc.

In an effort to eliminate waste through “box stuffing”, substitutions, or unrequested collections, only corals that are ordered should be collected or made available.

In the interest of preserving the resource as a whole, and for the long term ecological sustainable development (ESD) of this trade, it is recommended that species targeted for collection have high local abundances in the collection site, fast growth rates, high rates of reproductive replenishment, and high survivorship during collection, handling, and export.

Species targeted for collection shall be considered and be periodically updated as to their ability to be successfully used for end use purposes. Several species are identified for having low survivability in aquaria, or may have survival issues that need to be addressed. This includes the following corals: *Heliofungia actiniformnis, Stylaster* spp., *Distichopora* spp., *Goniopora* spp., *Tubastraea micranthus*.

Two examples of end-use problems arising as a result of trade are *Goniopora* and *Catalaphyllia*. Most species of *Goniopora* spp. have low survivability in captivity in most importing countries, but some, such as *G. panadoreaensis* are reported to survive in some cases. *Catalaphyllia jardenei* is generally extremely easy to maintain, but specimens for certain countries are recently showing physical signs of unknown etiology that severely compromises their health. High quality specimens of this species are currently being exported at low levels from countries such as Tonga, and these should continue to be available provided that they are sustainably harvested. In such cases, management and monitoring activities are needed to ascertain the nature and location of the problem, and the species should be prohibited for export from specific locations, especially when significant harvesting pressures are present.

In addition, species collected for the live coral trade generally known to have a high rate of mortality resulting from collection and/or transport, or a low rate or probability of long term success in an aquarium, shall be considered for potential limitation or prohibition of harvest. While common, fast growing branching corals are generally preferable to collect over the less common, infrequent recruiting massive coral species, these types of corals should also be subject to limititations if exporters are unable to demonstrate that the species has an acceptable rate of survival during shipping. For instance, both *Acropora* and *Stylophora* colonies exported from Tonga are reported to have low survivability during shipping, and even specimens that are slightly damaged or bleached are rejected and discarded (A. Petelo, Tonga Fisheries, 2002).

Species targeted for collection shall be considered as to their life history and abundance. Limitations on levels of colection or complete prohibitions of certain species may become necessary in the future based on information on their local abundance. These prohibitions should extend only to specific collection sites or countries, while the species may still be in trade from other locations where they are known to be more common. Monitoring plans are essential to provide information on species for which there is significant harvesting pressure and little scientific knowledge of their respective life history or abundances. In particular, monitoring data are required to ascertain the abundances of several highly targeted species that are currently believed to be rare. This includes: *Euphyllia* spp. , *Nemenzopyllia turbida, Cynarina* spp., *Plerogyra* spp., *Physogyra lichtensteini*, *Catalaphyllia jardinei*, *Trachyphyllia geoffroyi*, *Trachyphyllia (Wellsophyllia) radiata,* and *Hydnophora* spp.. The European Union (EU) recently prohibited imports of these taxa from Indonesia, due to concerns that they are rare and are being traded at unsustainable levels. However, the EU recently (May 2002) lifted the prohibition on *E. ancora, E. glabrescens, T. geoffroyi* and *Hydnophora* spp. in response to a reduction in the quota and new information on the abundance of these taxa.

Size classes for collections have been designed to facilitate collection and transport, ensure marketability, minimize reef impact, and maximize a continued presence and reproductive capacity. Currently, Indonesia has established a maximum allowable size of 15 cm for slow-growing corals and 25 cm for fast-growing

corals. While the Working Group recommends that collectors primarily take corals only within these size classes, they recognize that a small portion of their corals may be larger, to fill special orders for educational purposes, medical use and/or public aquaria. Special orders for specimens larger than the recommended maximum sizes should be dealt with on a case by case basis and must be coordinated with the governemnt agency in the exporting country responsible for managing the coral fishery. Farmed or cultured corals may be provided at any size, provided that they survive shipping.

The working group designates the maximum size of wild-harvested corals as follows:

1. Massive and submassive corals – 15 cm maximum diameter

2. Branching corals – 25 cm maximum branch length or colony diameter. It is preferable that branches be collected from mature colonies rather than collecting small, reproductively immature colonies. The group noted that most targeted branching corals have a relatively high abundance and high rates of recruitment , and collection of smaller individuals does not appear to currently pose a threat to the resource in those areas that have not been impacted by bleaching, *Acanthaster* outbreaks, storms, or other disturbances. As such, smaller colonies may still be collected in areas with over 30% live coral cover. It is also recommended that any coral fragments broken during anchoring or other activities be used as collections or replaced as noted in our protocol for managing broken or damaged colonies.

3. Plating and foliose corals – 25 cm maximum diameter across the upper, polyp-bearing surface of a specimen. Other conditions should be the same as for branching corals.

4. Special consideration is made for certain species which are highly targeted for collection and which do not fit in the above groups. In large colonies of *Euphyllia* spp. , no more than one specimen may be removed from an individual colony and the size shall be 25cm maximum across the upper polyp-bearing surface. For other uncommon corals, including *Nemenzopyllia turbida, Plerogyra* spp., *Physogyra lichtensteini*, *Catalaphyllia jardinei*, *Trachyphyllia geoffroyi*, *Trachyphyllia (Wellsophyllia) radiata*, a maximum size of 15 cm is recommended.

5. Solitary corals – many species such as *Cynarina lacrymalis* and *Scolymia* rarely exceed 20-25 cm in maximum diameter, while certain fungiids may grow much larger. Given the rare nature of *Cynarina* and *Scolymia*, maximum colony size should not exceed 10 cm. For the Family Fungiidae, a maximum allowable size of 15 cm across the maximum length or diameter of the upper, polyp-bearing surface of the species.

Resolution: *Species targeted for collection should be considered so as to maximize their continued presence and reproductive capacities in any collected area. All species of corals may be harvested, provided that the coral is common enough in the collection site so that its removal will not cause localized extirpations. In some cases particular species should not be collected in certain countries if they are known or thought to be uncommon, until monitoring information demonstrates that they occur at a level that can support limited harvest. These same species may be obtained from other countries where they are more abundant. Collectors should target species with high local abundance, fast growth rate, and high rates of reproductive replenishment, and avoid collecting species with low survivability. A maximum size is established based on the growth rate of the coral, its abundance and its recruitment potential.*

4. Should collectors remove only whole colonies or portions of colonies?

Certain branching and plating coral species can be fragmented, with a high survival of the remaining parent colony and the fragments. The working group recommends that collectors remove fragments from large branching and plating colonies, rather than removing whole small colonies when possible.

In all cases, only a small percentage of a parent colony may be harvested, and further harvest from that parent colony may not occur until healing or regrowth from previous collections has occurred. Injury mitigation from fragmentation, such as by using epoxy or cyanoacrylate to discourage opportunistic infection of fouling by epilithic organisms, should be encouraged.

Resolution: *Fragmentation to obtain small specimens from an adult colony is preferable over removing the entire colony, for species that exhibit high survival of fragments, with no more than 20% of the colony removed or 20% of the cover of a particular species in each collection area. Additional fragments should not be taken from those colonies until they demonstrate complete regrowth.*

5. How many collectors should be allowed to remove coral in one collection area?

The working group recognizes that certain countries (Australia) have licensed particular collection sites to individual collectors, while multiple collectors work in one collection area in other countries (Indonesia).

No recommendation is made to limit the number of collectors per site. Collection impact, provided that other guidelines are followed herein to ensure ESD, should be largely independent of the number of people working at a site. However, it is also recognized that limiting collectors is an effective way of preserving an exploited resource, and that the nature of the resource will determine limitations on the number of allowed collectors. Data must be provided before appropriate limits can be made.

Resolution: *A limit on the number of boats or the number of collectors may be necessary, based on the ecological carrying capacity of the resource and the interests of the community, but additional information is necessary before these limitations can be established.*

6. What code of practice should be established to address inadvertent damage to reef resources?

If corals or other reef organisms are inadvertently broken at any stage during the collection process, unutilized coral fragments should be placed as near to the point of breakage as possible, affixed or placed carefully within or on the framework so as to be stable (allowing for regrowth and healing processes to be maximized), and that the polyps face upward or outward, depending on replacement location. Broken edges should be placed so that water currents flush the area and encourage tissue regrowth, and living tissue should be in contact with the substrate.

Broken organisms should not be placed next to a different species to minimize detrimental competitive interactions. Whenever possible, coral fragments that are broken during collection should be used for mariculture or reef restoration projects.

Resolution: *Collectors should avoid damaging other organisms when removing a specimen. However, if breakage occurs, the branches, fragments, or portions of the benthic invertebrate should be secured near the mother colony or used for mariculture and other reef restoration projects.*

7. Should requirements for collection of curio corals differ from those established for live aquarium corals?

The dominant taxa collected for curios include *Acropora*, *Pocillopora*, *Heliopora* and other branching species, as well as free-living fungiids. Most often, these are removed from very shallow water, and specimens are substantially larger in size than live corals taken for aquaria. The trade in curio corals is currently prohibited in Indonesia. In addition, the participant from the Fisheries Ministry of Tonga recommended that the collection of corals for the curio trade should be prohibited, and a greater emphasis should be placed on artificial corals for decorative purposes.

In Fiji, one scientist recommended curio collection be confined to areas with greater than 50% live coral, whereas aquarium corals could be collected from areas with greater than 30% cover (Bowden-Kerby, pers. comm.). His recommendations also included the removal of no more than 20% of the live cover and no more than 50% of the cover of a particular species, with collection confined to areas with dense coral growth. However, the Working Group felt that removal of 50% of the cover of a species was too high.

At this time, only size recommendations are made for the collection of curio-type or dead corals. These should be restricted to the sizes listed above regarding live corals, with a maximum size overall of 25 cm diameter or height. The parties present have too little information on the scope and nature of this trade. It is recommended that issues be addressed immediately with parties more able to assess this trade.

Resolution: *Curio collection needs to be evaluated to ensure sustainability, as the trade targets branching species that are susceptible to mortality from bleaching, predation, storms and other disturbances and the colonies are removed at a much larger size. Corals should only be removed from dense areas, preferably with a minimum of 50% cover. The group also recommends limiting the size of specimens to the same adopted for live corals, with a maximum allowable size of 25 cm.*

8. What collection guidelines are needed for live rock?

Coral exporting countries have established different regulations for the type of material that can be removed and exported as live rock. In Indonesia, only loose rubble (recently broken coral branches) can be collected, while Fiji only allows the removal of reef material that has become cemented into the reef structure. If unconsolidated or unattached material is present, this group considers it likely that it would be the most appropriate material for collection. The breaking of hard substrate may be counterproductive to settlement and may negatively impact the structure of the reef. However, variability in the individual resource must be considered, and cooperation with monitoring and management groups is necessary to avoid resource or habitat loss.

The resource area will largely determine collection of live rock. It has been shown that because of the size of the resource in most areas, ESD is possible. Furthermore, some research suggests that collections can be made that actually enhance or promote habitat (Lovell, 1999). Live rock mining to create tidal pools should be studied as a potential mechanism to enhance biodiversity.

No recommendations are made regarding the zone of collection, noting that the reef flat or areas immediately inshore from the reef crest have the highest abundance of material. However, it is critical that reef flat mining does not compromise the basic habitat structure of the reef, collection should not destroy tidal pool environments, collection should not convert rocky habitats into rubble or sand environments.

Collectors should avoid breaking through the elevated "algal rim" at the edge of the reef flat, as this serves as a dam that traps water on the reef flat during low tides.

There are no recommended sizes or weight restrictions suggested at this time. Tools to be used should be a hammer and chisel at most, with no tools required for unattached material.

No recommendations are made limiting the number of collectors per site so long as the area is properly managed. The Working Group felt that limiting collectors is in the best interest of the resource. However, the participant from Tonga felt that limitations on total export, rather than a limitation on the number of collectors was a better approach to manage live rock resources.

One of the most significant aspects of live rock collection resulted from the halt of collection in Florida for the US market. Because of widespread availability of the Pacific live rock resource, prices on the market have fallen dramatically. As a result of a market demand for continued inexpensive live rock, the treatment and transport of live rock is compromised. This resource contains a myriad of benthic life that should be collected and handled with diligence and care.

Resolution: *Both unconsolidated and cemented reef material can be collected as live rock, with unconsolidated material preferable, when available. Collection can occur throughout all reef environments, but removal must not compromise the structure of the reef, it must not convert reef habitats into rubble fields or sand flats, and it must not lead to altered water transport patterns. The working group does not recommend limiting the size or weight of live rock material removed, until further information is available on the potential impacts; however, resource area will determine the total allowable harvest.*

9. What guidelines for handling can be adopted to maximize coral survival?

The care and handling of collected corals must be done at all stages so as to minimize stress and to maximize and ensure their health and survival to the exporter. We have identified the following stressors that may significantly increase mortality resulting from collection and proposed solutions:

a. Distance and time from collection site to exporter or other acclimation facility should be minimized. Unacceptable mortality rates arising from long transport without adequate packing and care to ensure optimal health are any above 1%.

b. Water quality - The production of mucus and/or secondary metabolites resulting from collection and/or breakage has the potential to severely compromise the integrity of a specimen. Water changes to containers should be made at least every two hours, and flushing be done by rinsing away excess mucus prior to placement in any container or storage facility and acclimated. Following acclimation, requirements are that proper packaging and transport are provided to ensure the aforementioned 1% mortality.

c. Sunlight – Exposure to direct sunlight may result in bleaching, photodamage, excessive heat, or increased salinity. Shading or covering of collected specimens is required to protect them from direct sunlight.

d. Temperature – All collections should be maintained in water less than $29^{o}C$ by whatever mean necessary that also allows the fulfilment of other requirements herein. Suggested methods are water changes, ice baths (but not direct application of ice to storage water), and shading.

e. Salinity – Collections should be made so as to maintain normal seawater salinity. Suggestions include frequent water changes where evaporation may be occurring and corals must be protected from freshwater sources such as rain.

f. All specimens should be maintained with one specimen per plastic bag (where used) or carefully isolated from other colonies to prevent mechanical damage or biologically competitive and damaging behaviours.

g. Handling of collected coral should be done gently and minimally, avoiding the living polyps as much as possible, and handling from the base or skeletal material only if possible.

h. Removal of fouling organisms, such as sponges, should be done in the field to prevent unnecessary loss or damage to collected specimens.

i. There will be no stacking containers or collections of specimens.

j. This group recognizes that various cultures have traditional collecting containers. It is suggested that plastic bags are likely the most appropriate for transport of many targeted species. However, collecting trays with corals protected or wrapped, various bins fitted with sponges, etc., may be effectively employed. It is important that any other materials used be non toxic to the organisms collected; for example some plastics can be toxic, and many sponges contain mildewcides. It is also recognized that some targeted species may fare better under such conditions and that water changes, recognized as being of critical importance, may be facilitated by the use of alternative means than plastic bags. The criteria required is that the above conditions be met at all times, and that containers are covered and cleaned to prevent accidental introduction of or exposure to noxious or toxic elements, such as boat fuels, paints, cigarette ashes, etc.

Resolution: *All collectors, middlemen, exporters and others that handle corals should ensure the highest standards to maximize coral survival. This includes (but is not limited to) minimizing transport time, limited handling (avoid touching polypar surfaces), individual packaging of specimens, frequent water changes, and limited exposure to sunlight.*

10. How should live rock be handled after collection?

Proper handling and treatment of live rock prior to export will result in a more valuable resource for the resource countries and ultimately provide a vastly more functional and valuable product for the end-use consumer. The Working Group recognizes that some exporters clean their rock, removing large attached organisms such as sponges that may die during transport, while others ship the live rock without any post treatment.

11. What other obligations should coral collectors and associated parties be responsible for?

Collectors should cooperate with monitoring and management groups as data becomes available regarding the appropriateness of various species collections. Several issues discussed in detail and listed below were deemed inappropriate for this working group, but should be reviewed by the other working groups.

It is the responsibility of the coral collector to report to the appropriate authority (those responsible for the collection area) any evidence of destructive methods of fishing being used within their collection area. Coral collectors should not participate in any other harvesting activity; for example, the collection of marine aquarium fish, live food fish, etc., that uses destructive methods of fishing.

A logbook should be kept that shows the number and type of corals collected; for each type of coral, the area of collection, the approximate depth of collection. In the interest of monitoring and management, the overall health of the reef for future collection should be noted by evidence of bleaching, disease, destructive fishing techniques, COTS, or any other obvious anomaly, or by indicators provided or requested by monitoring groups. It is recognized that the collectors may have extensive knowledge about a resource that can be used in protecting the ecology of a reef system, in helping establish good

All surface-breathing equipment and SCUBA equipment must be maintained in safe working order. Divers and collectors are to follow generally accepted safe diving practices at all times. Divers must also be in sufficiently good physical shape or of appropriate age to engage in collection activities.

It is the recommendation of this group that not only the collectors be subject to the guidelines herein, but also that any other parties (intermediaries, etc.) involved with the handling, storage, or transport of corals be required to maintain the same or higher standards of care.Training should be done that teaches:

1. recognition of species
2. record keeping/logbook entry
3. hygiene/first aid
4. safe diving procedure and equipment maintenance
5. proper harvesting methods, use of tools, handling and storage
6. proper transport methods, handling, and storage
7. proper acclimation procedures
8. proper packing for transport to exporter
9. proper replacement of broken or unused corals

Resolution: *All collectors should be licensed and required to maintain logbooks, ensure that SCUBA gear is in proper working order, follow safe diving practices, and participate in training courses.*

Conclusion:
Many of the guidelines established for coral collectors, such as the handling practices , also apply to the holding facility, middlemen and coral exporters. Although the group was not tasked with specifically evaluating and developing recommendations for coral holding and export facilities it is essential that corals are properly housed, handled, maintained and packed for export such that survival is maximized. This working group suggests that these guidelines are accepted into MAC best practice, and that self-policing of collectors by reporting violations to appropriate persons is in the ecological and economic interest of all parties.

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Monitoring Approaches for a Stony Coral Fishery

Report of the Monitoring Working Group

Introduction

The monitoring working group was tasked with developing a monitoring strategy that would provide information needed by resource managers to 1) develop a management plan for the sustainable harvest of corals; 2) develop specific regulations for the coral harvest in particular areas; 3) develop performance indicators for a management plan with information to verify that the established harvest and export quotas are sustainable and assess harvest and trade impacts and other factors contributing to coral decline/loss; and 4) modify regulations as appropriate based on changes in resource quality or quantity, especially if a particular taxon becomes rare or overexploited. The monitoring protocol should be a practical and rapid technique that can be used by scientists, resource managers, or other required personnel with minimal training, but it should be specific enough to determine the composition, abundance and population dynamics for each taxon collected. It should be conducted with sufficient frequency to properly monitor the impact of the collection and detect changes in the abundance or condition of a taxon of interest, but not so frequently that it is inefficient, too costly or destructive. It should be easily repeatable by any individual with expertise in corals.

1. What type of monitoring should be conducted for the live stony coral fishery?

Monitoring of the stony coral fishery is needed to determine the "health" of the fishery and to verify achievement of the management objectives of the fishery. This should involve two complementary approaches, the use of fishery-dependent data and fishery-independent data. One standard way of monitoring fisheries is to collect catch per unit effort (CPUE) statistics over a period of time. Unsustainability would be indicated by an increased time required to collect the total allowable catch (TAC), a shift in the fishery from a valuable to a less valuable species, or a reduction in the size of the specimens harvested.

Due to inherent problems with CPUE data for corals (unreported searching time, shift in market demand, demand for small, sexually immature specimens etc.), ecological sustainability must also be ensured through a fishery-independent monitoring program. Fishery-independent monitoring should provide information on the location of habitats where collection occurs, the baseline status of the resource in a collection site, and population information for target taxa within collection sites, with a periodic reexamination of these sites to meet management needs. This type of monitoring is possible when coral collection is restricted to specific areas, but will be very difficult when corals are removed from all environments, where the resource is vast, or when collectors remove corals outside of defined areas.

Resolution: *Both fishery-dependent and fishery independent monitoring is necessary to ensure sustainable coral harvest. Fishery-dependent data would be obtained through mandatory logbooks submitted by each coral fisher that include information on the species, size, number of specimens, location and depth of collection, search time and other information. Fishery-independent monitoring needs to be conducted using a tiered approach, with a flexible design that may change with time, that is undertaken in the context of serving management needs.*

2. At what scale should fishery-independent monitoring be undertaken?

In order to determine baseline abundance of target stocks and their recruitment rates, a variety of approaches were discussed at a range of scales. At the largest scale, countries need to determine the total area of reefs and associated habitats within territorial waters and the amount and location of reefs and other habitats that are open for harvest. Remote sensing offers a quick and powerful tool for calculating such parameters and useful organizations that may assist in obtaining this information include UNEPs WCMC and various U.S. Agencies such as NOAA. Countries should be able to present maps that show the boundaries of both coral collection sites and no collection sites, and the total area that is being collected for the stony coral trade.

At the more local scale and on the short-to-medium time frame, stock assessment teams or individuals need to accompany collectors to advise on proper methodology and help determine the extent (patch size and frequency) of habitats being collected for target species. Methodologies that might be suitable include manta tows and timed swims for covering large areas and where the target species is abundant, transect approaches, and free search methods for rare species.

To determine how much of a particular species can be removed from individual sites, an accurate estimate of the density, size frequency distribution and recruitment rate is necessary for each targeted taxon. Depending on the distribution and natural abundance of the species of interest, this may be determined using belt transects (for abundant species) or timed swims/manta surveys for uncommon or rare species of corals.

Resolution: *Fishery-independent monitoring should be conducted at varying temporal and spatial scales, including 1) initial (one-time) country–wide scales to map the total aerial extent of various habitat types occupied by corals; 2) localized assessments at a short-to medium time frame to determine the extent and type of habitats targeted by collectors and their condition; and 3) detailed, periodic monitoring of individual sites to determine the density, cover, size frequency distribution, diversity and other biological parameters of target corals, and also assess impacts associated with the fishery and other disturbances.*

3. What type of information should a monitoring protocol for an individual collection site provide?

A baseline assessment of all coral reefs and other habitat types needs to be conducted prior to the establishment of a coral fishery, or in the case of existing fisheries, prior to the implementation of a science-based sustainable management plan. This will allow mapping of various habitat types, demarcation of a collection area, and identification of individual collection sites and no-collection sites within this collection area. Once the specific coral collection sites have been established, transect surveys should be conducted to obtain information on the species diversity, cover, and size frequency distribution for the target coral species, as well as other benthic data if possible. Other useful types of information include the condition of the target corals (presence of disease, outbreaks of predators, bleaching events, storm damage, siltation etc.), abundance and types of coral recruits, and other uses of the collection area. Similar transects should be conducted in no-collection sites for comparison and verification of harvest impacts.

Resolution: *A monitoring protocol should provide sufficient information to demarcate individual collection sites and to assess the status and trends of the resource, including the distribution and abundance, cover, size frequency distribution, rates of recruitment, and condition of target corals within collection sites, with comparable data obtained for no-collection sites.*

4. What type of monitoring information is necessary to set harvest quotas?

Proposed approaches for biological profiling and setting harvesting quotas included calculating TAC (or Maximum Sustainable Yield = MSY) using a variety of fisheries stock assessment models and possibly forestry models. However, only a few examples of such approaches being applied to corals are available in the literature and no single method was decided upon, as it may vary depending on the taxon and the life stage removed. For instance, Rick Grigg developed a model for the sustainable harvest of black coral in Hawaii and discussed application of this model to stony corals. This model is based on the harvest of mature colonies and involves species with similar life history traits.

This is often not the case for live coral collected for aquaria, as specimens may be much smaller and, in some situations, they may consist only of a fragment of a larger colony. Furthermore collection involves a high diversity of corals with varying life history traits.

Participants recognized that much of the information needed to formulate such models accurately (distribution, abundance, growth rates, population size, size frequency, recruitment rate, mortality – including natural and other causes) is currently lacking and difficult and time-consuming to collect, but is highly amenable to study by students.

Participants also recognized that use of proxy species and groupings of functionally similar species may help initially in setting quotas until sufficient data are available on all target species. It was recommended that short-term and medium term goals should be to calculate MSY for representative target species in trade, focussing initially on the species in highest demand, and on those species of concern to the European Union (EU) that are under high collection pressure in Indonesia. Based on this information, managers could make simplifying assumptions as necessary for similar species. Long-term goals would be to determine MSY for other species of corals, once additional information is available on their biology and population dynamics.

Resolution: *To determine a sustainable harvest quota for a chosen species of stony corals, resource managers need to set a range of percentages that coral fishers could take of standing stock, based on the biology of that species or a closely related species and surrounding conditions in the collection site. They then would make a conservative estimate of the population dynamics of the species of interest within a collection site based on monitoring or existing data; set a percentage that can be collected from that site; monitor CPUE over time; and conduct periodic surveys within the collection area to assess resource status and condition. The group recognizes that much of the biological information on particular species is not currently available, but the use of proxy species and groupings of functionally similar species may help in setting quotas until more data are available.*

5. What monitoring approaches are needed to meet CITES requirements for export?

All species of stony corals are currently listed on Appendix II of CITES. These species can be legally traded on international markets, provided that all shipments from CITES Parties are accompanied by an export permit issued in the country of origin or a re-export certificate from transhipment points. According to the CITES treaty, such permits may only be issued when the relevant government authorities are convinced that: 1) the specimens were obtained legally; 2) the harvest is not detrimental to the species' survival; and 3) live specimens will be prepared and shipped so as to minimize damage to health, risk of injury, or cruel treatment. In addition, CITES authorities in each exporting country are expected to monitor

the actual volume of exports of each species and their status in the wild. If necessary, these authorities shall take steps to limit exports to maintaintain each species at a level "consistent with its role in the ecoystem." The mortality involved in the harvest and marketing of corals are parameters of high importance to the calculation of an export quota, as is a knowledge of the size of the domestic market. It is important that countries recognize the difference between harvest quotas (the grand total of the allowable harvest) and export quotas (deductions made of mortality and domestic markets). Export quotas are less than the total allowable harvest unless there is no domestic market or mortality associated with collection and handling. Monitoring of mortality and domestic markets is needed to establish export quotas, and to facilitate the required CITES permit findings on preparation and shipping protocols (see above).

During a brief discussion of compliance monitoring to ensure that harvest for international trade poses 'no detriment' and no ecological impact as per CITES, the following points were noted. First, it was noted that the biological and ecological role of target species within the larger reef ecosystem needs to be better understood to determine what effect removal of a species has on the ecosystem. Second, it was agreed that collectors should compile logbooks that provide data on the origin of material (location of collection) and CPUE, as a change in the CPUE can be a very useful indicator of over-exploitation and need for more detailed investigation. Information requested to be recorded in a logbook included the following:

1. Location (management unit),
2. Species (or genus), size class information, color, whole or fragments,
3. Date, name of collector/vessel, method of collection, whether SCUBA was used or not, depth, CPUE/ number of people (total hours of collection divided by the number of collectors), time of day, boat name and transport used from collection point.

Additional guidance on making non-detriment findings is available from IUCN at:
http://www.iucn.org/webfiles/doc/archive/2001/IUCN859.doc

The monitoring programs described in this report should generate objective and quantitative information required for issuing or refusing CITES export permits in source countries. In the absence of such information, it becomes difficult or impossible to determine the impact of a particular harvest on the given species' survival in the wild. Nontheless, it is generally agreed that the population dynamics and even the abundance of many stony corals is poorly understood at this time. In many instances, precautionary steps can be taken to permit exports in the absence of large monitoring datasets with long time series.

For instance, the United States allows the export of black coral (Order Antipatharia, listed in CITES Appendix II) in small volumes from the state of Hawaii without knowing total stock size, distribution, or recruitment dynamics. Instead, local researchers determined that sexually mature colonies had a minimum height of 122 cm or base diameter of 1.25 cm. It was assumed that with minimal effort in the fishery (less than 6 divers reaching maximum depths of 60 meters) and adherence to these minimum sizes, harvest would be sustainable over the foreseeable future. Stock assessments, by size category, were eventually conducted *in situ* and showed no substantial variation in the exploited population's size/age structure over 23 years. Subsequently, estimates of maximum sustainable yield were calculated and exports have been held well below that level by the U.S. CITES authorities. Plans are currently underway to assess the health and reproductive potential of the black coral beds below 60 meters (beyond the reach of standard SCUBA), which should enhance managers' understanding of recruitment patterns and the shallower stock's resilience. Thus, a step-wise approach to monitoring and management has been gradually implemented as time and resources permitted.

Recommendation: *Exporting countries should make use of the best available information for evaluating the impact of potential coral exports on wild populations as per the requirements of CITES. If there are insufficient data to determine the impact of a given harvest, then exports cannot and should not be authorized under the terms of the treaty. However, precautionary management measures can be implemented by using basic information on the species' biology or the population dynamics of similar species. As time and resources permit, more data can be collected through more intensive monitoring programs which in turn allow adjustments to fishery and export controls.*

6. What level of taxonomic specificity is necessary for field monitoring of collection sites?

There are over 600 species of reef-building corals found on Indo-Pacific reefs; the trade of about 200 of these have been recorded to the species level in CITES Trade Statistics, but for the vast majority of species the trade is recorded only to the level of genus. Researchers recognize the difficulty in identifying many corals to the level of species *in situ*, and in small and living colonies, due to similarities among species and the wide morphological variation within and among species from different reefs, depths, and environmental conditions. As such, many monitoring programs for coral have focussed only on growth forms, or in some situations (e.g., point-intercept surveys) only recording substrate types, with one type being live coral. While this approach allows for the assessment of live coral cover, it does not provide data needed to sustainably manage a stony coral fishery.

Given the difficulty in identifying corals to species, CITES has recommended that only specific groups of corals need to be identified to the species level on permits, while others can be identified only to the level of genus. These are listed at the bottom of the abstract by Dr. Vin Fleming on page 59.

The working group identified the need for an Identification Tool that includes scientific names and common names for species in trade, referenced to the taxonomic standard used by CITES. However, the group did not reach consensus on the level of detail that should be required for monitoring. A MAC Monitoring Protocol is under development by Reef Check for the ornamental trade overall, and because of the thousands of species involved in the trade it was felt that the protocol would be most effective with a small list of notable species for biological profiling, baseline assessment and compliance monitoring. For stony corals, this initial list consists of approximately 20 species (see paper by Hodgson). It should be noted that this list does not correspond to the list developed by CITES, and several dominant taxa in trade are not included.

Based on 1) the approach taken by CITES for reporting on permits; 2) international requirements of non-detriment as stated under CITES provisions; 3) management needs for the development of harvest and export quotas and for monitoring harvest impacts; and 4) limitations associated with coral reef monitoring (time limits based on safety/air availability), the Working Group recommends that detailed monitoring (for baseline assessments, determination of a harvest quota, and performance measures of the management plan) include assessment of all corals within transects, with each coral recorded at least to genus, unless a species is readily identifiable. At the very least, it is essential that those species of corals required by CITES as being reported on permits to species are being identified at the species level when undertaking assessment transects during field monitoring. Given the time and expense required by these detailed surveys, once the initial assessment is done, annual monitoring may involve a smaller list of notable species using the MAC Monitoring Protocol.

Resolution: *All stony corals should be identified at minimum to the level of genus, with identification to species for those taxa indicated by CITES as readily identifiable, as well as any other corals that can easily be identified to the species level. In addition, all corals recorded along transects should be identified (at least to genus) during baseline surveys and during detailed follow-up monitoring to allow appropriate management decisions, as monitoring of only a small group of "notable" species will not be sufficient to ensure sustainable harvest (see below).*

7. How often should monitoring occur?

An optimal approach in the development of a sustainable coral fishery would be to conduct baseline assessments prior to the start of a fishery. However, stony coral fisheries have been in existence for many years with different levels of management and monitoring. It is recommended that baseline assessments are completed in each location as soon as possible, and this information is provided to resource managers who can develop specific guidance on how much coral should be removed from an area. Once a management plan is in place, it is recommended that the collection sites are reexamined one year later, to ensure that the levels of harvest are sufficiently low enough to prevent depletion of the species and negative impacts to the resource.

Given the expense and time required to conduct detailed monitoring, it would be possible to delay subsequent monitoring at this level of detail for five years, provided that the established management scheme appears to be working based on the one year monitoring results. However, the group recommends that a rapid assessment be conducted in each collection site once each year (during the years that detailed monitoring is not conducted) to assess collection impacts and other threats. This could involve the protocol developed by ReefCheck for the Marine Aquarium Council, in which only a selected group of species are examined (but the species examined may vary depending on habitat type).

If there are reports of substantial damage or disturbance events [e.g., bleaching, hurricane, crown-of-thorns (COTS) outbreak] in a collection site, the site should be temporarily closed and reexamined as soon as possible using the detailed monitoring approach. This will allow adjustment to coral fishery regulations to be made before irreparable damage is done.

Resolution: *A detailed baseline assessment evaluating every stony coral taxon should be conducted in each collection site to provide information for the development of a science-based management plan. Detailed monitoring should be repeated one year after the management plan is implemented to ensure that the adopted management measures are sufficient to ensure sustainable harvest. Provided that no changes (or disturbances) are noted within a collection site, the detailed monitoring could then be conducted once every five years. However, rapid assessments using the MAC Monitoring Protocol should be conducted once each year, during periods when the detailed monitoring is not undertaken.*

8. Who should be responsible for conducting monitoring and covering costs of monitoring?

Most coral reefs that provide stony corals for aquaria and curios are located in developing countries. Few are in the position to design and implement national coral reef monitoring plans, and successful implementation will require considerable capacity building, technical assistance and financial resources. In terms of who should be responsible for carrying out such an assessment, it was noted that relevant issues

include objectivity, credibility/approval by appropriate government bodies, and cost and efficiency of carrying out such assessments. It was noted that some of the work could be done in part by the industry and that some of the cost should be borne by the industry and could be passed on to the consumer. Potential financial , technical and scientific contributors to the process include ReefCheck, MAC, and local scientific authorities, including universities. The types of technical and scientific advice could include, but are not limited to research projects such as student thesis and scientific authorities annual workplans, support of the industry in the development of the most appropriate logbook for collectors, in the training of these collectors and in the timely transfer of information included in the logbooks.

Resolution: *Monitoring should be conducted by unbiased parties, including students, scientists, NGOs, and fisheries agencies, with assistance by coral collectors. The cost of monitoring should be divided among the industry, consumers and the fisheries agencies, with financial assistance from developed countries that are the major importers of these resources.*

9. What type of monitoring should be required for harvest of live rock?

Live rock should be recognized as a very different issue from live coral collection. The encrusting organisms that are found on live rock do not appear to be potential limited in reef environments and may take only a few weeks to cover a freshly exposed surface. Whereas collection of live corals represents the taking of slow-growing, long-lived, animals, live rock collection is more akin to mining of rubble and reef substrate, that is covered by opportunistic, fast-growing common material. Unlike live coral collection, which needs to be sustainable on a **regional scale** (collection of live coral may lead to a reduction of coral cover that affects potential recruitment to other reefs) and a **local scale** (collection of live coral may result in localized depletions of species in defined areas), live rock needs to be sustainable on **a geological scale - the amount of live rock harvest must be less than the capacity of the reef to accumulate calcium carbonate material.**

Some studies suggest that collection of live rock, if carried out carefully, may actually have potential to enhance habitat complexity of the reef by creating tidepools and high relief in reef flat environments. However, live rock mining may also compromise the ref flat and nearshore coastal environments, if removal breaches the reef crest or seaward portion of the reef flat.

Artificial live rock culturing through placement of cement or similar substrate derived blocks in shallow marine environments is a viable alternative. In Florida, this involves placing reef limestone mined from land in the marine environment for grow-out of invertebrates and other micro-organisms that create a colorful and lively substrate. In Fiji, one operator has produced “artificial” live rock from cement and ground up reef rubble, which is then cultured in the marine environment.

It was noted that not all live rock is equally desirable and that collectors target rock that carried colorful zoanthids and other colorful encrusting invertebrates. There was recognition that the relative abundance of rubble versus hard-rock pavements varies depending on location, and live rock collection strategies varies among countries. For instance, Indonesia only allows export of unconsolidated rubble, while Fiji primarily exports reef substrate that has been cemented in place and is removed using a large crowbar.

The working group did not come up with a specific recommendation addressing how monitoring can be conducted for live rock harvest as a tool to develop sustainable harvest guidelines. The group did recommend that the harvest of live rock should be minimized to ensure that collection does not impact the

structure of the reef, it does not result in mortality to other benthic macroinvertberates like stony corals, and it does not negatively affect coral reef habitat utilized by other species of motile and sessile organisms. Some of the unanswered questions regarding live rock are summarized below:

1. Scale - baseline for abundance
2. Recolonization time and nature of scars
3. Habitat complexity
4. Biodiversity (i.e. what is alive on the rock)
5. What are follow-up impacts to ecosystem?
6. What organisms are dependent on live rock?
7. Socioeconomic impacts, i.e. does it drive tourists away?

Resolution: *In order better understand the impacts of removal of live rock and to develop sustainable harvest guidelines, basic research and monitoring needs to be conducted to determine the rate of deposition of live rock, the potential quantity of the resource and the scale over which harvest occurs, time required for replacement of harvested material, the impact of removal on associated flora and fauna and the ecosystem, and effects of removal of rubble versus cemented reef substrate*.

10. What biological information on coral species is currently missing to complete the knowledge that will be gained from the monitoring of commercially harvested reefs?

There are several aspects of coral reef monitoring that need to be addressed in order to develop a realistic sustainable quota for the harvest of coral and to make appropriate management decisions such as a closure to a collection site to allow recovery. These include two broad categories – the first involves research into the biology of individual taxa, and the second is a protocol for coral reef monitoring that provides information on the status and trends of the reef community and specifically of the stony coral resources.

There is relatively little information available on the growth rates of individual species, how this varies depending on the size of the colony, and in relation to specific environmental or physical conditions such as depth, wave exposure, light levels, sediment load and so on. An examination of growth rates of different species under different environmental conditions is necessary to begin filling gaps in our understanding of the biology of different coral taxa.

Other aspects related to the biology of corals, such as recruitment and mortality rates, and the resilience of species to natural or anthropogenic disturbances, are also key components that can help provide managers with information needed to determine how much coral can be sustainably harvested. These factors will also vary depending on location, depth and environmental parameters and should be considered in a long-term monitoring protocol.

Resolution: *There is a need for increased collaboration among scientists, resource managers, coral fishers and hobbyists to improve our understanding of the biology of stony corals including growth, recruitment, and effects of habitat, environmental processes, and disturbance on their life history, combined with a greater emphasis on field monitoring to determine sustainable levels of harvest of individual species and in specific areas and to quantify and mitigate potential harvest impacts.*

11. Chronological Steps of Assessment and Monitoring of Reefs Targeted for Commercial Harvest of Stony Corals

1. Define the management area (percent of reefs and associated habitats in the country available for collection and those closed to collection, linked to macroenvironment).

2. Conduct stock assessment at the genus or species level (see section 6) to determine the density and other population parameters of target corals in the management area, relying on specific methodologies that are appropriate to each species/depth.

3. Determine a maximum commercial TAC for a management area (at some crude level) based on biological information and stock assessment data.

Optimally, a quota should be developed based on:

1) the corals growth rate, longevity, recruitment success and other life history parameters;
2) the relative abundance and condition of coral species being considered for harvest in the area of collection;
3) size classes within the population in the area of collection, and the size classes being considered for harvesting; and
4) the area of harvest and presence and condition of neighbouring, no-collection areas (e.g., existence of source for larval replenishment in the surrounding area).

The working group recognizes that much of this information is not available and suggested the following: those species for which information exists, and that are relatively common,and fast growing (branching corals), a quota could be set at 10% of standing stock per year; for slow growing species this level could be set at 5%, and for relatively uncommon species where little is known about life-history, quotas could be set at 1% of standing stock per year.

- Quotas are meant to be conservative, and are totally dependent on quality of stock assessment.
- Quotas can change, especially if population models are developed for particular species.
- Any type of disturbance would trigger a new stock assessment, which would likely cause quotas to become modified also.
- These quotas are for harvest of whole colonies and do not account for removal of fragments.
- A need exists to include wastage monitoring into the feedback loop. Use of maximum commercial TAC quota to set export quota, taking into account domestic trade and loss before export.

4. Monitor the fishery using fishery-dependent and fishery-independent data and use this information to make future adjustments to the quota as necessary to conserve the resource. Specific changes in fishery-dependent data (e.g. 30% decline in CPUE over 3 years) would trigger a stock assessment, however fishery-independent surveys need to be carried out irregardless of CPUE data at minimum once every 5 years to ensure that target species are not being depleted.

- Natural and anthropogenic changes in the community (e.g. bleaching, COTS, hurricanes) and market changes need to be incorporated into fishery dependent and independent monitoring.
- If a quota is suspended after a decline has been detected, the stock will have to be reassessed and managers may need to redefine management area or modify the quota.

12. A Fishery Independent Monitoring Protocol for Stony Corals

Several different monitoring protocols exist, including point-intercept methods (divers record the organism under a link in a chain or at a specific interval along a transect), belt transects (every organism within a given area – ie. 1 m X 10 m belt – is assessed), and quadrats (all organisms within a certain area, generally 1 m X 1m) are assessed. For purposes of determining population dynamics of stony corals, the recommended approach involves multiple belt transects conducted in each site, with manta tows and timed swims used to identify rare or uncommon taxa.

The following protocol was developed largely based on discussions held during the workshop, with certain parameters incorporated from a protocol used in the wider Caribbean, the Atlantic and Gulf Rapid Reef Assessment protocol. This protocol was tested in Sulawesi following the workshop, and was found to provide a suitable methodology to determine the abundance of taxa and the potential sustainable levels of harvest.

Required Equipment:
10 m transect tape; underwater slates and pencil; 1 m bar marked off in 1 cm intervals.

1. Compile background information on the collection area. Define habitat types and quantify aerial extent of each habitat within the collection area. This includes sea grassbeds, deepwater soft bottom communities and specific reef zones (reef flat, back reef, reef slope, base of reef etc.).

2. Characterize each habitat type, including a discussion of the types of corals found their, other notable organisms, substrate type, depth, wave exposure, water clarity, currents etc.

3. Run belt transects in collection sites as follows:

At each SITE, haphazardly lay the 10-m transect line just above the reef surface, along depth gradients, in a direction that is parallel to the long axis of the reef.

For each coral that occurs within 1 m of the transect tape record the genus (species if possible) and measure colony dimensions (maximum and minimum diameter to nearest 1 cm; height). For small colonies (5 cm diameter or less) only record the taxon and number of individuals.

For colonies that cannot be identified to species, record the morphology if time permits (plating, foliose, branching, massive, free-living etc.).

If time permits, assess the condition of the corals (estimate percent live tissue, amount of recent mortality).

Estimate living coral cover using a point intercept method: record substrate type every 50 cm along the line, at 0, 0.5 m, 1.0 m etc. up to 9.5 m) (20 data points/ 10 m transect). Substrate categories include: hard coral, soft coral, dead coral, fleshy algae, turf algae, coralline algae, rubble, sand, sponge, other invertebrate) .

4. Compile all quantitative data on coral species into a spreadsheet. Be sure to keep data separate for each site, depth and/or habitat type.

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Draft MAC Monitoring Protocols: Discussion Document for the International Coral Trade Workshop

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1 BACKGROUND

The marine aquarium trade involves the capture and removal of living reef organisms, including fish, corals, macro-invertebrates and live rock. These activities can have an impact on reefs depending on the methods used and the numbers and age/size classes of organisms removed. Certification standards will define collection practices that seek to ensure the potential impacts of the marine aquarium trade are within the limits of what is environmentally sound and sustainable. It will be necessary to monitor coral reefs and reef animal populations to determine whether: a) the standards have set appropriate limits and b) whether certified marine aquarium collection operations actually remain within these limits. The fundamental question is whether these population reductions are ecologically significant in comparison to the natural background variation, i.e. do the effects of the collection methods used and/or the population damage the reef ecosystem or the ability of the populations of harvested species to replace themselves?

In early 2000 MAC contacted the Global Coral Reef Monitoring Network (GCRMN) to create the monitoring program and GCRMN requested Reef Check to take the lead on this. MAC and Reef Check have formed a partnership project to:

- Design the MAC Monitoring system, and select species to be monitored.
- Test and revise the MAC Monitoring program.
- Undertake the initial application of the MAC Monitoring program.
- Analyze the data to provide feedback into revision of the MAC Ecosystem Management Standards and the Collection and Fishing Standards.

This paper presents the draft monitoring protocol for review and discussion. Once established, the monitoring program will be used to:

- Regularly survey reefs that have been subject to harvesting by MAC certified operations.
- Determine the effects on reef health of collection of fish, plants, invertebrates and live rock from coral reefs by MAC members.
- Compare the health of the reefs where collection occurs with reefs where no known harvesting is occurring.

2 PROCESS AND OBJECTIVES

The overall objective of the MAC Monitoring program is to develop a set of scientifically rigorous assessment protocols for use by independent groups to monitor the effects of the certified marine aquarium trade operations on the health of the coral reef and the populations of harvested species and live rock.

The process of the MAC Monitoring program development includes:

- Literature review: collection levels and source areas (completed)
- Discussions with industry (completed)
- Choose criteria for proxy organisms (completed)
- Select a representative sub-set of all harvested organisms to act as a proxy for the total organisms to be monitored (completed)
- Choose criteria for site selection (completed)
- Design survey and statistical methods to detect specified level of change in the indicators of interest and captures the minimum data needed to answer key questions in the most timely and cost-effective manner (completed)
- Design a monitoring protocol that will produce data of use to the Reef Check global coral reef monitoring program (completed)
- Choose compliance criteria
- Field testing

3. MONITORING PROGRAM DESIGN

The marine aquarium trade involves the capture and removal of living organisms (and live rock) from coral reefs. The impact of the marine aquarium trade can be defined based on numbers and age/size classes of organisms removed from reefs. The fundamental question that needs to be addressed by MAC Monitoring is whether these population reductions are statistically or ecologically significant when compared with natural background variation. From the perspective of sustainability, the ecological question becomes: Are the population reductions sufficiently large that they damage the ability of the population to replace itself?

The specific questions that will be answered by MAC monitoring fall into the general category of a "Before-After/Control-Impact (BACI) design that has been used for many years in the Environmental Impact Assessment field. The BACI design allows the user to answer questions regarding whether a change can be detected before a given activity has occurred (in this case harvesting of reef organisms or live rock) when compared with after. In addition, it allows the user to compare changes on a site known to be subjected to certain impacts with those at sites that are believed to be free of impacts (control sites).

It is critically important to recognize that coral reefs, like any natural ecological system, vary naturally depending on physical factors such as the passage of storms and biological factors such as fluctuations in recruitment patterns and diseases. In addition, coral reefs may be subject to anthropogenic impacts unrelated to the marine aquarium trade including, pollution, fishing for food, and sedimentation. For these reasons, it is important to choose several control reefs for comparison with study reefs.

The objective of MAC Monitoring is to differentiate the impacts of certified harvesting from other natural or anthropogenic impacts. Thus if a reduction in the population of a given organism is detected at a study reef, looking for the same change at the control reefs will allow investigators to determine whether the change is regional or specific to the study reef. It will also be important to collect all information about known human impacts on both control and impact reefs to help link cause and effect. Sufficient temporal replication will be needed to determine the natural fluctuations with respect to seasonal patterns, particularly in reproduction and recruitment, and in some cases such as fish, diurnal patterns of activity which may affect local abundance.

Traditionally, statistical analysis of data collected using a BACI design has relied primarily on analysis of variance (ANOVA). ANOVA is a well-tested parametric method that allows the user to determine whether a change is statistically significant as pre-defmed by choosing the limits of significance, typically ($X < 0.5$. For the purposes of the MAC monitoring program, it will also be useful to use a variety of non-parametric methods, particularly ordination analyses such as multi-dimensional scaling. These methods allow the user to investigate patterns in data collected from a large number of sites and to represent these patterns graphically.

One limitation of both these types of statistical techniques is that they do not address the question of ecological significance. That is, a very small reduction in population size of a given organism may be statistically significant if a sufficiently large sample size is surveyed. Whether or not this reduction is ecologically meaningful or not is a completely separate and much more difficult question to answer. Typically, a great deal of detailed information about natural population variation will be needed to answer the question of ecological significance.

To assess the long-term prospects for harvesting marine organisms, it will also be necessary to use traditional fisheries stock assessment methods. Such methods are used to examine population structure of organisms to determine the trajectory of population growth and to determine maximum sustainable yield (MSY). Ideally, sufficient information can be obtained about each MAC Monitoring organism, both invertebrates and fish, for an MSY to be developed. Other techniques such as Virtual Population Analysis (VPA) can be used to assess those results. In some cases, the results of the stock assessment work could be used to set individual quotas for the harvest of organisms in a given area, i.e. Total Allowable Catch (TAC) limits, a standard fishery management technique. In some cases, it may be useful to attempt to set such limits for both invertebrates and fish in geographically defined areas.

The live rock trade presents very different questions from the harvest of invertebrates and fish. Live rock extraction involves the physical removal of a piece of non-living rock that is encrusted with a mixture of small living organisms. Unless that rock is replaced with an artificial substitute such as concrete, there is a net loss of material. Reef growth and accretion may balance the loss due to live rock removal, but usually this will occur at a different location, i.e. corals may not grow directly in the cavity produced by live rock removal. Eventually, if enough live rock is removed, the reef will be noticeably reduced in volume. Thus the question of sustainability with respect to live rock is - what is the size of the existing resource and how long can it last at a given rate of removal? In addition, other important questions relate to the speed recovery of a live rock crater and the density of live rock removal that is detectable by e.g. recreational divers or organisms dependent upon live rock organisms for food. It is likely that additional research will be needed on these latter questions before the live rock protocol can be finalized.

4. SELECTING ORGANISM FOR MONITORING

It is not cost-effective nor scientifically useful to try to monitor all organisms harvested for the marine aquarium trade. It is sensible to select a subset of commonly harvested organisms that are representative of a variety of organism types such that the effects of the trade on reef health can be assessed.

To choose the list of candidate indicator organisms a number of criteria were used. A starting list was obtained by reviewing available industry information. The starting point was a list of 800 fish and over 300 invertebrate species traded internationally. This was cut down to a list of 121 commonly traded fish species and 50 invertebrates (Appendix A). This included one hundred and seven species from twenty-nine families of bony fish, four species from three families of elasmobranchs and approximately 50 species from five invertebrate phyla. These include at least 30 species of scleractinian corals known to be commonly traded.

To narrow the list down to possible monitoring candidates, the selection criteria used included:

- Organisms collected in large numbers - potential for large population changes
- High priced (>$50 for fish) - reflects high demand, difficulty of catching
- Rare — organisms that are either naturally uncommon or have been depleted already but are still in demand
- Endemic species that may be rare vs. species of wide distribution that will be useful for monitoring everywhere
- Wide Indo-Pacific distribution -- useful for monitoring everywhere
- Threatened or endangered species or of special ecological value

Taxa that are easily identified in the field because they are:

- Large enough to be seen during a visual survey (>10 cm)
- Non-cryptic
- Not easily confused with similar species
- Clearly marked or colored

To categorize the demand for each fish species, a relative index was created of demand for families, and for species within families (1- 4: 1 = low volume). A similar index was created for price and trade volume. Organisms were selected that were in the upper half of the index as rated by importers. Based on these criteria, 67 species offish and 61 taxa of invertebrates were selected for MAC Monitoring. For example, the Yellow Tang *Zebrasoma flavescens* is a high volume (Class 4) organism but has a low price (Class 1). Due to its high demand, the Yellow Tang was included. In contrast, the Cleaner wrasses *Labroides dimidiatus* and *L. bicolor* have a medium high trade (Class 3), medium high demand (3), and medium low price: (2). While this popular aquarium fish is easily recognized in the field, it is quite small and hence was excluded based on size.

For the invertebrates, the practice within the trade is to clump a variety of species under one name to avoid detailed taxonomic questions. The soft corals are a good example, where the trade has adopted the practice of dividing soft corals based on genus-level taxonomy. To accurately identify many species of soft corals, it is necessary to collect a tissue sample, to extract and identify the skeletal elements in the laboratory. Therefore, in most cases, it will be sensible to match taxonomic detail of soft coral field monitoring to the genus level. If it is suspected that one species is harvested far more than others, then some species-level identification may be needed.

In other cases, where field identifications are possible, taxonomic separation can be made. For example, the trade lumps the two hard coral genera *Favia* and *Favites* into one group. Experienced coral taxonomists can easily separate these two genera in the field and identify specimens to species. When the monitoring program is set up in a given area, the taxonomic specificity selected to monitor the harvested coral should be matched to that for the impact monitoring. In practice, the species of harvested corals should be reviewed and the field monitoring should target the most commonly harvested species.

With respect to invertebrates it is important to recognize that collectors, exporters and importers typically do not use species names for many invertebrates and often mix several species under one common name.

Table 1. Candidate teleost species for MAC Monitoring (67 species)

Family	Common name	Number of Species
Acanthuridae	Tangs, surgeonfish	10
Balistidae	Triggerfish	3
Cheatodontidae	Butterflyfish	4
Cirrhitadae	Hawkfish	3
Haemulidae	Grunts, sweetlips	1
Labridae	Wrasses	7
Microdesmidae	Dartfish	2
Monacanthidae	Filefish	1
Muraenidae	Moray eels	2
Ostraciidae	Boxfish, Trunkfish	3
Platacidae	Batfish	2
Pomacentridae	Damselfish, clownfish	9
Pomacanthidae	Angelfish	13
Scorpaenidae	Scorpionfish, lionfish	3
Serranidae	Grouper	2
Gobiidae	Gobies	2
TOTAL		67

Table 2. Candidate list of invertebrate species

Family	Common name	Number of Taxa
CNIDARIA		
Actinarians	Sea anemones	9
Zoanthids	Polyps	4
Scleractinians	Hard corals	26
Alcyonarians	Soft corals	6
MOLLUSCA		
Bivalves	Clams	2
ARTHROPODA		
Decapods	Lobster, shrimp, crab	4
ECHINODERMATA		
Echinoidea	Urchins	4
Asteroidea	Sea stars	4
Holothuroidea	Cucumbers	2
TOTAL		61

5 DRAFT MAC MONITORING PROTOCOLS

5.1 SITE DESCRIPTION

Five types of data are needed to achieve MAC objectives and these can be collected using four types of survey. First, some general background information will be needed on each reef to aid in the interpretation of the biological information. A Site Description format has been developed for Reef Check (Appendix B) that will serve the purpose of MAC Monitoring. About 35 questions are asked which relate to location and type of anthropogenic impacts known to affect the site. Additional socioeconomic questions are currently being designed and some may be added to the list.

5.2 FISH

The objective of the fish protocol is to obtain a sufficient sample size of fish indicator species such that quantitative statistical comparisons among control and impact sites are possible. In the case of rare species, this may require a large number of replicate surveys. A total of 67 species of teleost fish was chosen for MAC monitoring covering a broad range of size, shape and behavior. The fish monitoring protocol will be based on the Reef Check (RC)core fish survey but will be more highly replicated both spatially and temporally. The RC core method is a combined time and area limited survey using a belt transect. Four replicate, 5 m wide x 20 m long x 5 m high belt transects are made along a 100 m transect line laid parallel to the reef front. Each replicate should be separated by at least a 5 m gap. For RC, surveys are made at only two depth ranges, 2-5 and 6-12 m deep. For MAC monitoring, surveys may be made at greater depths as needed to match the depth range where collection is heaviest. Therefore only experienced research divers should attempt such surveys and special care will be needed to avoid possible decompression problems. At least one survey should be made at one of the shallow depth ranges such that RC data can be extracted from each site.

The fish belt transect should be the first work done after the transect is deployed and should begin between 9:00 to 10:00 AM. After deploying the transect, work can be started after a 15 minutes period during which no divers disturb the area. The maximum height above the transect to record fish is restricted to 5 m in the water column.

Each diver assigned to count fish will swim slowly along the transect and then will stop to count target fish every 5 m, and then wait 3 minutes for target fish to come out of hiding, before proceeding to the next stop point. This is a combination timed and area restriction survey, 4 sections x 20 m long x 5 m wide = 400 m^2. There are four 5m gaps where no data are collected. At each depth contour, there are sixteen "stop-and-count" points, and the goal is to complete the entire 400 m^2 belt transect in 1 hour.

A measured 2.5 m colored wire or rod can be used to help estimate the 5 m belt transect width, and a series of 5, 10, 20 or 30 cm sticks (hand-held or floating tethered to a small weight) can be deployed to help estimate fish length.

If both divers are proficient at fish identification, one diver can record one side while the other can record the other side. Care is needed to carefully label slates to avoid confusion. For numbers less than 25 fish, tally the numbers on the slate using a vertical tick mark for each fish observed and after each four fish, draw a horizontal line through the four, thus creating easily counted groups of five next to the correct name and under the appropriate column. For numbers of fish over 25, the following abundance classes may be used: 25-50, 51-75, 76-100, 101-200, 200-500.

It is crucial to remember to keep the counts for each of the four segments of the transect separate and to avoid double counting by communicating with other fish counters.

For each fish or school offish, a standard length estimate must be given. The size estimate classes may be adjusted for each species. For fish less than 15 cm, the estimate should be +/- 1 cm. For fish larger than 15 cm, the estimate should be +/- 2 cm.

For each study area, sufficient sample size of a variety of size classes must be obtained for the species of interest to be able to assess stock size. There is no set number of surveys as this will depend upon the density of fish in a given area. As a rough guide, at each site it is expected that between five and ten 400 m^2 surveys will be needed to achieve a sufficient sample size for most of the 48 species. During one or two of these surveys, the standard RC indicator fish should also be recorded. The final number will need to be determined based on the sample size recorded during pilot tests. Ideally there should be at least three control sites, therefore based on 5 surveys per site, the total number of surveys required would be about 20.

For the purposes of detecting differences among sites and survey periods, a minimum sample size of about 5 fish should be obtained for the rarest species at the control sites. A much larger sample of a few hundred fish would ideally be obtained for the purposes of fish stock assessment and input to the models. This sample size can be obtained by combining all fish from the control and impact sites.

5.3 INVERTEBRATES

The same belt transects used for the fish survey will also be used for the invertebrate survey. If both divers want to record data, they can alternate 20 m segments as above or each do a 2.5 m wide strip. To avoid confusion later, it is imperative that divers carefully mark their sheets with location and diver names.

Each belt transect is 5 m wide with 2.5 m on either side of the transect line. The reason for choosing the relatively narrow belts is that visibility in many parts of the world is low, therefore it is necessary to restrict them globally for comparability. For each segment, the survey area will be 20 m x 5 m = 100 m^2, for a grand total of 400 m^2 for each depth contour, the same as the fish belt transect.

All of the items and organisms to be counted within the invertebrate belt transects are listed in Table 2. For all organisms size estimates are required. For sessile organisms including corals, the diameter of each colony should be measured in two directions, one perpendicular to the other. The invertebrate belt transect will also be used to measure the density and state of live rock scars.

Each scar recorded should be measured in two directions and the state of recovery noted using the following categories: 1 = fresh scar; 2 = <25% cover by epiphytic organisms, 3 = 26-50%, 4 =51-75%, and 5 = 76-100%. As more information is obtained about the type of recruitment experienced by live rock scars, it may be useful to record additional information.

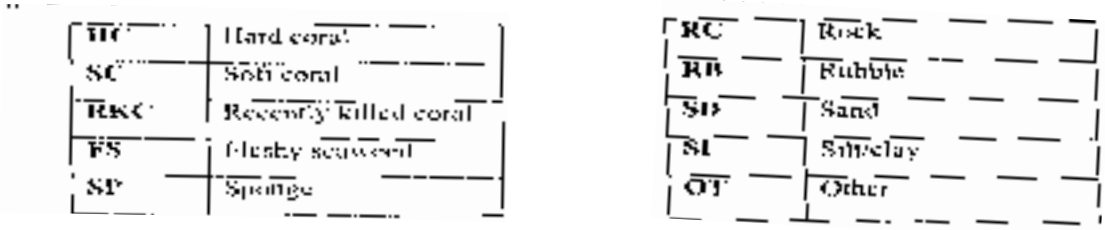
It is expected that the number of surveys needed at a given site will not exceed the numberneeded for the fish surveys (5-10). The final number will need to be determined based on the sample size recorded during pilot tests. Ideally there should be at least three control sites, therefore based on 5 surveys per site, the total number of surveys required per site would be about 20.

5.4 SUBSTRATE COVER ESTIMATE USING POINT SAMPLING

To judge the overall health of each reef, it will be useful to obtain an estimate of hard coral cover in relation to that of other organisms such as sponge and algae. For this purpose, each transect line will be point sampled at 0.5 m intervals using the standard RC protocol for substrate. When the invertebrate belt transect is completed, the point sampling can begin on the same line transect. The estimated time to complete this work is 30 minutes. Point sampling was chosen because it is the least ambiguous and fastest method of survey. In use, the diver can simply sample a series of points where the transect tape overlies the reef and note down what lies under those points. To remove any bias, it is useful to carry a 5 mm diameter nut or other small metal object tied onto a 2 m long cotton or nylon string for use as a "plumb-line." The object is dropped at each designated point and it touches only one substrate type which can be recorded. This removes the need for deciding what lies under the tape, especially in cases where the tape is hanging above the substratum and swinging back and forth with the surge. For Reef Check, substrate type will be recorded at 0.5 m intervals along the line, i.e. at: 0.0 m, 0.5 m, 1.0 m, 1.5 m etc. up to 19.5 m (40 data points/20 m transect segment). This procedure will be repeated for the remaining three transect segments at each depth contour chosen.

5.4.1 Substratum categories and abbreviations

The Line Transect pro-forma has a space for each point sample result, 1- 40 for the first 19.5 m segment etc The above abbreviations are used for the substrate types. There are many cases when the substrate type may be ambiguous. Please follow the guidelines below to identify substrata. Note that these may differ from other definitions with which you are already familiar.



5.4.2 Reef Check Guidelines for Determining Substrate Types

Hard coral: Include fire coral (*Millepora*), blue coral (*Heliopora*) and organ pipe coral (*Tubipora*) because these are reef builders.

Soft coral: Include zoanthids, but not sea anemones (the latter go into "Other").

Recently killed coral: The aim is to record coral that has died within the past year. The coral may be standing or broken into pieces, but appears fresh, white with corallite structures still recognizable, only partially overgrown by encrusting algae etc. This will be particularly important in detecting the impacts of cyanide and fish bomb blast sites.

Fleshy seaweed: The aim is to record blooms of fleshy algae that may be responding to high levels of nutrient input. Therefore do not include coralline algae in this category. When algae such as *Sargassum* that are a normal part of a healthy reef are present, please note the species in the comments section.

Sponge: All sponges (but no tunicates) are included; the aim is to detect sponge blooms that cover large areas of reef.

Rock- Any hard substratum whether it is covered in e.g. turf or encrusting coralline algae, barnacles oysters etc. would be placed in this category. Rock will also include dead coral that is more than about 1 year old, i.e. is worn down so that few corallite structures are visible, and covered with a thick layer of encrusting organisms and/or algae.

Rubble: Includes rocks (often laying over sand) between 0.5 and 15 cm diameter. If it is larger than 15 cm it is rock, smaller than 0.5 cm and it is sand.
Sand: In the water, it is sand if it falls quickly to the bottom.
Silt/Clay: Sediment that remains in suspension if disturbed. Note that these are practical definitions not geotechnical.
Other: Any other sessile organism including sea anemones, tunicates, gorgonians or non-living substrata.

6 FIELD TESTING OF PROPOSED PROTOCOLS

These MAC Monitoring methods should be field tested in a number of locations where the marine aquarium trade is an important economic activity such as Fiji, the Philippines, Indonesia, Sri Lanka, Hawaii and Australia. It is likely that some modifications may be needed to fit the protocols to the local conditions in each place. In particular, a number of the chosen invertebrate and fish species are not found in Hawaii. In the case where these species are not endemic, they can simply be dropped from the survey. For sessile invertebrates such as hard corals the time of year of harvesting may not be particularly important, as successful recruitment and growth may be so low as to not change the total population size or cover greatly. For fish, however, seasonal reproductive patterns mean that the time of year of the survey is critically important as the population size may change by orders of magnitude (at least for certain small size classes). There is thus a need to collect information on the timing of reproduction of all MAC species and to plan surveys accordingly.

A useful check on the ability of MAC monitoring to detect change can be made by doing some surveys in locations where known levels of aquarium fish harvesting have occurred. In this case,the numbers of fish removed should be kept secret until the surveys are finished. This type of blind testing will be the best way to determine whether the methods are working as expected. Once a first round of data collection has been accomplished, it will be important to hold a workshop to review the results. The data can be analyzed as suggested and questions such as appropriate sample size for each species can be addressed. The power of the statistical tests can be checked. Such early review will later prevent problems such as collecting insufficient data or the waste of collecting more data than needed.

7 INTERPRETATION AND FORECASTING

The most challenging aspect of this project will be to determine what level of abundance reduction is ecologically significant, and if such a change is detected, what action should be taken to reduce the impacts. A reduction in harvest intensity is one possible recommendation, while another would be to close the fishery entirely in a specified area until a return to “normal” can be demonstrated. For a few species, sufficient data will be available from previous ecological studies such that “normal” population levels will be known for a few locations. If significant reductions in abundance are detected, collection methods can be adjusted to reduce or minimize the danger. Where no significant reduction is detected, collection should be allowed to continue. One serious danger is that most reefs in the region have been subject to moderate to strong fishing pressure for many years leaving the populations in a very poor state with most large individuals missing. Therefore, finding suitable “Control” sites that are unaffected by fishing will not be easy. This also makes the use of standard fishery models problematic when certain (large) size classes are totally missing.

The MAC Monitoring program can also be used in a pro-active manner prior to any collection to determine which areas contain sufficient stocks to sustain collection. Rather than making an ad hoc visual assessment, qualified technicians could use MAC Monitoring protocols for determining the abundance of sought-after species. This information could be used by government managers or the companies themselves to self-regulate where collection is allowed. This proactive approach would help the companies to avoid overfishing and the resulting management actions that would restrict fishing access.

8 APPENDICES

8.1 APPENDIX A. LIST OF MAC MONITORING ORGANISMS (FISH)

Common name	Scientific name
Bony Fish	
Acanthuridae (Tangs)	
Blue Tang	Paracanthurus hepatus
Naso Tang	Naso lituratus
Yellow Tang	Zebrasoma flavescens
Sailfin Tang	Zebrasoma spp.
Powder Blue Tang	Acanthurus pyroferus
Achilles Tang	Acanthurus achilles
Clown Tang	Acanthurus lineatus
Scopas Tang	Zebrasoma veliferum
Niger Tang	Odonus niger
Bursa Tang	Rhinecanthes verrucosus
Balistide	
Clown Trigger	Balistoides conspicillum
Humu, Picasso Trigger	Rhinecanthus aculeatus
Humu: rectangle	Rhinecanthus aculeatus
Chaetodontidae (Butterflyfish)	
Black and white Heniochus	Heniochus acuminatus
Auriga (Threadfin)	Chaetodon auriga
Copperband BFF	Chelmon rostratus
Racoon BFF	Chaetodon lunula
Cirrhitidae (Hawkfish)	
Flame Hawkfish	Neocirrhites armatus
Longnose hawkfish	Oxycirrhites typus
Arc Eye	Paracirrhites arcatus
Haemulidae (Grunts/Sweetlips)	
Many Spotted (or Harlequin) Grunt	Plectorhyncus chaetodonoides
Labridae (Wrasses/Hogfish)	
Common cleaner wrasse	Labroides dimidiatus
Bird wrasse	Gomphosus varius
Dragon wrasse	Novaculichthys taeniourus
Lyretail (or Moon) Wrasse	Thalassoma lunare
Six line wrasse	Pseudocheilinus hexataenia
Tusk, Harlequin wrasse	Lienardella (Choerodon)fasciata
Red Coris	Coris gaimard africana
Microdesmidae (Dartfish)	
Decorated (purpleheaded) dartfish	Nemateleotris decora
Fire dartfish	Nemateleotris magnifica

Mohacanthidae (Filefish)	
Orangespot Filefish	Oxymonacanthus longirostris
Muraenidae (Morays)	
Snowflake Moray	Echinda nebulosa
Zebra moray	Gymnomuraena zebra
Ostraciidae (Trunkfish)	
Cubicus (or Yellow) Trunkfish	Ostracion cubicus
Boxfish	Ostracion meleagris
Longhorn Cowfish	Lactoria cornuta
Platacidae (Batfish)	
Orbicularis Batfish	Platax orbicularis
Tiera	Platax teira
Pomacentridae (Damselfish)	
Green Chromis	Chromis viridis
Clarkii Clown	Amphiprion clarkii
Tomato (Bridled) Clown	Amphiprion frenatus
Ocellaris Clown	Amphiprion ocellaris
Maroon clown	Premnas biaculeatus
3-Stripe Damsel	Dascyllus aruanus
3-spot Damsel	Dascyllus trimaculatus
Blue devil	Chrysiptera cyanea
Yellowtail Blue Damselfish	Chromis xanthurus
Pomacanthidae (Angelfish)	
Bicolor Angel	Centropyge bicolor
Coral Beauty	Centropyge bispinosus
Emperor Angel	Pomacanthus imperator
Flame Angel	Centropyge loriculus
Lemon Peel Angel	Centropyge flavissimus
Koran Angel	Pomacanthus semicirculatus
Scribbled Angel	Chaetodontoplus duboulayi
Blue Face	Euxiphipops xanthometapon
Majestic (Blue girdled)	Euxiphipops navarchus
Personifer Angel	Chaetodontoplus personifer
Rusty Angel	Centropyge ferrugatus
Keyhole Angel	Centropyge tibicen
Halfblack Angel	Centropyge vroliki
Scorpaenidae (Scorpionfish/Lionfish)	
Volitan Lionfish	Pterois volitans
Dwarf	Dendrochirus spp.
Antennae Lion	Pterois antennata

Zanclidae (Moorish Idols)	
Moorish Idol	Zanclus cornutus
Tetraodontidae (Pufferfish)	
Porcupine puffer	Diodon hystrix
Dogface puffer	Arothron sp.
Siganidae (Rabbitfish)	
Foxface	Lo spp.
Pseudochromis	
Purple	Pseudochromis porphyreus
Purple stripe	Pseudochromis diadema
Strawberry psuedochromas	Pseudochromis porphyreus
Serranidea (Groupers)	
Miniatus	Cephalopholis miniata
Panther grouper	Cromileptes altivelis
Gobiidae (Gobies)	
Goldenhead goby (sleeper)	Valenciennea strigata
Diamond goby (watchman)	Valenciennea puellaris

8.2 APPENDIX A. LIST OF MAC MONITORING ORGANISMS (INVERTEBRATES)

Common Name	Scientific Name
Starburst, Green	*Zoanthus spp.*
	Clavularia spp.
	Parazoanthus spp.
	Palythoa spp.
Anemones	
Bubble	Actinodiscus spp.
Saddle	Entacmaea quadricolor
Ritteri	Heteractis aurora
Schae	Heteractis sp.
Sebae	Heteractis magnifica
	Heteractis malu
	Macrodactyla doreensis
	Stichodactyla gigantae
Soft Coral	Stichodactyla mertensii
Colt coral	Xenia sp.
Flower	Cladiella sp.
Leather	Dendronephthya sp.
Leather	Sarcophyton sp.
Tree	Sinularia sp.
	Litophyton sp.

Hard Coral	
Staghorn coral	Acropora florida
	Acropora formosa
	Acropora hemalis
	Acropora hyacinthus
	Acropora palifera
Elegant	Cataphyllia jardinei
Ridge/Hammerhead coral	Euphyllia ancora
	Euphyllia cristata
	Euphyllia divisa
	Euphyllia flmbriata
	Euphyllia glabrescens
	Favia favus/ Favites
Plate, short tentacle coral	Fungia spp.
Flower pot coral	Goniopora lobata
Plate, long tentacle coral	Heliofungia sp.
Brain, closed coral	Lobophyllia corymbosa
	Lobophyllia hemprichii
	Platygyra daedalea
Bubble coral	Plerogyra sp.
Slipper coral	Pocillopora damicornis
Tongue coral	Polyphyllia talpina
Pearl	Physogyra sp.
Brain, open coral	Trachphyllia geoffroyi
Brain	Wellsophyllia spp
	Alveopora sp
Pipe organ	Tubipora musica
MOLLUSKS	
Tridacna giant clam	Tridacna maxima
Flame Scallop	
CRUSTACEANS	
Banded coral Shrimp	Stenopus hispidus
Cleaner Shrimp	Lysmata grabhami
Lobster	Enoplometopus sp.
Fire Shrimp	Lysmata debelius
ECHINODERMS	
Sea Cucumbers	
Greenfish	Pseudocolochirus sp.
Sea apple	
Urchins	Euchlaris sp.
Pencil urchin	Heterocentrotus mammilatus
Pencil urchin	Diadema spp.
Longspined Black Urchin	Respsilli globolus

Trends in International Trade in Stony Corals: a Synopsis of CITES Data

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Stony corals and reef substrate (live rock) enter the international trade as aquarium organisms, curios, jewelry, and for biomedical purposes. All stony corals and live rock are listed on Appendix II of the CITES and can be traded commercially, provided that the exporting country finds that the take does not constitute a significant risk to the species, or its role in the ecosystem. Most coral in trade originates in the Indo-Pacific, although several former exporters in this region, including the Philippines and Mozambique have banned the trade in stony corals. In addition, the United States prohibits the harvest and export of its coral from the Atlantic and most locations in the Pacific. Currently, the largest exporter is Indonesia, followed by Fiji, Vietnam and the Solomon Islands, with smaller volumes from Tonga, Vanuatu and the Marshall Islands .

During the 1980s and early 1990s, the dominant component of the trade was dead coral (skeletons), but live coral now constitutes over half of the total trade. The volume of dead coral in trade has remained fairly constant since 1993 but increases were noted in 1998 and 1999 with coral supplied from Vietnam. The trade in live coral has increased by 12-30% annually, from about 200,000 colonies in 1992 to 800,000 in 1999 (Fig. 1). Trade in material reported as **"**Scleractinia", which includes live rock and reef substrate, also increased dramatically in the late 1990s; over 1 million pieces and 1.2 million kilograms were exported in 1999 (Fig. 2). Most Scleractinia reported by piece was from Indonesia (reef substrate), most exported by weight is from Fiji (live rock), and over 85% is imported by the U.S.

The taxonomic composition of live coral in trade differs quite notably from the skeleton trade, and the types of coral in trade also differed among exporting countries. The most common genera of live coral in trade are *Euphyllia*, *Goniopora*, *Trachyphyllia*, *Acropora*, *Catalaphyllia*, *Heliofungia* and *Plerogyra* respectively (Fig. 3b). These taxa constitute over 50% of the live trade, with close to 50 additional genera in trade at lower volumes. With the exception of *Acropora*, the dominant taxa of live coral in trade are relatively slow-growing, and may be locally uncommon or are vulnerable to overexploitation due to their life history. Raw coral (skeletons traded as curios) consists predominantly of *Pocillopora* (55%), *Heliopora* (13%), *Porites* (13%) and *Acropora* (10%) (Fig. 3a). Although these taxa are often abundant and exhibit faster rates of growth and greater recruitment success than many massive species, they are harvested at a larger size, and are more susceptible to mortality from physical damage, predation and bleaching.

Over 60% of the trade from Indonesia is *Euphyllia*, *Goniopora*, *Trachyphyllia*, *Catalaphyllia*, *Heliofungia* and *Plerogyra*; only live coral can be exported as the export of recently killed skeletons was prohibited in 1998. Over 50% of the coral exported from Fiji is *Acropora* and >50% from Vietnam is *Pocillopora*; both countries export live and raw coral.

International trade in stony coral provides an important source of revenue for coastal communities. Unregulated coral collection may lead to overexploitation of certain taxa, and collectors can cause substantial habitat damage, but the trade can be developed in a sustainable manner. This requires that exporting countries develop a management plan that includes 1) specific provisions for licensing, training and certifying fishers; 2) an annual quota for sustainable harvest based on the coral's biology and population dynamics, and the location and condition of the harvest area; and 3) a monitoring program that can be used to assess harvest-related impacts and can provide data on the status and trends of the harvested corals in collection and no-collection areas.

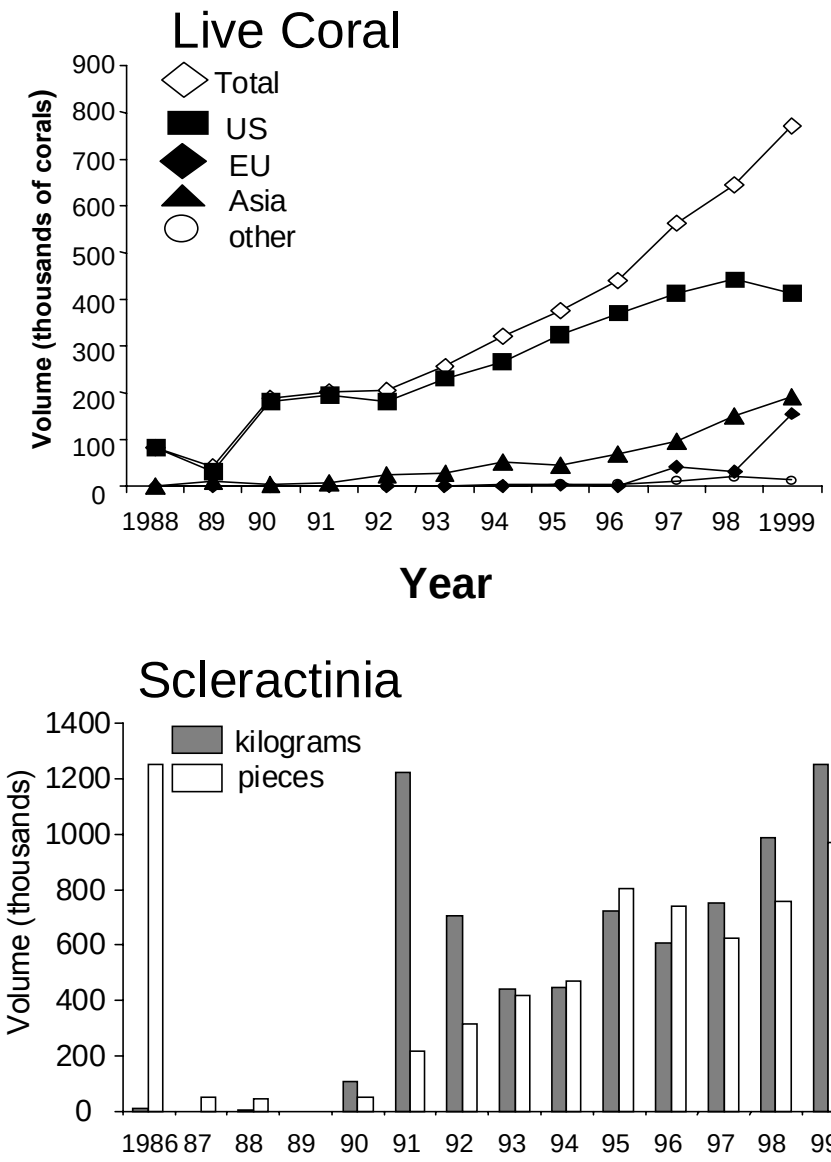
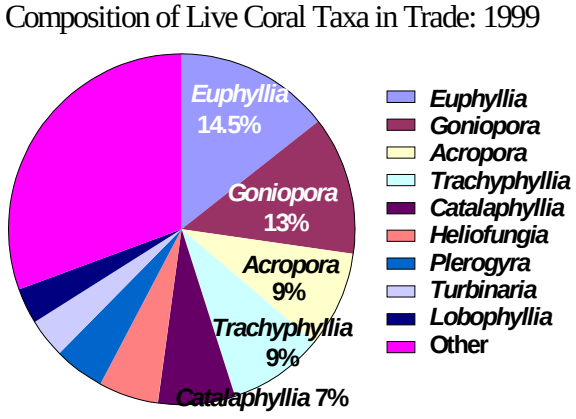
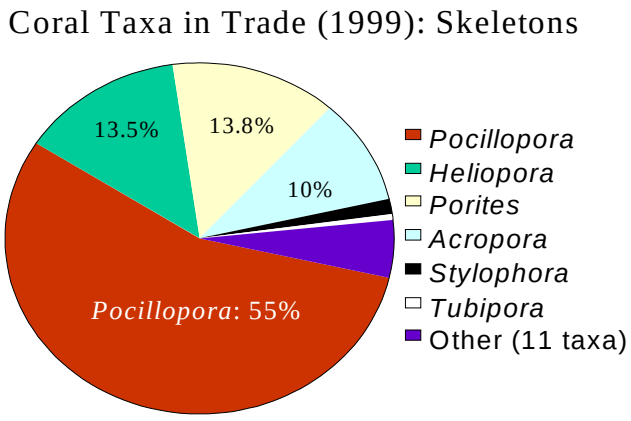

Live Coral
Total
US
EU
Asia
other
Volume (thousands of corals)
900
800
700
600
500
400
300
200
100
0
1988 89 90 91 92 93 94 95 96 97 98 1999
Year
Scleractinia
kilograms
pieces
Volume (thousands)
1400
1200
1000
800
600
400
200
0
1986 87 88 89 90 91 92 93 94 95 96 97 98 99

Fig. 3


Composition of Live Coral Taxa in Trade: 1999
Euphyllia 14.5%
Goniopora 13%
Acropora 9%
Trachyphyllia 9%
Cataphyllia 7%
Euphyllia
Goniopora
Acropora
Trachyphyllia
Cataphyllia
Heliofungia
Plerogyra
Turbinaria
Lobophyllia
Other


Coral Taxa in Trade (1999): Skeletons
13.5%
13.8%
10%
Pocillopora: 55%
Pocillopora
Heliopora
Porites
Acropora
Stylophora
Tubipora
Other (11 taxa)

Management and Enforcement of Coral Imports in the United States

John Field, Fisheries Specialist, Division of Scientific Authority, U.S. Fish and Wildlife Service
4401 N. Fairfax Dr. Room 750, Arlington, VA 22203 USA,

The United States is a range country for many species of stony corals, with an estimated 4 million acres of coral reefs under local or national control in the Caribbean and Pacific regions. Nonetheless, the country has essentially banned commercial harvest of Scleractinian corals through state and federal legislation. At the same time, the U.S. marine aquarium hobby continues to grow rapidly and demands for imported live corals have reached historic highs.

The large and growing volume of imported stony corals (and the absence of a domestic fishery) have prompted federal law enforcement agencies to shift their efforts on corals to border interdiction. The U.S. Fish and Wildlife Service (USFWS) is the primary federal agency involved in wildlife law enforcement, including implementation of CITES provisions for Appendix II Scleractinia. USFWS wildlife inspectors are stationed at 14 designated ports throughout the country, and must process each of the thousands of wildlife shipments entering and leaving the United States each year. American coral importers, like all wildlife traders in the country, must purchase a standard wildlife import/export license each year, and pay fees to process each shipment they receive at a U.S. port. USFWS wildlife inspectors analyze each coral shipment's paperwork, including the importer's license, and make case-by-case decisions whether to perform visual inspections of the shipment itself.

Wildlife inspectors consider several factors when deciding whether to perform a visual inspection, including the species' status in the wild, the importers' violation record, and the species' CITES status. Currently, USFWS personnel inspect approximately 25% of all wildlife shipments (coral and other species), and these inspections may cover the entire shipment or just selected specimens. These inspections are expedited by clear external labelling indicating quantity and species involved, transparent packaging material, and complete paperwork. Common problems encountered during routine inspections include permit/shipment mismatch, "overages" (shipment larger than permitted amount), and specimen misidentification. These are resolved through consultation with source countries, abandonment of disputed shipments, or a prescribed resolution process.

Even in the absence of an active domestic coral fishery, the United States may be able to offer sources of information and perspective to southeast Asian reef management. These include the U.S. Coral Reef Task Force products, precious coral management regimes, and various internet-accessible databases.

Trade in Hard Corals – CITES Requirements and Recent Developments

Dr. L.V. Fleming, Head – UK Scientific Authority (Fauna), Joint Nature Conservation Committee, Monkstone House, Peterborough PE1 1JY, UK.

The requirements of CITES for the export of hard corals are briefly reiterated, especially in relation to making non-detriment findings under Article IV.2.a and in limiting exports to maintain corals at a level consistent with their role in the ecosystem (Article IV.3). Special emphasis is placed on the resolution (Conf. Res. 11.10) and related decisions adopted at the most recent (11th) Conference of the CITES Parties (Nairobi, April 2000). The implications of these changes, namely the definitions of corals in trade, the exclusion of coral sand and coral fragments from the provisions of the Convention, the application of Article IV.3 to the export of coral rock, and the reporting requirements for corals in trade, are explained.

Work currently being undertaken by the coral working group of the CITES Animals Committee is outlined and the contribution of the workshop to this process is recognised and welcomed.

Specimens of the following genera **MUST** be identified on CITES permits to species level:

1) All mono-specific genera (*sensu* Cairns *et al*., 1999)
2) Blastomussa Cladocora, Colpophyllia, Dichocoenia, Diploria, Euphyllia* (live)*, *Galaxea, Halomitra, Heteropsammia, Hydnophora*, Lithophyllon, Merulina, Mycedium, Oulophyllia, Pachyseris*, Physogyra* (live), *Plerogyra* (live), *Podabacia, Polyphyllia, Seriatopora*, Sandalolitha, Solenastrea*.

The following genera of corals can be identified on CITES permits to Genus only:
Acanthastrea, Acropora, Agaricia, Anacrapora, Alveopora, Astreopora, Balanophyllia, Barabattoia, Caulastrea, Coscinaraea, Ctenactis, Cyphastrea, Dendrophyllia, Distichopora, Echinophyllia, Echinopora, Euphyllia (dead), *Favia, Favites, Fungia, Goniastrea, Goniopora, Leptastrea, Leptoseris, Lobophyllia, Madracis, Millepora, Montastrea, Montipora, Mussissmillia, Mycetophyllia, Oculina, Oxypora, Pavona, Pectinia, Physogyra* (dead), *Platygyra, Plerogyra* (dead), *Pocillopora, Porites, Psammocora, Scolymia, Siderastrea, Stylaster, Stylocoeniella, Stylophora, Symphyllia, Tubastrea, Turbinaria*.

EU Trade Controls on Stony Corals from Indonesia

Caroline Raymakers, TRAFFIC Europe Regional Office (WWF-B), 608 Chaussée de Waterloo, 1050 Brussels, BELGIUM (on behalf of the European Commission)

In the 1990s the world trade in corals fluctuated between one and six million pieces annually as reported by CITES importing Parties. These data were available following the listing of "hard corals" species (including Antipatharia) under Appendix II of CITES. According to the most recent available data, Indonesia was the largest supplier (roughly 36%, 900,000 pieces) of corals in 1999 when the United States (US) was the main consumer (81% of world imports, roughly 2 million pieces). However, the demand in the 15 European Union (EU) Member States has increased significantly during the past decade, representing 2% of the world market in 1990 and 18% (440,000 pieces) in 1999. In 1997, the EU countries adopted Regulation (EC) No 338/97 on the protection of species of wild fauna and flora. This legal measure covers CITES requirements and a few more constrains for EU Member States, particularly the obligation to issue an import permit in addition to the export permit requested from the exporter. Among bodies that are responsible for the concerted implementation of the regulation in the EU is the SRG (Scientific Review Group). The main task of the SRG is to review the non-detriment findings of export quotas established by certain range States, the trade data reported for selected species and specific concerns raised by Member States, e.g. application for an import permit.

The EU import restriction adopted for seven species of stony corals from Indonesia illustrates the role that the SRG plays in the implementation and enforcement of CITES provisions and the conservation of species listed under CITES. In 1998, concerns were raised about the level of export quotas for live corals set by Indonesian authorities. In September 1999 (14th meeting of the SRG), after consultation with all relevant Parties, including the range States, a temporary trade restriction was adopted for seven coral species (*Blastomusa merleti*, *Catalaphyllia jardinei*, *Cynarina lacrymalis*, *Euphyllia divisa*, *E. glabrescens*, *Plerogyra simplex* and *Trachyphyllia geoffroyi*). This trade suspension will be lifted as soon as the scientific bases for the establishment of CITES coral export quotas are provided. Scientific information and recent data are the bases required to verify that the level of trade will not have any detrimental effect on the survival of the species or other species, and on its population and habitat. In the case of coral exports from Indonesia, concern was raised due to the lack of knowledge on the status of populations (their estimated size), the distribution and abundance as well as growth and recruitment rates of the species.

The preliminary analysis of reports on Indonesian coral trade brings-up additional questions, particularly on discrepancies between CITES annual reports on coral trade from importing and exporting Parties and the fact that, for several species, reported exports from 1997 to 1999 exceed the export quotas set, e.g. for the six genera of the species targeted by the EU trade restrictions since September 1999.

Fig. 1. Export quotas established by Indonesia for taxa under EU suspension

Table 1. Indonesian export quotas for taxa of concern

(Unit: Pieces of coral)	**1997**	**1998**	**1999**	**2000**	**2001**
Total export quotas	*765.000*	*810.000*	*825.890*	*852.660*	*891.000*
Blastomusa spp.	8.100	8.550			
Blastomusa merleti			8.100		
Blastomusa wellsii				7.200	6.000
Catalaphyllia spp.	83.250	89.775			
Catalaphyllia jardinei			67.500	58.500	56.000
Cynarina spp.	7.200	7.200			
Cynarina lacrymalis			9.900	9.000	10.000
Euphyllia spp.	110.250	124.200			
Euphyllia ancora				36.000	40.000
Euphyllia divisa			72.000		
Euphyllia glabrescens			54.000	36.000	40.000
Plerogyra spp.	51.300	45.000			
Plerogyra simplex			36.000		
Plerogyra turbida (*discus*)				16.200	15.000
(syn. *Nemzophyllia turbida*)	13.500	18.000			
Plerogyra sinuosa				31.500	3.600
Trachyphyllia spp.	70.650	72.000			
Trachyphyllia geoffroyi			83.700	76.500	80.000
(syn. *Wellsophyllia radiata*)	9.000	9.000			

Certification for a Sustainable Trade in Marine Ornamentals: The Marine Aquarium Council

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Marine Aquarium Council: Background, Objectives and Structure

The Marine Aquarium Council (MAC) was established as an international multi-stakeholder institution to address the situation comprehensively and achieve market-driven quality and sustainability in the marine aquarium industry. The Council began as an initiative of a cross section of organizations representing aquarium keepers, the aquarium industry, conservation groups, international organizations, government agencies, public aquariums, and scientists. From the broad network of stakeholders that constitutes MAC, the15 person Board of Directors is required to have a majority of non-industry members.

Following incorporation in 1998, MAC is now established as an independent, third party institution whose goal is to transform the marine aquarium industry into one that is based on quality and sustainability. MAC is making this happen by:

- Developing standards for quality products and sustainable practices;
- Establishing a system to certify compliance with these standards and label the results; and
- Creating consumer demand and confidence for certification and labeling.

In addition, MAC is:

- Raising public awareness of the role of the marine aquarium industry and hobby in conserving coral reefs and other marine ecosystems;
- Assembling and disseminating accurate data relevant to the collection and care of ornamental marine life; and
- Encouraging responsible husbandry by the industry and hobby through education and training.

MAC is now fully established and recognized as the lead organization and global voice for developing and coordinating efforts to ensure sustainability in the international trade of marine ornamentals. MAC has made rapid progress in creating a global network for raising awareness of the needs and opportunities for certification, and initiating certification system development. As of early 2001, the network included 2,200 stakeholders in over 60 countries and territories.

MAC is also forming key partnerships to meet strategic needs in developing a market based approach to sustainability for the marine aquarium trade. To ensure that there is consistent, comprehensive, quality information on the marine ornamentals trade, MAC is collaborating with the World Conservation Monitoring Center (WCMC) to develop an international data recording and reporting system. To ensure that reef habitat and resources are sustained in the long run, we are partnering with the Global Coral Reef Monitoring Network/Reef Check programs to develop aquarium collection area monitoring based on internationally accepted methods and expertise.

Certification System Development

Developing the standards of practice and certification system is at the core of MAC's efforts. In late 2000, most effort was being put into developing the MAC Certification Standards and an initial set of "Core Standards" to address critical urgent issues affecting sustainability is rapidly moving to completion. The Standards Advisory Group, an international, multi-stakeholder committee, is reviewing the draft standards into early 2001, following which the standards will be available for public review.

The Core standards cover:

- Ecosystem Management Practices: in-situ habitat, stock, species management and conservation.
- Collection and Fishing Practices: fish, coral, live rock and other harvesting and related activities, e.g. field handling and holding practices.
- Handling, and Transport Practices: holding, husbandry, packing, transport etc. at wholesale and retail.

During the first half of 2001, MAC will undertake a major outreach effort to widely inform the marine aquarium industry and hobby of the standards and certification system and provide materials on how to participate. There will be training to ensure that the industry in developing countries (especially collectors) has the skills and capacity to supply certifiable marine ornamentals. The standards of practice are to be tested and then put to work in pilot areas. Pilot certification will seek to include operations in at least the Philippines, Fiji, Australia, Indonesia, and Hawaii that will be linked to numerous importers and retailers in the US and Europe who are waiting to participate in the pilot phase of certification. Following the pilot phase, the certification system will formally be launched and become operational in late 2001, and certified marine ornamentals will be available in 2002.

Over the two years following the implementation of the Core Standards, a more comprehensive set of "Full Standards" will be developed to address the broader more complex range of issues and approached to ensuring sustainability for the marine aquarium trade. The Full Standards will expand on the Core Standards and also include a set of standards for Maricuture and Aquaculture Practices.

Management Measures and CITES Trade Controls for the Stony Coral Trade in Indonesia

Samedi and Puspa Dewi Liman
CITES Management Authority for Indonesia.

Introduction

Indonesia is an archipelago which comprises of more than 17 000 islands, and has more than 80,000 kilometers of coastlines and 3.1 million square kilometers of territorial waters. It is believed that Indonesian waters is the center of coral species diversity, supporting more than 362 species of stony corals dominated by species from the genus of *Acropora* (62 species), *Montipora* (29 species) and *Porites* (14 species). The coral reef of Indonesia accounts for 10 -15 percent of the world's total and the reefs are enormously rich in species.

Approximately two third of the Indonesian coastlines are covered by coral reefs and all of the world's reef types are present in Indonesia. There are four types of coral reefs found in Indonesia : fringing reef, barrier reef, atoll and patch reef. Among this type, fringing reef are the most common. Latest survey based on the percentage of coral coverage analyzed from 416 locations in 43 areas in Indonesia showed that 6.49 % reefs was in an excellent condition, 24.28 % was in good condition, 28.61 % was in intermediate condition and 40.62% was in poor condition. It is also shown that the condition of coral reef in western Indonesia was the worst, compared to those in the middle and eastern Indonesia. It has also been widely known that the disturbances are mainly caused by explosive and poisoning fishing and extraction of dead corals for building or construction materials. Collection and trade of live coral for ornamental purposes may in some extent contribute disturbances to the coral reef, but the impact has been regarded as relatively small and controlled.

The management of control of coral collection and international trade have evolved since some of stony coral species was listed in CITES appendices in 1985 and then all of Scleractinian species were subsequently listed in 1990. Since then the Ministry of Forestry has deeply involved in the management of control of the trade of these fishery species because the Ministry has been the only Management Authority of CITES in Indonesia. The problem began when Indonesia has to make "non detriment finding" as directed by Article IV of the convention. Establishment of collection quota is the basis for making non-detriment finding. But in order to fulfill the non detriment finding principle the quota must also be scientifically established. Despite the problem in making non detriment findings (e.g. data lacking, external pressure) the involvement of Indonesian Institute of Sciences on this matter has been enormous.

Policy and Legislation concerning trade on wild flora and fauna

The following legislation and regulation are the basis for undertaking control and making non detriment findings in utilization of stony coral species by the CITES Management and Scientific Authority.
1. Act No. 5/1990 concerning Conservation of the Living Resources and their Ecosystem;
2. Act No. 10/1995 concerning Customs and Excise;
3. Act No. 23/1997 concerning Basic Provisions on the Management of theLiving Environment;
4. Act No. 41/2000 concerning Basic Provisions on Forestry;
5. Government Regulation NO. 13/ 1994 concerning Hunting of Game Animals;
6. Government Regulation NO. 7/ 1999 concerning Preservation of Flora and Fauna;
7. Government Regulation NO. 8/ 1999 concerning Utilization of wild Flora and Fauna;
8. Government Regulation NO. 25/ 2000 concerning Decentralization;
9. Decree of the Minister of Forestry No. 62/Kpts-II/1998 Concerning Administrative Directive for Wild Plants and Animals Traffics;

Management of control of species utilization (including CITES implementation) has been basically based on the Government Regulation No 8 of 1999 concerning Utilization of Wild Plants and Animals. This legislation specifically directs the Ministry of Forestry as the Management Authority and the Indonesian Institute of Sciences as the Scientific Authority for Conservation of Living Resources, including CITES in Indonesia. The Government Regulation has also provided basic regulation on quota establishment, export, import, re-export, captive breeding, ranching and internal trade in species whether protected or unprotected including those listed in CITES Appendices. Further regulation concerning preservation of species are provided by the Government Regulation No.7 of 1999. This regulation provides regulation on preservation of species including population management in their habitat and capture.

These two national regulations have made Indonesia upgraded from class 3 to class 2 in terms of national legislation to implement CITES. This means that Indonesian legislation mostly meets the requirements for CITES implementation. However, the Ministry is aware that these regulations contain some weaknesses which must be reviewed and amended, in order to achieve class 1 legislation which meets all the requirements for CITES implementation.

Current Management of Control of Trade in Coral

About 71 Indonesian species of stony coral from the order of Scleractinia, Coenonthecallia, Stolonifera and Milleporida, which have been all listed in appendix II CITES, are now in trade. In order to guarantee sus+ainable utilization of coral species, certain principles are adopted. These principles include:

- corals can only be harvested from outside the protected areas and tourism sites;
- harvest rotation to allow natural population recovery;
- corals are harvest below the regeneration rate of each species;
- coral are harvested with size limit in accordance with the growth rate of the species;
- harvest in assessed sites;
- population monitoring and evaluation when necessary.

Currently, monitoring and control on coral utilization are undertaken through the following mechanisms:

a. establishment of collection quota;
b. issuance of collection permits;
c. registration of traders (middlemen and exporters);
d. issuance of domestic transport permits;
e. issuance of CITES export permits;

The harvest levels (quota) in selected provinces are established through an annual decree by the Directorate General of Forest Protection and Nature Conservation (PHKA). This is then followed by harvest sites assignment by the regional forestry offices; based on the recommendation by the Scientific Authority.

License to trade (export) in stony corals may be given to registered companies only. in accordance with the Decree of the Minister of Forestry (No. 62/Kp+s-II/1998). The registration is undertaken under the following criteria (requirements):

- The companies are established in accordance with the National Trade Regulation;
- The companies must provide sufficient facilities and equipment to ensure minimum death and injury.
- The sufficiency of facilities and equipments is verified by the local Conservation Agency (KSDA);
- The companies must have sufficient understanding on conservation and wildlife sustainable utilization concept, including understanding on CITES requirements. This is examined through the examination of their proposal when requesting for registration.

The licensed companies, then, have right to undertake harvest . collection, transport and trade in stony corals. The local Conservation Agency (KSDA), based on quota and collection permits given to the companies, issues permits for domestic transport. CITES permits, which are then issued by CITES head quarters, mainly based on this permit after being verified by the KSDA officers.

Besides the obligation to follow all national and CITES regulations, the companies (exporters) have also social obligation such as providing assistances to the fishermen by incorporating them within one system of management in order to improve their knowledge on good collection practices in order to reduce death or injuries and also in some extent may participate in preventing illegal activities such as blasting and poisoning, which result in pollution and damages to the coral reef. The companies through Trade Association (AKKII) have also played important roles such as assisting the Scientific Authority in assessment and monitoring of stock. The registration to export is valid for 3 years, while the harvesting/collecting license is valid for 1 year. Export permit valid for 3 months and may be extended up to 3 months.

Further Development of Policy on the Utilization of Stony Coral

It has been found that the current policy possess some weaknesses, such as lacking of guidelines to undertake good harvest practices and its monitoring procedures. Furthermore, with potentially large areas of Indonesian coral reef, the control and monitoring mechanism should allow the involvement of non government bodies, including NGOs. private sectors and self assessment, control and monitoring by fishermen and collectors and traders. In the near future, the following procedures and protocols must beestablished;

1. Production harvest guides: best collection practices;
2. Training to the fishermen on the best collection practices;
3. Strengthening the collection site control and monitoring during and post harvesting and collection by incorporating fishermen as part of the monitoring and control systems;
4. Development of Rapid and Cost Effective Population Assessment and Monitoring in order to fulfill the requirement of CITES non detriment finding principle;
5. Increase activities of the local Conservation Agencies (KSDA) in dealing with coral reef rehabilitation activities, monitoring and evaluation;
6. Encourage Coral Reef Trade Association in undertaking and extending of coral reef transplantation activities;
7. Provide training to the field officials especially on coral identification, transplantation, monitoring and evaluation;
8. Encourage research by universities, NGOs and other relevant agencies;
9. Review current policies and legislation.

Overview of Indonesian Coral Trade: Importance to Coastal Communities, Health and Safety Issues, Users' Conflicts and Illegal Trade Concerns

Arief Wicaksono, M. Putrawidjaja, and M. Imran Amin
IMA-lndonesia and Yayasan Telapak Indonesia

BACKGROUND

Coral reefs are one of Indonesia's most important and highly diverse natural resources. Spanning an area of about 85,700 km2 distributed in more than 14,000 reef units in 243 sites (LIPI 1997), they are one of the most extensive of the world. The ecosystems provide an important habitat for valuable food and ornamental fish species, as well as a food and income source to thousands of coastal communities. They are also offering coastal protection and tourism revenue.

Live coral trade, together with live food fish and ornamental fish trade, is one of significant live reef fisheries industry in Indonesia. Occupy only five percents of total country's fisheries industry; it contributes more than forty percents of total country's annual income. No detail reports on its volume and value available recently. On the other hand, the industry also significantly contributes the reef habitat destruction. Live coral collection produces more loss than benefit, about 75 times, while live food fish and ornamental fish catch produce loss as more than 100 times as its benefit.

Some national laws and regulations also pertain coral industry, including The Wildlife Protection Ordinance of 1931 and Law No. 5/1999 regarding The Conservation of Natural Resource and Its Ecosystems. On the contrary, neither of these laws has been well enforced since some of the practices have continued. The construction of Soekarno-Hatta International Airport and land reclamation in north Jakarta reportedly mined sand and corals in Kepulauan Seribu and suspected to be responsible for the disappearance of six small islands in the archipelago (Anon. 1997a in Bentley 1998).

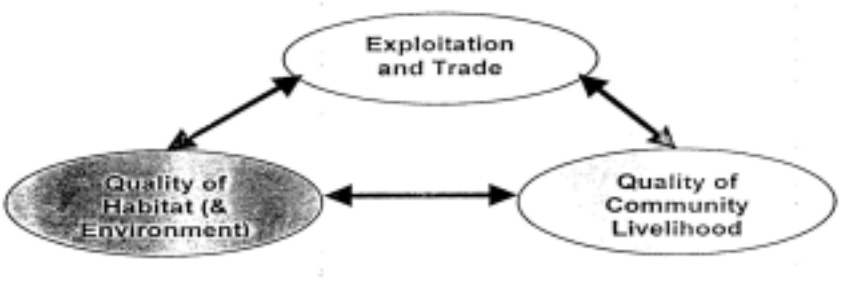
OBJECTIVES

International Marinelife Alliance (IMA) Indonesia, Ministry of Marine Affairs and Fisheries (MMAF) of Indonesia and Yayasan Telapak Indonesia trying to arrange an overview of the coral exploitation and trade in Indonesia with two major preliminary monitoring sites in Jakarta and Denpasar as well as several fishing ground monitoring sites (Lampung, Kepulauan Seribu, Ujung Kulon, Kep. Karimunjawa, Sumenep, etc.). The picturesque will also contribute to the 2001 Country Status Overview of Live Reef Fisheries Exploitation and Trade in Indonesia.

Annually, this mosaic will expectedly be updated and developed continuously as a foundation for designing intervention strategies on policy, trade, laws and socioeconomic with the involvement by local fishing communities, NGOs, business communities, and the government.

OBSERVATION APPROACH

To observe coral trade and industry, we assume that change paradigm is an integrated aspects of resources exploitation and trade, quality of habitat (and the environment), and quality of life of the community. Those three aspects are interdependent.



Based on the aforementioned paradigm, Indonesia, as a world's major coral collecting sites, receives only very limited values and long-term benefits generated from regional and global trade. Whilst, traders, or other major beneficiaries of the industry on the demand side, did not receive depression and risks concerning intensive habitat degradation due to the intensive exploitation.

INVESTIGATION APPROACH

The investigation gathers information from all actors involved in the industry, including who potentially harm the habitat and community livelihood quality, either directly or indirectly. It focuses on picturing the industry in large scale, with some in-depth case studies. Most of them are secondary information, vary from export tables produced by several government bodies to experts' and scientific institutions' reviews. The report also relied on many interview to credible sources as a mean of verification of the secondary data gathered.

All the data gathered are purposively arranged to have the overall mosaic.

IMPORTANCE TO COASTAL COMMUNITIES
LIVE CORAL TRADE

Live stony corals are largely traded for aquarium, both export and local. The industry is centered in Jakarta, since Jakarta airport is the CITES's preferred export gateway due to the proximity to some facilities, including permits, proper transport and handling facilities, etc.. Besides, the CITES Management Authority for Indonesia holds by the Directorate General of Nature Protection and Conservation is located in Jakarta. More than 80 % of the daily hundred-boxes exporters' shipment contains live coral from the Jakarta International Airport. Bali is also center of the trading, with lower volume and numbers of exporters. Most of live fish exporters in Bali ship out more fish than stony corals. Primary destinations of the industry are European countries and the United States. Jakarta is also a major local market for the commodity, where the majority of traders locate in Jalan Sumenep, Central Jakarta. Another smaller markets distributed in Jakarta, as well as some pet shops in main shopping centers. Primary markets are largely five-stars hotels and restaurants, shopping malls, and high-raised offices, as well as hobbyists coming from the high-level society. Lower-level individual consumer prefers freshwater aquarium because it has easier and cheaper pet-keeping procedures. Some local merchants admit that they offer lower quality coral than the export one.

Most of stony corals are collected in fishing ground surrounding those two major gateways, such as Lampung, Kepulauan Seribu, North Sumatra, Bangka, Belitung, Kepulauan Karimunjawa, Sumenep, and Flores. Cruz (2000) reported Kepulauan Seribu - off north coast of Jakarta - is one of collection sites of the Acropora branching coral, mostly staghorn; even though the 2001 Telapak/Palung survey reported that intensity has been decreased significantly during last decade. Cruz (2000) also reported that rare red Goniopora coral harvested in Kendari, Makassar (South Sulawesi) and Lampung.

Despite its very small margin, coastal community gains some profit directly from coral trade, mostly the local fishers. Obviously, the corals collected are very under price, compared to the profit received by the exporters. In Lampung and Ujung Kulon price of some stony corals is Rp. 500 to 2000 (US$ 0.5 to 2 cent7) per piece, while the exporters sold it for US$ 5 per piece, at the very least, to their importers (IMA Indonesia 2001).

DEAD CORAL INDUSTRY

Despite its impact to coral reefs - which is assume to be large - coral also represents an important, cheap and abundant construction material in small island community for centuries. Bentley (1998) reported that coral also used for construction in Java, Kalimantan, Bali, Lombok, Sulawesi and Maluku, either crushed and fire to produce lime (an important constituent of cement), or as pieces for us as building blocks for walls and foundations. Most of them are the member of dense calcium carbonate skeletons genera of *Platygyra*, *Porites* and *Favia* (Putra 1992 m Bentley 1998). Bentley (1998) stated that coral limestone has been mined from Jakarta Bay for jetties construction since 1800s, until Jakarta provincial government banned it in 1970. It is also had been outlawed in Bali since 1985. Ten of more than 200 species of black coral (mostly Antipathes) had been commercially exploited for jewelry production. Recently, the industry is getting rare and anecdotal reports throughout Indonesia suggest that it is now hard to find (Bentley 1998). Last, branching coral is also commercially exploiting in curio trade, which is widely sold in most public beaches.

HEALTH AND SAFETY
IMPACT TO REEF HEALTH

Reef extraction produces impact to the industry itself, both directly and indirectly. The industry potentially destroys the reef, if it always harvests wild coral instead of culture one. Local fishers require digging up a square meter of reef to harvest 10x10 cm^2 coral (Telapak, pers. comm. 2001). Local fishers harvest more live coral than needed to meet their family daily needs and some little extra to pay their debts to middleman. Furthermore, only 50 % of live coral shipped out from collection site die before received by the exporters. The situation forces middleman and local fishers to collect more coral than ordered, usually 100 percent, often includes unordered species as well. Other reef extraction practices, such as destructive fishing (such as cyanide and blast fishing, muroami, etc.) and coral mining, contributes bigger threat to less than 29% good condition reefs (LIPI data 2000), the number uses to set the quota.

While exporters enjoy higher profits, local fishers directly dealing with the decrease of quality of the collection site, with the absence of coral reefs management. Once the coral reefs damaged, local fishers will have to sail further just to find better reefs to collect stony corals. On the contrary, other actors, particularly middleman, will easily hire fishers who will likely to fish further. Moreover, exporters or larger scale dealers will easily find other collecting sites.

IMPACT TO THE LOCAL FISHERS HEALTH AND SAFETY

Coral harvest is carried out by local fishers using “hookah” - surface compressor air supplied diving apparatus - or by free diving. Usually they use industrial oxygen supplied compressors, while some divers use huge tire inflator as often uses in Eastern Indonesia. Hookah divers risky to inhale compressor’s lubricant polluted air supply and also suffer decompression sickness, vary from light deaf to paralyze, due to improper decompression procedure to be followed.

It is also known that most of coral harvest fisher are also catch ornamental fishes. Since most of ornamental fish catch usually using cyanide, the divers also potential to expose the cyanide contamination. They can suffer lung disease, as well as eye and skin irritation from the exposure.

USERS' CONFLICTS

Conflict among users occurs for several reasons, such as collection sites dispute, price competition and access to market. Most conflict suspected to be occurred between middlemen. Basically, middleman committed to deliver their product to the exporters who support his operation with money. Since the exporters tend to under price the delivery and sometimes does not pay it full as a portion of a loan amortization, middleman tempted to secretly divert his inventory to other exporters who willing to pay in cash. Collection sites sometimes disputes between local fishers and local community who does not harvest coral. Some local community complains that they are threaten by coral collection practices in fishing ground, as that happened in some islands north of Central and East Java a while ago. Debt amortization is another potential conflicts, since there is not any formal agreement. Debt gives only based on trusteeship.

ILLEGAL TRADE CONCERNS

Illegal trade of live coral is not very common. Cruz (2000) stated that it is unclear to what extent export quotas have been enforced: AKKII8 claim to be within their quota, while other non-member companies based in Makassar and Manado are also exporting corals without permits. Those undocumented corals usually export to non-CITES signatory countries or less strict in implementing the convention. Practically, they insert live corals inside boxes contain ornamental fish. Bentley (1998) also reported a gross trade volume reported by the importing countries in 1995 is 7% higher over the quota level. Theoretically, the only tools to monitor the coral trade is the export quota for various taxa issued by CITES. The quota sets by the Directorate General of Asosiasi Kerang, Karang dan Ikan Hias Indonesia (Indonesian Shell, Coral and Ornamental Fish Dealers Association)

Nature Protection and Conservation - as the management authority, based on scientific advice from the National Institute of Sciences (LIPI) - as the scientific authority, before divided among members of AKKII. The system regulates under the Government Regulation No. 8/1999 regarding Wildlife Flora and Fauna Use. Unfortunately, the regulation only regulates a smaller volume and taxa of corals allow to be harvested than market demand. Only 72 Indonesian species belongs to Agariciidae, Pectiniidae, Poritidae, Siderastidae, Favidae, Peciniidae, Trachyphylliidae, Dendrophylliidae, Mussiiddae (except some Lobophyllia sp.), Galaxea, Hydnophora and Scapophyllia has been regulated by the CITES for collection (2,000,000 pieces) and export (1,000,000 pieces) in 2001. The situation offers an opportunity to legallyexport the commodity for non-member companies, who does not have incentive to report their trade. And even that, the quota estimation refers to reef accretion rate and coral growth rate, without any consider external factors such as pollution and natural disasters. In practice, reef accretion and coral growth are highly depend on many factors, whereas we do not have adequate capacity to monitor real growth. It may be negative rate or decrease in population and coverage since the destruction rate is high. Above all, Indonesian reef is patchy distributed in more than 14,000 units, which is not always large but mostly in small-sized unit. Each unit is highly susceptible to any threats. The situation getting worst since the management authority does not develop reporting protocol from collection site, not to mention the local staffs do not have adequate capacity to monitor the trade.

They treat the coral trade as logging industry; the SKA10 and SIAS11 document arrangement generalizes as timber product documents (SAKO12 or SAKB13) and other wildlife products, whereas coral handling is completely different from forest products handling. The export volume recorded by HS (Harmonized System) Code does not represent the coral, but marine ornamental fish species. And even that confused with freshwater ornamental fish species and pumices. The situation makes the government difficult to monitor the trade. The law would also be harder to enforce in local level, as it is difficult to identify live from dead coral, particularly when specimens split and dried for lime production.

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The Status of the Ornamental Trade in Australia: Collectors, Collection Areas and Management Strategies for Coral Resources in Queensland.

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Mr Randall Owens (Great Barrier Reef Marine Park Authority).

Coral harvesting in Australia takes place in the tropical state of Queensland and the Northern Territory and the tropical half of Western Australia. Queensland supports the highest level of participation and harvest, with Northern Territory and Western Australia reefs only contributing a small part of the Australian coral harvest.

In Australia, CITES controls are administered under the Wildlife Protection (Regulation of Exports and Imports) Act 1982 and, as such, the Commonwealth Government is involved in regulating coral trade and export in Australia. Coral is not listed on schedule four of the Act, therefore it is subject to Ministerial approval to allow export. To date no Ministerial approvals have been given to export coral from any part of Australia, therefore the fishery supplies the domestic market exclusively.

In Queensland, regulated coral harvesting began in the 1930s. Over the next decade the booming tourist trade to North Queensland demanded large quantities of dead coral specimens for highly sought after decorative ornaments and souvenirs. With better technologies, husbandry techniques and filtration systems, and a better understanding of coral biology, a trend towards live aquarium corals has occurred over the past ten years. From 1985 the percent of coral taken in Queensland for the live aquarium market increased from 14% to about 90% today.

Queensland's commercial coral fishery now supports 36 coral collectors and its estimated value is in the order of $1 million annually. Collectors are permitted to harvest coral only from a limited area of the reef, which has been estimated at less than 0.0003% of the total Great Barrier Reef World Heritage Area, and less than 0.006% of the total reef/cay area. There are 50 coral areas in Queensland waters, of which 48 occur within waters of the Great Barrier Reef Marine Park. Each coral area has a Total Allowable Catch of 4 tonnes attached to it. Up to four licence holders can access one coral area.

The 1999 harvest comprised about 10 tonnes of hard coral for the ornamental trade, 12 tonnes for the live hard coral market, 1 tonne of soft coral and about 20-30 tonnes of living rock and rubble.

With increasing demand for live coral, careful management is required to esnure that the fishery is ecologically sustainable. There are many issues currently facing the coral fishery in Queensland. Most of the coral collection activities in Queensland occur in waters of the Great Barrier Reef World Heritage area, which is managed by the Great Barrier Reef Marine Park Authority (GBRMPA) independently of the Queensland Fisheries Service (QFS).

The GBRMPA and the QFS collaboratively manage coral collection in the Great Barrier Reef Marine Park and permits/licences are required from both agencies to undertake collection.

The responsibility of the GBRMPA is of course different to that of the QFS. The obligations of managing and presenting the Great Barrier Reef World Heritage Area impose a critical responsibility to conserve the area for future generations with its values intact as a self-perpetuating ecological system. GBRMPA has clear national and international obligations to protect the species, communities and habitats in the Great Barrier Reef Marine Park and World Heritage Area.

In terms of the management of fisheries, including coral, it means that GBRMPA must assess the impacts that fisheries have on the values of the World Heritage Area.

Under the Great Barrier Marine Park Act (GBRMP) Act, the GBRMPA must have regard to:

- Conservation;
- Protection while allowing reasonable use;
- Regulation of activities that exploit resources so as to minimise the effect of those activities;
- Reservation of areas for appreciation and enjoyment; and
- Preservation of areas undisturbed by man.

These responsibilities mean that the GBRMP Act has significant influence on the management and access to fisheries resources primarily by zoning plans that regulate activities, including fishing.

Concerns that the GBRMPA has with the coral fishery include:

- Ability to audit ESD;
- Impact of collection on non-target species, habitat and benthic communities;
- Compliance with fisheries and GBRMP management regulations; and
- Interaction with tourism and recreational usage of GBRMP.

Within the GBRMPA, one of four critical issues groups, the "Fisheries Issues Group" has as its major responsibility the task of ensuring that fisheries are ecologically sustainable and do not compromise the values of the Great Barrier Reef Marine Park and World Heritage Area.

The challenge for the GBRMPA is to achieve its objectives and fulfil its legislative responsibilities through cooperation and negotiation with QFS (and other agencies) rather than using its legislative mandate in areas that are considered by many to be the responsibilities of fisheries managers.

The challenge for the commercial coral fishery in Queensland is to meet ESD objectives and to maintain its status in the face of increasing pressures and community concern for the maintenance of world heritage values in the areas in which the bulk of the fishery occurs.

Country Report: Status of the Trade in Stony Corals, Republic of Fiji

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ABSTRACT

In Fiji, the trade in stony corals is characterised by a variety of products and uses. The curio trade provides bleached skeletons for decoration. The aquarium trade collects live coral with associated invertebrates, fish and live rock for the overseas market in 'mini-reef' aquaria. The medical industry collects certain species for bone reconstruction. Domestically, they are used for lining soakage pits in septic systems. Mariculture of live coral and live rock for aquaria is being researched and have been marketed.

Beginning with curio coral collection in 1984, adding greater value to reefs through coral collection continues to be a task that has been hindered by uncertain management and the lack of scientific research. This has resulted in conflicts within industry, tourism, and Government. Despite this, the industry has been thriving with exports growing steadily. Though a positive indication that the rate of field collection is sustainable, without scientific validation concern will continue to be expressed that wild caught stocks may be over exploited. The recent mass coral bleaching events of 2000/2001 has impacted the industry as has the coup of May 2000. In the latter instance, the decline in tourism resulting from the political turmoil has led to a reduction in the flight and freight services to Fiji. This reduction is of particular concern with regard to the access of markets for live material. The post-coup Government approach to expanding the industry to more participants is at odds with previous policy.

Generally, the presence of the marine tenure system whereby local communities are responsible for well-defined coral reef areas has meant that local partnership is required. Traditional concern for coral reef fisheries has translated, in most cases, to an attempt to formulate and adhere to sustainable practice techniques. Poor practice through greed is still uncensored. The knowledge of 'best practice' methods is still not industry wide. Neither is the awareness at the village level that this industry is operating on a basis not yet confirmed by science and that the industry should be considered experimental.

Management decisions, at Government level, are still hindered by the lack of scientific assessment and monitoring of the resource. The only export quota in place is for the curio trade and this is based on a restricted freight space limitation rather than species or their numbers. There is no formal management plan though there are Fisheries Division guidelines developed for the curio coral trade and now adapted to the new industries. The omission of the coral trade activities from coastal management decisions has resulted in conflict with elements in the tourism sector. Legal obligations are confined to CITES reporting and the requirement by Government for permits and licenses.

Coral assessment is still categorical in nature, with both techniques for assessment and monitoring still being developed. Active research concentrating on these problems is largely non-existent, though one post-graduate topic is addressing some of the live rock trade impacts. There is a serious lack of capacity to adequately conduct such assessment, as coral identification skills are weak and SCUBA certification uncommon.

1.0 Background information on the trade in stony corals

1.1 What types of coral trade exist in Fiji?

In Fiji, the trade in stony corals utilizes corals for a variety of purposes. The curio trade provides bleached skeletons for decoration. The aquarium trade collects live coral with associated invertebrates, fish and live rock for 'mini-reef' aquaria ecosystems. The medical industry requires certain species of corals for bone reconstruction. Domestically, corals are removed for lining soakage pits in septic systems. Lime is derived from coral sands for agriculture and cement. Mariculture of live coral is being developed and both live coral and rock are currently on the market. Description of the aquarium and curio trades in Fiji may be found in Lovell (1995, 1999, 2000).

1.2 When did the trades start?

Coral harvesting started in Fiji in 1984 with Seaking Trading Company engaging in the curio trade and the aquarium fish trade began in that year with Aquarium Fish, Fiji. Live rock exports began in 1992 with South Seas Export (now trading under Tropical Fish, Fiji). Limited live coral exports of coral began in 1994 with the establishment of Turagaiviu Pty Ltd., which later became Ocean 2000. Aquarium Fish Fiji, after 17 years of collecting only fish, began exporting live coral in 1999. A second curio trader, Acropora International appeared in 1992. Walt Smith International (WSI) in 1995. Recently, Mare Research has been allowed to export live rock placing in question the Fisheries Division moratorium on the issuing of licenses until a national management plan is in place.

Table 1 shows the figures for the varied exports over the last four months with annual estimates.

Table 1. Total Exports of Aquarium Products and Curio Coral for 2001

Category	Product	Quantity	Fisheries Division Annual est.
Curio	Decorative coral	41,683 pcs.	125,049 pcs.
	Medical coral (some trans-shipped)	13,712 kg.	15,000 kg.[2]
Aquarium	Live Rock (Coral Base)	662,552 kg.	1,987,656 kg.
	Coral pieces	367,308 pcs.	661,154 – 1,101,924 pcs.
	Fish	103,699 pcs.	311,097 pcs.
	Invertebrates	7330	21,990 pcs.
	Clams	16,631	39,893 pcs.
	Sand	20,941	62,823 kg.

[1]The Fisheries Division annual estimates are derived from it's database for the months of Jan-April. April figures have been estimated by the Fisheries Division. They are incorrect with regard to the live coral exports. See following explanation.

[2] The annual estimate is the result of intermittent shipments

Comparing the Fisheries database estimates with the exporters' actual estimates shows a large disparity. This is due to the Fisheries Division database not reflecting the true exports as the result of inattention to the methodology. The Fisheries Division records export statistics that are based on permitted numbers issued mixed with actual exports statistics.

The fragile nature of the live exports and the odd hours of shipment due to the airline schedules, a permitting protocol exists whereby the Fisheries Division issues permits in advance with excessive numbers so as to cater for the numbers in the shipment. The system should allow the permitted numbers to be rectified by the companies submitting the figures actually shipped and these are then entered into the database so that a faithful tally is recorded. What has been occurring is that the permitted numbers have been very large and these numbers have not been corrected for actual exports giving an overly inflated export figure. This situation has been highlighted several times in the past four years and though attempts have been made to remedy the problem, the recorded export numbers in the Fisheries Division database are at least 6 times the actual exports for live coral. These false numbers have given rise to consternation both in Fiji and abroad within regulatory agencies such as the CITES secretariat. The live rock estimates and the curio coral exports approximate the actual exports.

It has been suggested by the Aquarium Traders and Curio Coral Council that a professional audit firm is employed to accurately account for the exports. The scheme would involve the submission of the actual export figures to the accounting firm. The firm would have the opportunity to audit the individual export figures on a bi- or annual basis. This accurate accounting will be important in the progressive monitoring of annual quotas.

2.1 The Taxonomy and Numbers of Corals Exported

Tables 2 & 3 provide some of the 1998-99 export details of the leading companies in the aquarium (Walt Smith International) and curio trade (Acropora International). A bold line through the listing denotes the ten most common corals in the live coral and curio trade. The annual volumes are indicated. Multiple sources of the country of origin represent transshipment of products through Fiji.

3.0 Variability in Exports

3.1 Season

There is seasonality in market demand, which relates to the Northern Hemisphere summer and winter. Aquarists are more inclined to buy aquarium products during the winter when outside activities are limited by weather.

3.2 Competition among Exporters

New entries into the industry have given rise to a price war with regard to live rock, which has caused the price to plummet from a high in 1996. The current price is three times lower at US$1.10 per pound. With different approaches to the collection and preparation of the live rock, poor practice can give a false competitive advantage. Fickleness in the market, naïve consumers, and exporters with little market understanding or strategy tend to depress the price and diminish the reputation of *Fiji Live Rock*. Inferior rock means a lower return on sale price. The moratorium on industry entry has been ended with a license being issued by the Fisheries Division. An export problem is the limitation of cargo space on the airline. The coup caused areduction in airline capacity, which now looks like being further reduced. With the limiting of flights and the reduction in plane size servicing Fiji, freight space becomes limited and also more expensive.

Table 2: Walt Smith International Exports (Jan. - July, 1999)

Genera	No. of Pieces (pcs.) shipped	Source with highest % of export listed 1st
Acropora	3393	F/T/S
Distichopora	1289	V
Lobophyllia	1031	F/T
Hydnophora	840	S
Stylastrea	775	F/T
Euphyllia	693	F/T/S
Tubastraea	662	F
Fungia	613	F/S
Porites	611	F
Montipora	604	S
Plerogyra	542	T
Goniastrea	527	F/T
Favites	519	F/T
Platygyra	475	F
Turbinaria	470	F/T
Caulastrea	460	F
Seriatopora	450	F
Goniopora	399	T/S
Pocillopora	374	F
Pavona	266	S/F
Pachyseris	261	T/F
Pectinia	246	S/F
Stylophora	225	F
Catalaphyllia	215	B/T
Millepora	180	F
Galaxea	159	F/T/S
Heliofungia	133	S
Trachyphyllia	124	B/S
Scolymia	120	B
Polyphyllia	101	S
Oxypora	82	S/F
Mycedium	60	S/F
Acrhelia	12	T
Heliopora	8	S
Montastrea	4	S
Blastomussa	2	B
Echinopora	2	F
TOTALS	16927	
Non-Scleractinia pcs.	22804	B/T/F/S/V
Assorted Species	32333	B/T/F/S/V
Assorted Invertebrates	15520	B/T/F/S/V
Live Clams		
Tridacna crocea	2070	S/V
Tridacna derasa	827	T/S
Tridacna gigas	39	S
Tridacna maxima	2719	F/T/S
Tridacna squamosa	90	T/S
Hippopus hippopus	23	S
Live Rock		
Assorted types Coralline Algae rock	291837 kgs.	F/T

- F = Fiji
- T = Tonga
- S = Solomons
- B = Bali
- V = Vanuatu

* (includes 20 different varieties of Soft corals, Mushroom Rock and Zoanthid Rock)

Table 3. Curio Coral Export Figures for Acropora International 1998

Species	Common name	Pieces shipped
Pocillopora verrucosa	Brownstem	28,587
Stylophora pistillata	Elkhorn Pacific	10727
Acropora palifera	Catspaw	8071
Pocillopora eydouxi	Cauliflower	7372
Acropora hyacinthus	Table	7027
Acropora nobilis	Staghorn	4666
Seriatopora hystrix	Birdnest	4407
Acropora humilis		4287
Pocillopora damicornis	Lace	4277
Acropora echinata	Tree	4069
Acropora latistella	Table	2783
Acropora microlados	Table	2759
Acropora nasuta	Table	2330
Merulina ampliata	Merulina	2261
Lobophyllia hemprichii	Open brain	1768
Acropora digitifera	Table	1692
Acropora granulosa	Table	1445
Acropora vaughani	Branch	1275
Millepora tenella	Fire	1263
Turbinaria frondens	Blackcup	814
Tubipora musica	Pipe Organ	750
Leptoria phrygia	Close brain	700
Acropora valenciennesi	Branch	528
Pavona lata	Cactus	497
Millepora exaesa	Slabfire	484
Pavona clavus	Pillar	403
Tubastrea micrantha	Octopus	326
Echinopora lamellosa	Poca	199
Pavona cactus	Glass	99
Acropora florida	Branch	89
Pachyseris speciosa	Speciosa	75
Turbinaria reniformis		51
Porites lobata		23
Pachyseris rugosa	Rugosa	19
Coscinaraea exesa		16
Montipora aequituberculata	Poca	15
		Total: 106,154

3.3 Community and Political Disruption

Particularly a problem in the curio trade, differences of opinion, fishing rights disputes and general envy has given rise to aggressive confrontation both between villages and village and exporter. The aquarium trade has been largely immune but disputes between operators have highlighted the industry in a poor light. This has given rise to political intervention.

3.4 Mass Coral Bleaching

Another circumstance affecting the industry was the mass coral bleaching phenomenon that severely affected Fiji in the Feb. /Mar of 2000 (Lovell (in prep), Cumming et al. (in prep.), Toscano et al. (in prep)). Mortality on coral reefs varied between 10-80%. In Bau Waters where both types of collection occur, the curio trade

went from collecting 36 species to 11 due to bleaching mortality. The aquarium traders are now only collecting soft corals due to the lack of marketable species and sizes. Reports of a decline in coral stocks also occurred in the Beqa Lagoon.

4.0 Methods utilized in extraction

Whether in the curio, aquarium or live rock trade, the village collectors go to the reef area and remove the corals with steel bars. In the case of WSI collectors, large screwdrivers are used for the collection of live coral, which is less likely to damage the coral or create collateral damage. The corals, whether curio or aquarium, are stockpiled on the bottom prior to transferring them to the boat. The curio coral is carefully loaded so as not to cause breakage. The aquarium coral pieces are packed individually in a plastic bag and filled with water and submerged in a flow through holding tank that is temperature controlled.

5.0 Coral collectors

Collectors hired by the exporters are made available through a chiefly village arrangement. Currently, there are 371 collectors. They work in groups out of a single boat or as teams collecting live rock. The collectors may rotate duty in some cases. They are all supposed to have fishing licenses but licensing is often confined to a single member of the team and is not policed.

Fiji is ideally suited for such an industry as there is an intrinsic partnership required with the exporter that offers benefits to the coastal village. By law, the villages are the custodians of the fisheries resource and are responsible for well-defined marine areas. Boundaries have been surveyed and charted by the Native Lands and Fishing Commission are available as public information. With this arrangement, exploitation of the resource conveys benefits at the community level. This presents an opportunity to institute a conservation practice in the form of a one-operator/one area constraint on collection. This practice has the benefit of accountability for the operation and allows the exporter to take only appropriate specimens and only that which is needed for immediate shipments without concern from competitors collection.

Limits on the amount of collection are imposed by the availability of international air service and roads. For the curio trade, collection is by skin diving and the use of SCUBA is forbidden. For the aquarium trade, the use of SCUBA is gained through Fisheries Division exemption. There is no compulsory adherence to a resource extraction plan, per se, as might be found in a management plan but rather is dictated by the availability of the resource. Collectors discuss the current state of the resource and collection requirements with the exporters. There is a collection strategy but no reporting is conducted except as required by CITES. The listing of only corals precludes records being kept for both fish and invertebrates. For CITES purposes, corals are recorded as to the number of pieces per genera. For live rock and sand, kilograms are used.

Collecting is on request as dictated by export demand. This means that there are some standing requests for species that are always in demand. Likewise, there is a list of species that are never to be collected usually due to their unsuitability for aquaria.

As well as the collectors, the industry employs 75 staff permanently, and it is estimated indirectly 5,000. The resource rent amounts to $100,000. The industry generates foreign exchange earnings valued at approximately F$12m annually. 25-30% but with estimates as high as 60% for some products like live rock, of revenues goes to Air Pacific as aquarium products are air freighted predominantly to the United States.

6.0 Management of coral resources

Fisheries Division guidelines were developed in 1984 in response to the beginning of the curio trade. A management plan was proposed in 1999 (Lovell and Tumuri, 1999). This has yet to be accepted. In response to the report, a senate subcommittee was formed to review the industry. Before their deliberations were known, the country was gripped by a coup that led to the institution of a new government. Despite many management recommendations in the report, it has yet to be implemented.

At present, there is no formal regulation for the aquarium trade in terms of quota or constraints on collection other than those imposed by the Fisheries Act (e.g. use of poisons or explosives) and the Fisheries Division Guidelines. The curio trade is limited in collection to 49 containers of freight space but with no limitation on species composition or the number of specimens. The Department of the Environment is required to impose quotas as part of their CITES responsibilities. This has yet to be done as it should be based on field assessment, which has yet to be carried out. The question remains as to how to set the quotas. Using the option of denying export permits or of license renewal may enforce the Fisheries Divisions guidelines or other infractions. This has never occurred.

All species of coral can be collected & there are no limitations on size or number. Guidance on collection of species, forms and collection technique comes from the exporters. Optimizing correct species identification and minimizing damage is part of the on going efforts by companies and collectors to become more efficient.

There are no 'no-take' areas, per se, but large areas of reef are forbidden for collection due to villages deciding not to engage in it. Collection occurs only around Viti Levu with most coastal parts of Fiji not utilized by the trade for logistical reasons.

7.0 Handling of wild-harvested corals

Every effort is made to minimize injury or damage to specimens as it diminishes their value. During the collection process, material is accepted or rejected at the warehouse and payment is not made for damaged items. For the aquarium trade, the holding facilities usually receive the organisms 2-4 hours after collection. They attempt to export the material as soon as possible and ship 2-3 times a week. For the curio trade there is no urgency with the drying, wrapping, boxing and filling of the containers a continuous process. Shipments are by sea.

8.0 Monitoring, Assessment and Research

The nature and abundance of species has not been assessed. The capacity for assessment within the Fisheries Division is limited do to a lack of resources and skills. There are few certified divers with identification skills either within the Fisheries Division or at the University. Presently, there is no protocol to monitor and assess the coral stock and consider the impacts of collection. CITES requirements are the only monitoring available and that is confined to the general categories of pieces and weight.

Research efforts are very limited although there are 17 post-graduates in the Marine Studies Program at the University of the South Pacific. There is a single research topic being undertaken to assess the impact of the taking of coral and live rock on fish numbers.

Research to develop mariculture as an alternative is being undertaken by WSI, who now has 30,000 specimens under cultivation. The Foundation of the Peoples of the South Pacific through the Coral Gardens project is developing commercial mariculture at the community level in the same manner as seaweed culture. Efforts have been hindered by floods, crown of thorns starfish, coral bleaching and large waves.

The prospect of growing corals at the village level is promising but techniques need to be refined, the market assessed, access to and the size or capacity of the market remain as constraints.

9.0 Legal Obligations

The Department of Environment is the CITES Management Authority and issues CITES permits. Coral shipments are sometimes inspected by the Fisheries Division. For the curio coral, the product is packaged so only the container is sighted. Permits are issued by the Department of Environment and the Fisheries Division several days in advance of shipment with the actual CITES numbers corrected after shipment. As there are few limitations on collection, the usefulness of inspection is minimized.

The Department of Environment needs additional assistance to fully understand CITES responsibilities and its implementation. Additionally, there is little capacity within the country to identify coral even at the generic level. Other obligations require adherence to the Fisheries and Customs Acts.

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A Brief Country Report: Status of Trade in Stony Coral in the Solomon Islands

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INTRODUCTION

Basic Geography

The Solomon Islands (5-12°S - 152-170°E) is a double chain with two "strands" enclosing the New Georgia Sound (The Slot ofWWII) between Choiseui, New Georgia and Santa Isabel and Indispensable Strait between Malaita and Guadalcanal. Six main Islands are: Choiseui, Santa Isabel, New Georgia, Guadalcanal Malaita and Makira. The island stretches 1700 km northwest to southeast between Bougainville (PNG) and Banks group (Vanuatu). Third largest in South Pacific to PNG and NZ with 28,370 million KM2. EEZ of 1.34 million KM2, twice that of Vanuatu and slightly larger than that of Fiji. Internal Waters (12 mile Zone) is 0.3 million KM2 - most coral reef occur. Archipelago formed recently (25 million yrs ago) by tectonic plate movement, earthquake and submergence and emergence. Of the 1500 Islands (comprising small islands, atolls and islets), most are raised volcanic limestone islands. Predominantly fringing reefs on steep slopes of volcanic islands. Situated within the "Pacific Ring of Fire" - active volcanoes: Kavachi and Tinakula. Dormant: Savo and Paraso.

Climate system

South-easterly trade winds (ARA) occurring from May to October - characterized by dry and fine weather. North-westerly monsoon winds (KOBURU) occurring December to March - characterized strong winds and wet weather. Mean daily temperature all year round 28°C and rainfall range between 3000 - 5000 mm per year.

Human history and Demography

Indigenous people of SI diverse. Melanesian settled SI 4000 - 6500 years before present. Polynesians 2000 - 3000 years ago. Leary (1993) - Melanesians 94.2%, Polynesians 3.7%, Micronesians 1.4% and those of Chinese and Caucasians 0.7%. First contact with "whiteman" when discovered in 1568 by Alvaro de Mendana. 1897, Great Britain administered SI as Protectorate. Political Independence gained from Great Britain on 7' July 1978. Divided into 9 provinces. (1) Temotu province (2) Makira/Ulawa province (3) Guadalcanal province (4) Malaita Province (5) Rennell and Bellona province (6)Central Islands province (7) Isabel province (8) Western province (9) Choiseui province. 1999 national census: Total population of SI is 408,358. Population density of 14 persons per square kilometer. Population growth rate at 3.6% per annum (1986 census). Majority of people live in coastal communities.

Tenure and Ownership

Customary Marine Tenure (CMT) system is an important part of the cultures ofSI and varies between different cultures. CMT has been described as complex and dynamic and recognized under SI constitution (Fisheries ACT 1998). Under CMT, coral reefs and adjacent coastal areas (lagoons and barrier reefs) are owned under a kinship group based ownership. Owners are part of reef system and any impacts on reef system will have a bearing on them. Success or failure of projects or conservation effort on coral reefs depends on owners.

Coral reef systems
Coral Reefs Distribution and Description

Coral reef mainly fringing and intermittent around all islands (Wells and Jenkins, 1988). No corals on sandy beaches and near major river mouths. Largest areas of coral reef occur where there are large lagoon complexes variously protected by volcanic islands, raised islands, sand cays or barrier reefs. Significant areas are: Around Shortland and Bougainville; Inside barrier reefs along the northeastern shore ofChoiseu; On either side of Manning Strait between Choiseui and Santa Isabel; In the Gizo - Vonavona - Roviana lagoonal areas on New Georgia's southern shore; Marovo lagoon - encircling Vangunu (southern NG) and along the northeastern coast past Ramata almost to Lever Harbour; Malaita: North Lau lagoon and west Langalanga lagoon; Marau: eastern Guadalcanal.

Long submerged barrier reefs (tens of Kilometres) like the Great Sea Reef (Fiji)do not occur in SI; though small examples are: Reefs along northeast coast of Choiseui; Near Gizo and Munda (NG); Off Star Harbour (eastern Makira); Northeast of Russell Islands; Across Kangava Bay (south coast Rennell); Around Utupua (Santa Cruz); In Reef Islands, a line of four reefs stretches westwards for 21 km; The Great Reef slightly further north 25 km long.

Atolls are uncommon though some examples are: Ontong Java is the larger one - 70 km long and 11-36 km wide (reef flats enclosing 1400 km2 of lagoon); Sikaiana - small atoll 10 km wide with 45 m tall remnant of original volcano; Oema atoll in Bougainville Strait; Rennell and Bellona are raised atolls with cliffs and fringing reefs.

Infrequently visited mid ocean reefs (presumably covered with coral): Roncado and Bradley reefs south of Ontong Java; Indispensable reef south of Rennell; Several shoals south of Santa Cruz.

Artificial Reefs for coral: WWII transports, small vessels and aircrafts sank in shallow lagoons and waters, mainly in Western province. Most of 67 warships, transports sank lie too deep in Iron Bottom Sound for coral growth.

A. BACKGROUND INFORMATION IN ON THE TRADE IN STONY CORALS

Sporadic exports (mainly dead corals) since 1984 but no proper records kept as there was no database then. Trade in corals (hard and soft) was properly established in 1996 (Table 7). Table 1 gives some indication of how much coral is exported annually since 1996. Figures however, represent number of pieces exported rather than weight. Live specimens are exported mainly but sometimes, skeletons and rocks (live and dead) are also exported.

Two companies exported corals between 1996 and 2000. These are the Solomon Islands Marine Exports and Aquarium Arts. This year, both are exporting under Aquarium Arts only.

The trend since 1996 is obviously a declining one. Whether this is due to localized overharvesting is clear as no monitoring or assessment studies are in place to ascertain this. The ethnic tension recently experienced in 1999 and 2000 may have affected the exports in these years respectively though.

At this stage it is difficult to determine the most common coral species and volume exported in the trade due to the naming system used (mostly common names). However, species from the following genus are mostly exported:Euphyllia, Acropora, Goniopora, Montipora, Tubastrea, Favites,Galaxea, Heliopora, Lobophyllia, Merulina, Pachyseris and Fungia.

B. CORAL COLLECTORS

The actual number of collectors are not known but Exporters are required to keep proper record of who, when and where corals are collected. Collectors are independent but they get assistance from the Exporter.

Collectors may not be necessarily hired by Exporter or even work for the exporter. Most collectors are from Ngella in the Florida Group. Some from Marau Guadalcanal) and Munda (Western Province).

Collectors are not Licensed and required to have a permit. They are actually traditional reef owners - CMT. Coral Collection is done by collectors in reef areas owned traditionally by their Tribe/clan. It is not clear however, whether they are limited to certain portions of their reefs, depth or specific locations. There are no established collection sites other than the Exporter facilities in the capital Honiara. Most collectors obtain corals by snorkeling but there are unconfirmed reports that SCUBA and Hookar are also used in certain areas. It is not clear whether collectors use site rotation but I believe this does not happen. However, under CMT, seasonal closures for marine resources are practiced in many communities in Solomon Islands - Ngella.

Collectors mainly collected what Exporters/buyer requested.Collectors do not produce annual reports on numbers and sizes of species collected and where they were collected. Exporter(s) is required to provide these information to Ministry of Fisheries and Marine Resources (MFMR). Collectors do not have information on mortality associated with collection.

Mortality information may be recorded by Exporter for those occurring at holding facilities.

C. MANAGEMENT OF CORAL RESOURCES

Currently, there is no Management Plan for coral resources but MFMR is definitely going to develop one after this Workshop. But a “Fisheries Regulation on use and extraction of Corals and coral sands prohibits (i) extraction of dead or live corals and rocks from Protected Areas and (ii) extraction of corals and sand using heavy machinery”. Lime Production exempted. Under Solomon Islands Constitution, CMT is recognized. Under CMT, short term protected areas or closed/open seasons/areas can be declared by traditional reef owners (tribe/clan) for marine resources including corals. A Coral mariculture (farming) project is currently implemented by a local NGO Solomon Islands Development Trust (SIDT) on Malaita.

D. HANDLING OF WILD-HARVESTED CORALS

Some guidance on best practices to minimize injury and mortality during transport are expected to be provided by Exporter. Some guidance are expected from Exporter with regard to handling and replacement of unwanted corals. MFMR does not have Information on how long after corals are collected before these are provided to the Exporter in Honiara. There are proper tanks with aeration and good water circulation system at the Exporter holding facility in Honiara. No information given to MFMR on how long specimens are held in these holding facilities before export.

E. MONITORING, ASSESSMENT AND RESEARCH.

The condition of coral reefs and abundance is never assessed before collection. There is no protocol in place to monitor the status of resources and assess impacts associated with coral extraction. There is currently no scientific research examining the life history features of corals in trade in specific collection sites. SI is getting assistance from the Canadian Government to join in the Global Coral Reef Monitoring Network. An Interim Steering Group has been elected to spearhead setting up of a National Coordinating Committee. The NCC will then Plan the in- country coral monitoring activities and programmes.

F. LEGAL OBLIGATIONS

MFMR and ECD (MFEC) issue permits for coral export. Coral shipments are inspected by Officers from MFMR before exported. Country is not experiencing overexploitation of corals at this stage and it is our wish that this Workshop would greatly assist us in developing a Management Plan for the resource. However, should the need for assistance arise in future, we will surely request it from proper experts. The Solomon Islands would certainly need training in coral identification for our law enforcement officers. Our database needs to be revised to cater for more accurate and relevant information on the trade.

TABLE 1: Coral export 1996 to 2000

Product Type/$	1996	1997	1998	1999	2000
Pieces	175,203	6397	84755	58181	27,331
$SBD	587,584	289,970	203,628	211,785	110,837.50

Source: Statistics Office and MFMR.
Note: These figures include both hard or stony corals (including rocks) and soft corals and represent pieces exported rather than weight.

Country Report of the Kingdom of Tonga: Status of the Trade in Stony Corals

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A. BACKGROUND INFORMATION ON THE TRADE IN STONY CORALS

The trade of stony corals in Tonga started in 1988 by one tropical aquarium fish operator and exporter called the Exotic Tropic of Tonga. Stony corals, ornamental fish and invertebrates were harvested and exported to the United States of America for aquarium purposes only. The beginning of the aquarium industry in Tonga can be dubbed as an American-and-Tongan view initiated by a party consisted of Americans and Tongans. The first company ceased operation in a few years then another operator was established called the Walt Smith International. Thus, from 1988 to 1992 harvesting of corals for aquarium trade was undertaken by only one operator/ exporter. After 1993, three additional operators joined the industry; Intra-Pacific, Sea of Colour, and the Dateline Aquarium Fish. In 1995 the Ministry of Fisheries set up a policy that only 5 aquarium operators per year be allowed to conduct aquarium activities in the Tongatapu group, the main island group of the Kingdom of Tonga (refer the attached map). By the end of 1996 two operators stopped operation, then two companies Mele D. Vaha'i and Topac Marine filled up the vacancies. Both operation stopped after less than 12 months. In 1999 there were only two players in the industry, the Walt Smith International (Tonga) and the Dateline Aquarium Fish Co. Ltd., then the Vanisi International joined in the year 2000. At present, three operators are currently active on the stony coral trade. The coral harvesting activity mainly confines to Tongatapu and is yet to be extended to other groups, such as Ha'apai and Vava'u.

Two major types of stony coral exported from Tonga, the dead rock (hereinafter referred as aquarium rock, live rock or dead coral) and live coral. The aquarium rock are mainly *Scleractinia sp.* of which each aquarium operator/ exporter is allowed to export no more than 100 metric tons per annum. This quota was set in 1995. Regarding live coral harvest, each operator is allowed to harvest 300 pieces per week.

The harvest of live coral started in mid-1997 following survey on aquarium fish and coral conducted by the South Pacific Commission, now the Secretariat of the Pacific Community. The species harvested include: *Acropora sp, Alveopora sp., Caulastrea sp., Euphyllia sp., Favia sp., Favites sp., Fungia sp., Galaxea sp., Goniopora sp., Goniastrea sp., Lobophyllia sp., Millepora sp. Montipora sp., Oxypora sp., Pachyseries sp., Pavona sp., Platygyra sp., Plerogyra sp., Pocillopora sp. Seriatopora sp., Stylaphora sp., Stylaster sp., Stylophora sp., Tubastrea sp., Tubipora sp., Turbinaria sp.,*

Almost all corals are exported to the United States of America with very small amount being exported to Europe. Table 1 shows the quantity of aquarium rock and live coral exported from Tonga in 1997 - 2000 with corresponding fob (free on board) values. This figure is believed to be 'under- valued' and it does not reflect the true value of the industry. Table 1 shows a decrease on quantity of aquarium rock exported in 1998 (decreased by 10.5 metric ton) and 1999 (12.3 MT) compared to 1997 (40.5MT). In the year 2000, the aquarium rock export quantity increased to 137.5MT, a 339% increase compared to 1997. On the other hand, the live coral harvest depends on the number of pieces. The data shows a slight increase of the live coral quantity in 2000 compared to 1997.

Furthermore, the annual trends in the trade poses a high demand from the market in October to April and low demand from May to September according to one operator. That high demand is shown on the

graphs for live and aquarium rock/ dead corals export from 1998 - 2000. The trend in coral trade in Tonga primarily depends on the international market as well as the freight capacity. On freight, the aquarium industry competes with fresh tunas, snappers and groupers for airline space. The monthly trend in coral trade (live coral and aquarium rock) is shown in Figures 1 & 2. Again, the degree of increase and decrease depends on the market and freight capacity.

The current operators were requested to comment on the ten popular generas/ species of coral they have exported. Two operators responded, one gave the percentage proportion while the other prioritize by number all the corals its company has exported. The former indicated the percentage proportion: *Acropora 40%, Pocilliapora 5%, Stylophora 5%, Montipora 5%, Lobophillia 5%, Turbinaria 5%, Seriatopora , Euphillia , Tubastrea , Favites and Favia 20%, other 15 %.*. The latter showed the order ranging from the most to the least as follows: (1) Mushrooms (*Rhodactis inchoata, Discosoma sp*. & many other types of mushrooms) (2) Brown, Green, Yellow Polyps such as *Pachyclavularia violacea* and *asbestinum* (3) *Alcyonium sp*. or commonly called colt coral (4) Leather corals such as *Sarchophyton sp*. and *Sinularia* (4) *Acropora sp* - acro being the common name (5) *Montipora sp*. - name used by the aquarium trade (6) *Caulastrea sp*. or trumpet coral (7) *Lobophyllia sp*. or brain/ meat coral (8) *Pocillopora sp*. or Birdnest Coral, and (9) Live Rock or *Scleractinia*.

In essence, the overall harvest of stony corals in Tonga (Tongatapu group only) at present is believed to be undertaken in a sustainable manner. The method being used for collection of aquarium rock and live coral complies with the code of practice being set for this industry (refer Appendix). The dead coral or rubble are picked by hands while the live corals are strictly harvested on a rotational basis from certain locations of the Tongatapu reefs. Noteworthy to mention, an earlier comment from the South Pacific Regional Environment Programme (SPREP) suggested that in order to know the sustainability of the aquarium collection activities one must allow collection to be undertaken with appropriate data/ statistics to be collected (by operator and the Ministry of Fisheries) for onward monitoring and assessment. Subsequent reports on the aquarium industry by SPREP 1994 and SPC 1996 indicated that the current exploitation for both aquarium fish and coral harvest in Tonga is sustainable and should be sustainable with the 5 operators being set for the Tongatapu group.

B. CORAL COLLECTORS

The number of people involved on coral collection in Tonga is very small and is currently ranging from 12 - 15 for all the three current operators. All collectors are certified divers and well trained on sustainable practice for coral collection. A collector must be an employee for an operator and he will work in accordance with the code of practice (refer Appendix) which can be reviewed from time to time should needs arise. During collection time, each operator has a supervisor to ensure that the code of practice is observed. In addition, a fisheries inspector/ observer do often accompany collectors to the reef for coral collection.

Aquarium rock collection is done on the outer reefs while live coral is strictly harvested on a rotational basis from certain locations directed by the code of practice.

The common gear used for coral collection is snorkel while the hookah and scuba are sometimes used on at least 10 metre depth. Collectors confine their collection to market requirement and freight capacity. They record the weight of the dead rock/ live rock harvested while the live coral harvest is recorded in a logbook. All information are submitted to the Ministry of Fisheries prior to export shipment authorisation. The log

book is to be submitted on a monthly basis for inspection by the fisheries inspector which he signs and dates to confirm that the logbook data complies with the collection activity being undertaken.

Regarding the question of whether or not the collectors have information on mortality associated with collection and handling, all collectors commented that hardly any mortality occurred during the course of collection and handling. Therefore they do not have any information on coral mortality.

C. MANAGEMENT OF CORAL RESOURCES IN TONGA

The current management regime for the harvest of stony corals in Tonga emanated from the SPREP 1994 Report to the Prime Minister's Office on the collection of corals and aquarium fish from the Kingdom of Tonga by Jamie Oliver & Andrew Smith (1994) and another follow up report by SPC entitled: "The aquarium-fish fishery in Tongatapu, Tonga: status and recommendations for management by S. Matoto, E. Ledua, G. Mou-tham, M. Kulbicki & P. Dalzell (1996)". Both reports were noted by His Majesty's Cabinet.

Hard coral is any coral with a stony skeleton belonging to the Order Scleractinia, Coenothecalia, Athecata, and Stolonifera. This group contains all common hard or stony reef corals including the Genera *Acropora* and *Goniopora*. It also includes blue coral, organpipe coral and fire coral.

It is noteworthy to mention that hard coral (live coral harvesting) harvest was banned by Cabinet in December 1993 and re-confirmed by Cabinet Decision in April 1994 after the report by Jamie & Oliver (1994). The latter decision recommended that a field survey must be done to consider whether or not the live coral harvest is sustainable. Although the live coral harvest affected the industry the ability to control its ban opened the door for some of the operators to consider extending to other countries in the South Pacific. Coral harvest has been a subject of many discussions and heated debates in Tonga. However, it is the view of the Ministry of Fisheries that every marine resource should be subject to exploitation/ use, so long it is carried out in a sustainable way employing total allowable catch, best practice, etc. Thus, live coral harvest resumed in 1997 following assistance of the South Pacific Commission (SPC) Resource Assessment Section. At the second quarter of 1996 a team of research scientists conducted a survey of the aquarium fish stock and hard corals in Tongatapu. In essence, both the above reports (SPREP & SPC) concluded that the current state of exploitation in the aquarium industry is sustainable though the first report make precautionary approach to live coral harvest due to recommendation of the Ministry of Fisheries.

In 1997 the Ministry of Fisheries prepared the code of practice for harvesting of live corals in Tonga. Fisheries (Conservation and Management) Regulations 1994 make provisions for coral as follows: (1) No person shall remove or take any coral from within the fishery waters except with the written permission of the Secretary for Fisheries. (2) The Secretary may impose such conditions as he may specify, including, but not limited to, conditions relating to: (a) the quantities that may be removed or taken; (b) the location or locations from which it may be removed or taken; (c) the duration of any permission granted; (d) the method of removal or taking; (e) measures necessary or desirable to conserve and protect the marine environment; (f) the fees, royalties or compensation to be paid in respect of the permitted operations.

At present, Tonga employs good collection practices that are stipulated by the code of practice. The areas for collection are inspected for damage and abundance. The operator always attempts not to collect more than 2 weeks of shipping. The collection is planned ahead as per market order. The size of coral collected is determined by the Ministry of Fisheries following consultation with the operator on best practice to be adopted.

As a guide for best collection practice one operator has been working on fraging corals and attempt is made to make them popular in the coral community. Some areas have been designated as no take areas such as the fringing reefs adjacent to Tongatapu, marine parks and other locations (refer Appendix A). Inspectors always attend to make on-site inspection, and also present at the packing to ensure compliance.

D. HANDLING OF WILD-HARVESTED CORALS

Handling of wild-harvested corals is important to minimize or eliminate injury and mortality during transport. To ensure good handling a fisheries inspector always inspect the export facilities and attend packing. A guidance for best practice on handling to minimize coral injury and coral mortality will be incorporated into the current code of practice. At present only one operator treats broken coral during collection, i.e. by turning it into a frag (when a coral is glued to a piece of rock using underwater putty) while the other operators do not make any precautions.

Transporting of the corals from collection site takes 1 - 2 hours depending on the distance from the collection site to the shore and another hour to the operator's establishment. The corals are then kept on facilities using the best and latest technology available (i.e. protein skimmers, ultraviolet sterilizers, filtration system, etc.). One operator keeps live coral on saltwater tanks and store rocks in the ocean to help the curing, when excess matters such as sponges and certain algae are removed. The holding time is no more than 2 weeks prior to air-transport to the market. On export to the USA all operators try to ship on 20 hour flights or less in order to minimize coral injury.

E. MONITORING, ASSESSMENT AND RESEARCH

The condition and abundance of the coral resource within a particular area is always assessed by the Ministry of Fisheries and collection supervisors from aquarium operators before collection is undertaken. In this assessment the sustainability of the area for collection is considered. This is particularly important for live coral.. In addition, the current protocol being used to monitor the status of the resource and any impacts associated with coral extraction is the using of harvest logbooks and inspection of sites. This provides specific information such as types, sizes, weight, location, dates, quantities, name of divers, and operators.

Regarding scientific research there is currently no activity to examine life history features of corals in trade that may be relevant to management such as growth rates and recruitment in specific collection sites. However, research program is now being done to explore alternatives to wild harvest, such as coral mariculture. One operator indicated that some mariculture corals are now being harvested by its company. Notwithstanding the above, the Ministry of Fisheries plans to seek assistance for a review of the aquarium fish and coral harvest by June 2002, i.e. the completion of the first five years of the live coral code of practice (management plan).

The legal obligations for the stony coral trade in Tonga is vested specifically with three ministries. The Ministry of Fisheries prepares the management plan and gives authorisation for collection actitivities *vide* the Fisheries Act 1989 (Fisheries Amendment Act 1993) and the Fisheries (Conservation and Management) 1994. The Ministry of Fisheries issues the permit for coral export as per list of species submitted by the operator/ exporter prior to shipment. Although Tonga is not a party to CITES all matters relating to export of corals are dealt with in accordance with the CITES guidelines. At present every shipment from Tonga is attended and inspected by a fisheries inspector.

Although each of the three operators and the Fisheries Inspector use CITES guidelines, none of the personnel involved has attended a workshop, short term training or attachment on how to implement CITES obligations. Most of the personnel involved have learnt coral identification from coral textbooks such as the book entitled ''Coral of Australia and the Indo-Pacific (1986) authored by JEN Vernon. Therefore, additional assistance to manage coral resources in a sustainable manner, coral identification training for law enforcement to verify the accuracy of permits and prevent illegal coral shipments and other related issues are required as soon as possible.

The only other government departments involved are the Ministry of Labour, Commerce and Industries which issues the commercial licence for exports and the Customs Department, Ministry of Finance, which involves on export inspection in accordance with the provision of the Customs and Excise Act. This Act prohibits export of raw unprocessed coral and live coral without the consent of the Collector of Customs.

REFERENCE

1. Ministry of Fisheries Annual Report 1997 - 2000

2. Legislation : Fisheries Act 1989, Fisheries Amendment Act 1993, Fisheries (Conservation & Management) Regulations 1994; Customs & Excise Act, Parks & Reserves Act

3. SPREP 1994 Report to the Prime Minister's Office on the collection of corals and aquarium fish from the Kingdom of Tonga by Jamie Oliver & Andrew Smith

4. SPC 1996 Report entitled "The aquarium-fish fishery in Tongatapu, Tonga: status and recommendations for management by S. Matoto, E. Ledua, G. Mou-tham, M. Kulbicki & P. Dalzell".

APPENDIX A

GUIDELINES TO ISSUING OF LICENCE FOR COLLECTING AND EXPORTING LIVE (HARD) CORAL FOR AQUARIUM PURPOSES 1997

1. There should be no more than 5 operators permitted to collect and export live (hard) coral in Tongatapu.

2. A new aquarium operator must have had sufficient proven experience that ensure safe, less hazard and sustainable harvesting techniques before the issue of a licence.

3. The aquarium operator wishes to harvest and export live (hard) coral must submit a proposal to the Ministry of Fisheries, including but not limited to, the market which it intends to export, the likely international prices of the specific coral generas/ species, the likely cost insurance freight value of the coral to be exported and any other conditions designated *vide* section 17 of the Fisheries Conservation & Management Regulations 1994.

4. That harvest and export of live (hard) coral be allowed to resume with a maximum allowable catch of no more than 300 pieces per week collected in total by any exporter. No more than 14, 000 pieces of live coral should be exported per year per collector

5. That the maximum size in length of hard (live) coral to be harvested as per following genera: *Montipora* (20cm), *Acropora* (12cm), *Alveopora* (10cm), *Caulastrea* (10cm), *Euphyllia* (15cm), *Favia* (12cm), *Favites* (15cm), *Galaxea* (15cm), *Goniastrea* (15cm), *Goniopora* (15cm), *Lopophyllia* (20cm), *Millipora* (15cm), *Platygyra* (12cm), *Pocillopora* (12cm), *Tubastrea* (15cm), and *Tubipora* (15cm) *Turbinaria* (20cm). Any additional generas will be approved by the Ministry of Fisheries.

6. The entry of any new foreign company or Tongan registered company involving non-Tongan nationals into the industry should involve 50% Tongan national equity participation.

7. That a resource rent (fees) shall be paid to the Ministry of Fisheries. The levy is 10% proportion of the fob (free on board) price.

8. The licence/ permit fee for the harvest of live (hard) coral shall be $300 per operator which shall be valid for 12 months.

9. That a company involving full Tongan nationals as shareholders shall be subject to only 1% resource rent.

CODES OF PRACTICE FOR HARD (LIVE) CORAL HARVESTING

1. Harvest must be undertaken on the areas specified on the Table and the attached Map.

2. Harvesters should be employees of the aquarium fish operator/ exporting company that has been registered in Tonga and the company should be responsible for the harvester's actions.

3. Coral must be cut by hands or any other techniques recommended from time to time by the Secretary for Fisheries.

4. Harvest Logs, designated from time to time by the Registrar must be filled by companies showing areas harvested and quantity taken. Logbooks must be submitted to Fisheries on a monthly basis or as directed by the Registrar.

5. Separate records should be kept on the number of pieces per species and total weight and dollar value of all coral exported. This data should be submitted to the Ministry of Fisheries when applying for an export licence per shipment

6. Destructive fishing techniques such as using of hammers and crow-bars are prohibited.

7. Management officers (fisheries inspectors) should accompany harvesters on harvesting trips at least 4 times per year

8. Unless directed by the Secretary for Fisheries, Fisheries inspectors should carry out a spot check of the contents of boxes approved for export.

9. If any application to relax these restrictions is made, it should be justified (at the proponents expense) by providing supporting information in the form of an environmental impact assessment

10. The Government review this policy in 1-2 years time in the light of the data collected by exporters and any other studies which may have been conducted.

COLLECTING SITES FOR LIVE CORAL (HARD CORAL)

Note:

a) Collection should be refrained from the marine parks and adjacent reefs surrounding the mainland Tongatapu - this would mean that no coral collection be permitted in the Hahake shoreline, Nuku'alofa shoreline, Hihifo shoreline and the southern fringing reefs of Tongatapu (Liku Cliff); unless otherwise authorised by the Minister of Fisheries. Most of the above areas are spawning grounds for coastal marine lives and fishing grounds for coastal communities/ local fishermen. The reef areas and marine parks can be used for "underwater ecotourism". In essence, these reefs support local consumption and easy access to Tongans who cannot afford boats.

b) Collection should be restricted at the present time to the northern reefs of Tongatapu (see Table below for the proposed collection sites). The northern reefs are divided into 4 areas. Where appropriate, the designated areas may also be divided into sections. Rotation on the 4 areas should take 12 months to complete.

c) All aquarium boats should be registered and licensed immediately for ease of monitoring and keeping track of coral harvests.

d) Future expansion on sites can be done on outer islands, Ha'apai & Vava'u Reefs

e) The harvest of live corals should be rotational harvest, following instructions from the Ministry of Fisheries , conducted on

Table 1: Live coral and aquarium rock exported from Tonga in 1997 - 2000 taken in its essential from the Ministry of Fisheries Annual Reports 1997 - 2000

Coral	**1997**			**1998**		
	PCS	**W**	**TOP$**	**PCS**	**W**	**TOP$**
Aquarium Rock *(branched, slap and solid)*		40531. 00	121593. 00		30, 314. 09	90, 944. 70
Live Coral	6, 494		28, 397. 25	13, 178. 00		79, 068. 00
TOTAL	**6, 494**	**40, 531**	**149, 990. 00**		**4, 560. 9**	**170, 012. 70**
	1999			**2000**		
	PCS	**W**	**TOP$**	**PCS**	**W**	**TOP$**
Aquarium Rock *(branched, slap and solid)*		27779. 0	83337.6		137, 459. 07	412, 377.20
Live Coral	24, 975		113, 141. 00	26, 053		159, 018. 00
TOTAL	24, 975		**196, 478. 60**		137, 459. 07	**571, 395. 20**

Table 2: Coral Harvest Site Locations and the duration of harvest

Sites Number	**Name of Site Locations as per small islands on the north of Tongatapu**	**Duration of Harvest (month)**
AREA 1	North & East of 'Atata (same as no. 3)	2
AREA 2	Ualanga Lalo Ualanga 'Uta Mounu.	(1 month on each surrounding reefs)
AREA 3	Northern edge of Fafa (to avoid the resort) 'Onevai 'Onevao Velitoa (Hihifo & Hahake)	2
AREA 4	Reefs stretch from Motutapu islet to Tau islet (a big area)	5

Figure 1: MONTHLY TRENDS OF LIVE CORAL TRADE IN TONGA 1997 - 2000
The graphs present the number of pieces of live coral export on a monthly basis with corresponding fob value in Tongan Pa'anga (TOP) (The length of a live coral piece ranges from 5 - 20cm depending on the species harvested. TOP$1.00 ranges from USD$0.57 to $0.61 depending on the daily rate)

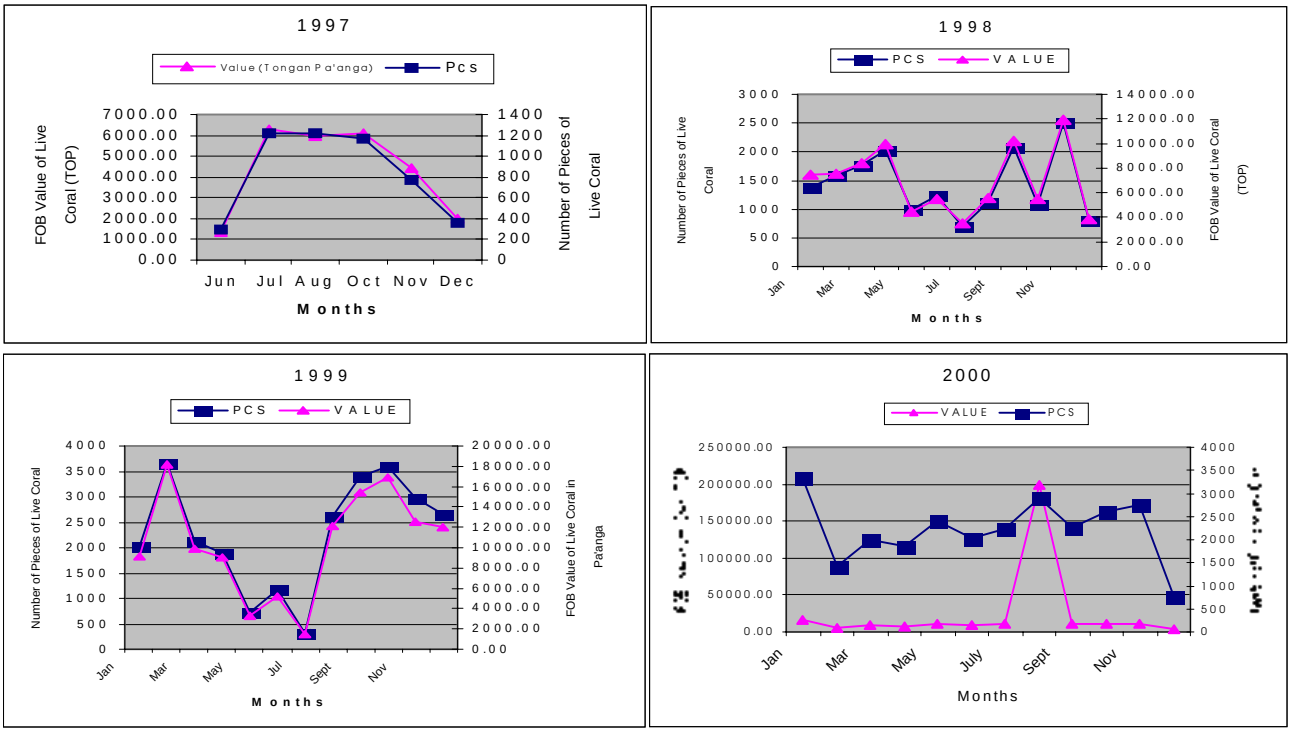
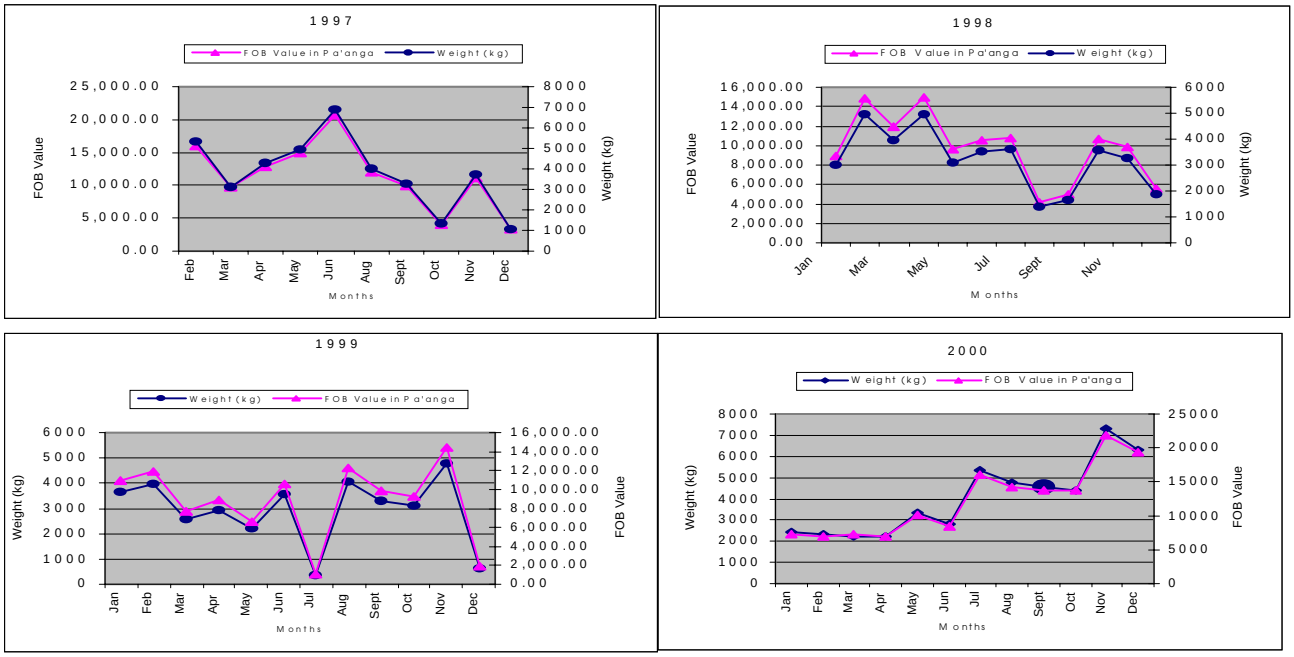


Figure 2: MONTHLY TRENDS OF AQUARIUM ROCK EXPORT FROM TONGA 1997 – 2000
The graphs represent the monthly weight (kilogram) of aquarium rock export with corresponding TOP$1.00 ranges from USD$0.57 to $0.61 depending on the daily rate)



Country Report: Status of the Trade in Stony Corals in Vanuatu

William Naviti and Trinison Tari

Background Information on the trade in stony corals

The trade formally began in January 2000. The units used in the trade of trade of stony coral is kilograms for 'live rock' and pieces for 'cultured' coral. Since this is a relatively new trade, export quantity has been small. Records show that in 2000, 7,675kg of live rock, and 251 pieces of live cultured coral was exported. Like-wise, till March 2001, 4,100 kg of live rock and 'cultured' corals were exported. See table 1, figurel,2,3 and 4 for details. There are 3 coral exporters presently exporting corals. All corals exported are either live rock or cultured coral. There is no export of live coral colonies that have been dislodged directly from the wild.

Live coral species exported are acropora, porites & pocillopora. Live rock sometimes reported as scleractinia, is also exported. There is no export of curio corals, but there are small quantities being sold locally. Very small quantities are taken overseas as well by visitors.

Coral collectors

Coral collectors are usually the reef custodians themselves including those employed by exporters who are foreign investors. There is no formal licensing regime for collectors yet.

Cultured coral is collected and planted in the outer islands of Vanuatu. These are areas where locals are interested and willing to participate in the trade, on reefs where there has been signs coral damage as the result of cyclonic activity, grow-out sites on reefs where there's security from product damage by people, and on outer islands where there are regular flights to Port Vila.

As for live rock these are collected at depths between 10 and 20 metres by using only the exporters own experienced and qualified hooker or SCUBA divers. The areas of coral collection are usually on the inner and outer reef slopes especially in areas which has been ravaged by past cyclonic activity.

With respect to the exporters, coral collection in any area is currently restricted to one exporter.

Overseas customers requirements usually determines what species should be collected.

It is a requirement under a fisheries export license, that all exporters provide monthly reports about the species collected, date collected, island collected, and area on island collected. However there are no requirements for reporting size. In addition there is no requirement for exporters to quantify or quantify mortality rates associated with collection and handling, or even that concerning the fate of the rejects. However there is a plan to ensure that each 'culture coral' is tagged in some way to facilitate audit checks.

Management of coral resources

There is currently no management plan for stony corals in place, although there is a regulation limiting the harvesting of corals (Fisheries Regualtions, 1983). As a matter of licensing, only live rock and cultured coral

can be collected and exported. There currently aren't any restrictions as to what species can or can't be collected, or what areas can or can't collection take place in, nor restrictions on size limits and annual quotas.

Handling of wild-harvested corals

The only live coral that is harvested is the fragments. No natural colony is wild-harvested. As for live rocks these are wild-harvested. There are currently no formal guidelines in place to advise as on best harvesting practices, nor guidance on handling and replacement of unwanted pieces or whole specimens, apart form that as advised by the exporters.

Fragments are tied to flat pieces of dead coral using rubber bands or nylon fasteners, then left on the seafloor to grow. After 3-4 months corals will have attached to the substrate. The substrate themselves are 'flat' dead corals. Only those which are of export quality are exported. The others are retained as brood stock or returned to the sea. Stock to be exported are harvested 1 day before the export date. They are washed in filtered fresh seawater to remove excessive slime before being packed carefully in a manner so as to avoid coral damage.

Grown live coral fragments are usually harvested at 2 days before the export date and pre-packaging treatment given 24hrs before departure date.

Live rock is harvested at least 1 week before export date and treated at least 3 days before the departure date.

Because the export establishments are small, no large quantities of products can be held indefinitely before being exported. An establishment will usually have between 2 to 10 (1000 - 2000 litres) holding tanks made from reinforced plastic or concrete, to hold specimens.

Monitoring, Assessment and Research

Coral collection is permitted without any pre-assessments of areas in which corals are to be collected. Likewise there is no protocol in place to monitor the status of the resource and assess any impacts associated with coral extraction. The only informal research being carried at present is by a member of the private sector. The research looks at what types of coral that could be man-cultured, growth rates, best grow out sites etc.

There is no formal research that specifically looks at coral life history features of corals that may be relevant to management such as recruitment in specific sites etc. There are no research programs in place to explore alternatives to wild harvest, such as coral man-culture. Vanuatu however allows only the export of live coral fragments that have been grown. This in itself will not technically qualify as a cultured product if one were to be strict.

Legal obligations

In Vanuatu, authorization to export corals is given firstly, by the Minster responsible for Fisheries, in terms of a fish export processing establishment license and an export permit for every export consignment. Secondly, one would also need to obtain a CITES permit from the Environment Unit, which is the in-country designated CITES authority. Vanuatu is a party to CITES since 1989. Before an export permit is issued by the Fisheries Department, the exporter will need to produce evidence of a CITES permit for the particular

consignment in question. A fisheries inspector inspects all coral shipments before a consignment is exported with the officer being regularly present during packaging. This has been possible since the activity takes place in Port Vila and over-time pay to the officer on duty.

Vanuatu does need additional assistance to manage coral resources in a sustainable manner, such as the development of a coral management plan.

One of the most common problems is the difficulty of enforcement officers' ability to identify what is really coral as opposed to what's not, including identifying individual species. It would be beneficial if a training of this sort can be provided to enhance the verification of permit accuracy and prevention of illegal shipments of corals. Vanuatu understands its CITES obligations but there is a need to strengthen CITES information and education awareness particularly to law enforcement officers, including the general public who hadn't been targeted in the past.

Table 1: The export trade of Stony Corals from January 2000 to present

Date	Exporter	Species	Quantity	Value	Area	Island
04-Jan-00	Aqua Life Exports Ltd	Live rock	500 kg	USD 500	Ifira	Efate
07 Apr 00	Aqua Life Exports Ltd	Acropora	100 pieces	USD 400	Lamen Bay	Ep
12-Jun-00	Aqua Life Exports Ltd	Porites	50 pieces	USD 150	Lamen bay	Ep
05-Jul-00	Aqua Life Exports Ltd	Pocillipora	51 pieces	USD 151	Lamen Bay	Ep
17-Jul-00	Aqua Life Exports Ltd	Live rock	100 kg	USD 300	Port Vila	Efate
17-Jul-00	Aqua Life Exports Ltd	Live rock	300 kg	USD 300	Moso	Efate
08-Aug-00	Pacific Marine Life Ltd	Live rock	225 kg	USD 280	Erakor	Efate
08-Aug-00	Aqua Life Exports Ltd	Live rock	250 kg	USD 1400	Port Vila	Efate
13-Sep-00	Aqua Life Exports Ltd	Live rock	100 kg	USD 100	Port Vila	Efate
13-Sep-00	Aqua Life Exports Ltd	Live rock	500 kg	USD 500	Port Vila	Efate
13-Sep-00	Aqua Life Exports Ltd	Live rock	200 kg	USD 200	Port Vila	Efate
13-Sep-00	Reef Life Vanuatu	Acropora	20 pieces	USD 20	Erakor	Efate
19-Sep-00	Aqua Life Exports Ltd	Live rock	500 kg	USD 500	Port Vila	Efate
04-Oct-00	Aqua Life Exports Ltd	Live rock	600 kg	USD 600	Port Vila	Efate
09-Oct-00	Aqua Life Exports Ltd	Live rock	600 kg	USD 600	Port Vila	Efate
18-Oct-00	Aqua Life Exports Ltd	Live rock	550 kg	USD 550	Port Vila	Efate
18-Oct-00	Aqua Life Exports Ltd	Live rock	500 kg	USD 500	Port Vila	Efate
18-Oct-00	Aqua Life Exports Ltd	Live rock	200 kg	USD 200	Port Vila	Efate
23-Oct-00	Aqua Life Exports Ltd	Acropora	30 pieces	USD 90	Moso	Efate
02-Nov-00	Aqua Life Exports Ltd	Pocillipora	20 pieces	USD 60	Moso	Efate
02-Nov-00	Aqua Life Exports Ltd	Turbinaria	5 pieces	USD 15	Moso	Efate
20-Nov-00	Aqua Life Exports Ltd	Live rock	750 kg	USD 750	Port Vila	Effate
11-Dec-00	Aqua Life Exports Ltd	Live rock	1200 kg	USD 1200	Port Vila	Efate
12-Dec-00	Aqua Life Exports Ltd	Live rock	1000 kg	USD 1000	Port Vila	Efate
12-Dec-00	Aqua Life Exports Ltd	Live rock	300 kg	USD 300	Port Vila	Efate
07-Jan-01	Aqua Life Exports Ltd	Live rock	1000 kg	USD 1000	Luganville	Santo
12-Jan-01	Aqua Life Exports Ltd	Live rock	500 kg	USD 500	Luganville	Santo
12-Jan-01	Reef Life Vanuatu	Acropora	150 pieces	USD 300	Moso	Efate
16-Jan-01	Reef Life Vanuatu	Acropora	180 pieces	USD 160	Ifira	Efate
31-Jan-00	Aqua Life Exports Ltd	Live rock	800 kg	USD 800	Luganville	Santo
14-Feb-00	Aqua Life Exports Ltd	Live rock	1000 kg	USD 1000	Luganville	Santo
07-Mar-01	Aqua Life Exports Ltd	Live rock	800 kg	USD 800	Port Vila	Efate

Figure 1.
Vanuatu Live Rock Exports from January 2000 to present

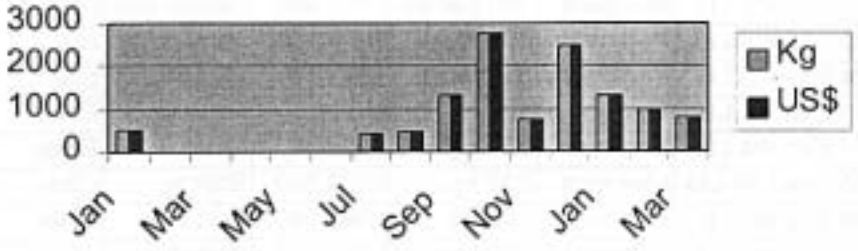


Figure 2.
Vanuatu Live Acropra Coral from January 2000 to present

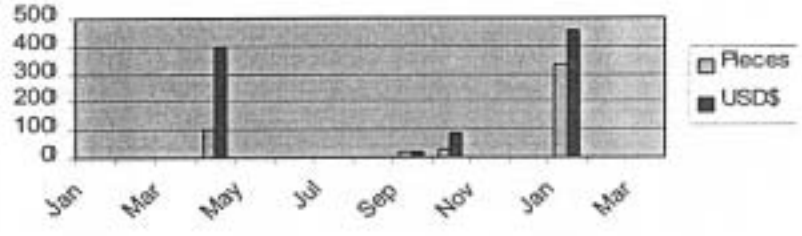


Figure 3.
Vanuatu Live Porites Exports from January 2000 to present

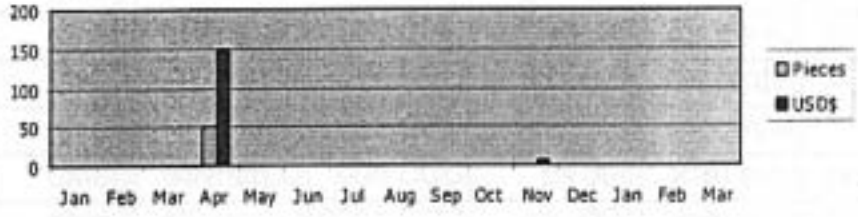
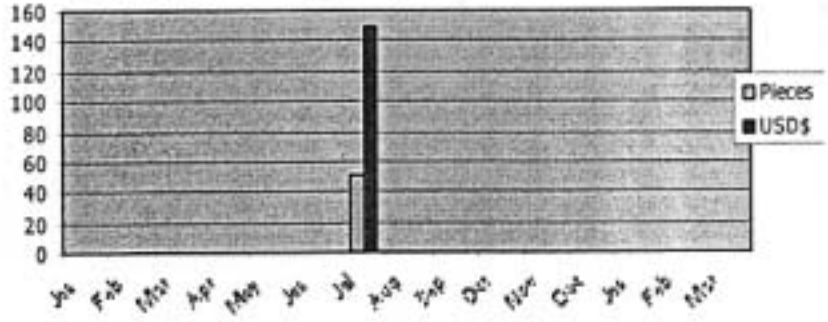


Figure 4.
Vanuatu Live Pocillopora Exports from 2000 to Present



Documentation of Coral Reefs and Coral Trade in Vietnam

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Introduction

The coastline of Vietnam extends for some 3,260 km through more than 15 degrees of latitude from 8^0 30' N to 23^0 N and shows a variation in climate and biodiversity along this broad N-S cline. The country has more than 3,000 inshore and offshore islands and islets which extend to claims covering the Spratly and Paracel archipelagos. There are broadly five distinct marine areas that differ according to coral diversity: (1) western Tonkin gulf, (2) middle central, (3) south – central, (4) southeastern, and (5) south-western (Vo Si Tuan, 1998).

Coral reefs are the richest marine habitats in the country with the greatest diversity of species. Over 300 species of scleractinian corals are found in Vietnam's coastal waters with 277 species belonging to 72 genera identified in the south, compared with the less diverse areas in the north of the country with 165 species in 52 genera. All coral reefs in the north are fringing reefs; although these are also the most common reef type, the more complex coastline and insignificant effect of rivers has also favored the development of platform reefs in the south. Atolls in the Spratly archipelago enclose reefs hundreds of meters in length; these have a high species diversity and cover. Up to present, 28 reef areas have been known in the coastal waters of Vietnam. They play an important role not only for coastal fisheries but also for tourist development, coastal protection and other factors.

1. Coral reef status

1.1. Coral reef condition

During 1994 – 1997, 15 reef areas were surveyed in 142 study sites. The results showed that the overall condition of the coral reefs is not good. Only 1.4% of the study reefs were considered to be in excellent condition . The number of poor reefs were 37.3 %, while 48.6 % of the reefs were in fair condition and 31 % in good condition. The detailed information in Table 1 indicates that the reefs located in offshore islands or the sites far from population center are in the best condition.

Corals reef fish communities have been assessed at 10 study areas based on information in published papers (Nguyen Huu Phung & Nguyen Van Long, 1997; Nguyen Van Long & Nguyen Huu Phung, 1997 and unpublished data (Table 2). The highest species diversity occurs in the south-central regions. However, only the reefs located at offshore islands (Con Dao, Phu Quoc islands) have a high density of reef fishes. The reefs of Tonkin gulf have low species richness, with 30 – 60 species each area. Coral reef fish and invertebrate fisheries are considered untraditional fisheries. Because of this, there are few statistics on status and fisheries production.

During 1997-1998, coral reefs in Vietnam suffered natural catastrophic destruction from storms, bleaching and other factors. Linda typhoon (November 1997) destroyed a large area of coral reef habitat at Con Dao islands, even though these are the best protected reefs of Vietnam. Bleaching events in the summer of 1998 were recorded at Con Dao islands, north Binh Thuan province and Nha Trang bay. Recovery of

Table 1. Categories of coral cover before 1998 at 15 studied reef areas of Vietnam

Study sites	No. transects	76-100%	51-75%	26-50%	0-25%
Co To	14	0	7	6	1
Dao Tran	4	0	0	1	3
Ha Long Bay	24	0	3	9	11
Cat Ba	14	0	2	6	6
Bach Long Vi	5	0	0	2	3
Hon Me	7	0	0	0	7
Hon Son Duong	5	0	0	1	4
Con Co	4	0	0	1	3
Hai Van - Son Tra	3	0	1	2	0
Cu Lao Cham	20	0	5	10	5
Van Phong	5	0	0	2	3
Nha Trang	13	0	0	9	4
Cu Lao Cau	6	0	3	3	0
Con Dao	23	0	17	5	1

corals influenced by these impacts has been very slow. The density of butterfly fish also clearly decreased, and their recovery has been slow in all study reefs. In 2000, an increase of coral cover and fish density was recorded. Corals at north Binh Thuan province recovered very well after bleaching, following the water temparature decline during an annual upwelling period (June – September) which occurred just after the onset of bleaching.

A serious degradation of coral reefs at Cat Ba islands and Ha Long bay was also recorded. Number of reefs in poor condition increase from 25% before 1998 to 50% in 1999. In parallel, the proportion of good reefs decreased from 33.3% to 9.15 during this period (Table 3). High rate of sedimentation was considered to be the major reason causing reef degradation (Nguyen Huy Yet, 1999).

Table 2. Density (ind./500m2) and species richness of coral reef fish at 10 studied areas of Vietnam

Sites	N	Average density	Density range	Species number
Co To	14			45
Cat Ba	14			32
Hon Me	7			56
Con Co	4			60
Cu Lao Cham	17	540	148-1446	188
Van Phong	7	676	223-1814	100
Nha Trang	14	226	109-486	256
Cu Lao Cau	12	346	164-566	211
Con Dao	23	2017	71-5143	202
Phu Quoc	11	748	438-1412	135

Table 3. Ratio (%) of the categories of coral cover at Cat Ba islands and Ha Long bay

Category	before 1998	1999
0 - 25%	25	50
26 -50%	41.7	40.9
51 - 75%	33.3	9.1

1.2. Threats to coral reefs

The recent treats to coral reefs have been mentioned in recent publications (Vo Si Tuan, 1998, Dang Ngoc Thanh & Vo Si Tuan, 1998, Nguyen Huy Yet, 1999) and RRA interviews in the framework of ADB 5712-REG project.

Over-fishing, especially non-selective and illegal forms from poisons, explosives and fine mesh nets has decreased somewhat. Destructive fishing practices are still a serious threat in some provinces including Quang Ninh, Nghe An, Quang Binh, Thua Thien - Hue, Quang Nam, Da Nang, Quang Ngai and Khanh Hoa, where destroyed coral reefs have been observed everywhere along the coast. Other forms of non-selective fishing such as sluice traps, electric fishing, gill nets and the traditional trawling net continue to take their toll on marine fisheries. Destructive fishing methods were found to be issues in 21 or 29 provinces during RRA interviews conducted by this project ADB 571-REG in early 1999. The dimensions of this issue include indiscriminate killing of incidental species, small fry and seedlings necessary for stock regeneration, and environmental damage, and the use of these methods is a major source of community conflict both with resident and non-resident marine harvesters.

The RRA studies (project ADB 5712-REG) conducted in 29 coastal provinces in early 1999 revealed that non-resident marine harvesters from China and Hong Kong are competing with local fishermen in offshore waters. The decline in marine resources are linked to 1) the overall poverty context of inshore marine harvesting households; 2) fishing methods; and 3) changes in the marine environment. Declining marine resources were identified as an issue of concern in 18 provinces at a variety of levels. Decreasing marine resources and the disappearance of some common, commercially important species is very real to those who live in the coastal communes and whose livelihoods come from the sea. Declining marine resources were identified in all 29 provinces.

Live trade in groupers and other fish species for the Hong Kong and Chinese markets operate with impunity in the northern and central parts of the country, and even in the productive waters near the Con Dao National Park. Figures are difficult to determine, but fishermen illegally take the fish and sell them at sea to larger 'tenders' for onward transport. Capture methods employ divers and cyanide poisoning to stun the fish, which in turn kill coral and other biota outright.

Much of the seafront is being physically developed as tourism areas, factory sites or fishing villages. There is almost no natural, undisturbed coastline left. Marine and coastal tourism is driving a new demand for souvenirs. The wildlife trade is largely uncontrolled in Vietnam, and many endangered or protected marine species can be found in local markets, particularly at large tourism centers such as Vung Tau. Marine turtles, principally Green and Hawksbill turtles, have been heavily hunted for tourist souvenirs with the centers of trade at Nha Trang, Vung Tau and Ha Tien. Fewer and even smaller animals such as mollusks, sea stars and urchins are being taken every year and are openly sold to tourists in great numbers in the major coastal recreational centers. Coral, particularly staghorn varieties of *Acropora,* are most sought after for the tourist and aquaria trade, and are now becoming rare in places such as Nha Trang Bay, the center of the coral trade in the country.

Sea cucumbers are heavily exploited and are pre-processed and sold as dried animal products to markets in China, Hong Kong, Singapore, Taiwan and Japan. The estimated annual production amounts to some 150-180,000 tons. Collecting of ornamental fish for trade to Singapore is also a growing problem. It is particularly offensive when destructive methods such as stunning with poison are employed.

The development and expansion of industry along the coast is beginning to add to the pollution load, particularly poisonous heavy metal waste which is often released into the sea without attempt to reduce toxicity. The expansion of ports and unregulated bilge cleaning is now becoming a more frequent source of coastal pollution, in particular in the northern areas of Quang Ninh and Hai Phong. In the small bays and lagoons, pollution derived from pesticides and fertilizers from agricultural runoff and associated pollution derived from shrimp ponds are beginning to become more serious causing eutrophication in some areas. Seaweed overgrowth or algal blooms have been observed with increasing frequency in the coastal waters of Binh Thuan province, Van Phong Bay (Khanh Hoa province) and at the mouth of the Dong Nai River in Ho Chi Minh City.

The coastal waters of Vietnam have always suffered from the influence of large rivers making turbidity high and visibility low. This, combined with upstream pollutants, is a serious stress to coral reefs and seagrass beds, particularly along the coast of western Tonkin Gulf and the eastern gulf of Thai Lan. For example, river pollution including upland silt wash-off, plus domestic and industrial discharge is a serious threat to the marine environment.

2. Coral trade

2.1. Development of the trade

In the past, dead corals were only exploited for lime production in the central provinces such as Khanh Hoa, Ninh Thuan and Binh Dinh. This activity has been more extensive with collecting corals in littoral and even sublittoral in parallel with higher requirement of lime. The products could not identified to species and sometime to genus. Broken branch corals on the beaches or buried on land have been exploited for cement production of two factories in Khanh Hoa and Ninh Thuan provinces. Limestone product exploited in 1998 is about 50,000 tonnes.

Recently, tourist development has increased demand for the curio trade in the tourist centers such as Nha Trang, Vung Tau and Ha Long cities. Almost corals for the curio trade have been exploited from south central region, where corals are the most diverse and are located along the nearby shoreline. The corals of curio trade include *Acropora florida, Pocillopora damicornis, P. verrucosa* and others...

Coral export has been recorded over the last 5 years. This market is not formal and is managed by mainly private business. The dominant corals of the live trade are *Goniopora spp. and Euphylia spp*. Coral rock is exported with attached reef invertebrates such as sea anemones. Their production has not recorded in formal statistics. An informal record showed about 200 live corals and sea anemones brought out Nha Trang city every week.

Live corals have been harvested and cleaned to export as coral skeletons. This activity has been done by private traders. The coral composition of this business is very diverse, and depends on the purpose of export (E.g. in a container identified: *Acropora yongei, A. danai, A. sp. Pocillopora verrucosa, Heliopor coerulea, Montipora aequituberculata*, broken *Acropora*, dead massive corals). There are also no formal statistics from Vietnamese manegement. It is known that, 15,000kg of coral skeleton were allowed to exploited from Binh Thuan province in the year of 2000.

2.2. Information on collection

Coral collection is a spontaneous activity that has done by fishermen when there is market demand. Fishermen use mainly hookah to collect live corals and other reef organisms. Their activities have carried out without permission in some provinces. Meanwhile, business of reef organisms has been accepted by a number of local government. The main areas of collection of reef organisms is coastal waters of central provinces. Because of spontaneity, there is no data statistics on collectors and mortality of reef organisms during exploitation, reservation and transportation.

2.3. Management issues

The activities for management of the coral trade are considered not to follow the situation. There is no regulation for this trade including quota, size, area of collection. The support from Vietnam scientific institutions and international agencies is essential for sustainable use of the resources.

There are 20 existing protected areas considered as coastal and marine protected areas. Beside Cat Ba and Con Dao National Parks and Halong Bay World Heritage, the others have not included marine areas and coral reefs. The project ADB 5712-REG has proposed the national system including 30 coastal and marine protected areas. This includes 3 existing ones of priority for only strengthened management, 8 existing ones

of priority for expansion and strengthened management, and new establishment of 9 protected areas with coral reefs involved. With this plan, the area of coral reefs that are protected will increased significantly from 1528 ha to 3118 ha. Ministry of Fisheries has authorized by government to develop national plan of Marine Protected Area which focuses on marine component. The activities in future for sustainable development of coral trade should be done in parallel with MPA management. MPAs will be pilot sites for controlled coral collection, coral farming, coral reef rehabilitation.

The activities of coral reef monitoring in Vietnam have received international support and are conducted at three sites including Nha Trang Bay, north Binh Thuan Province and Con Dao islands since 1998. Three sites Ha Long bay, Van Phong Bay & Phu Quoc Islands and Ninh Thuan province were added for 2000. Methods used in monitoring are Line Intercept Transect (LIT) & Reef Check. Activities to monitor species of reef organism trade have not been carried out in Vietnam. The practice of Reef Check with adding target species of the trade should be useful for monitoring of coral trade.

Recommendation

There are so many challenges concerning the coral trade in Vietnam. This activity is one among important impacts to coral reef degradation. The support of scientific institutions and international agencies are essential for sustainable use of the resource in general strategy for coral reef conservation of Vietnam.

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Community-based Coral Reef Rehabilitation Program

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The Philippine Coral Reef

The Philippines archipelago has one of the most diversified biological systems in the Indo-Pacific Region. It is blessed with 7,106 islands, 18,000-km coastline and 27,000 km^2 reef area. Not to mention majority of Filipinos rely on these resources as their food basket for protein. Coral reefs per se have contributed big revenues to fisheries as well as in the tourism industry. In biological terms, Philippines is endowed with high species diversity and endemism per area (Heaney, 1993). Specifically, the coral reef ecosystem supports an array of life. Eighty three percent (83%) of the world's coral out of the 600 extant species is present here. Fish biodiversity is well represented with 2,200 fish species and tens of thousands of invertebrate species.

Threats to the reef

Since the dawn of time, man has interacted with nature and since then, he created impact. Until the latter version has evolved to create a bigger anthropogenic stress e.g. dynamite fishing, cyanide fishing, over fishing, pollution and population increase. Natural causes have also contributed to the whole scenario e.g. El Niño Southern Oscillation (ENSO), which consequently resulted to coral bleaching, typhoons and natural predators.

Status of the Philippine Reef and its implication

Presently, the status of the Philippine coral reefs is not something to be envied but to be sympathies. Only 2.4% (Figure 1) left in excellent condition and majority of it in fair status with 51.7% cover (Gomez et al., 1994). Undoubtedly, the Catch Per Unit Effort (CPUE) of fisheries product, have been directly affected by this situation. Take for example a good reef has a potential of 36 tons/ Km^2 /yr, while a damage reef can only provide 3.6-5.4 tons/ Km^2 /yr of fishery product. In historical accounts, during the 1960's, an average of 20 kg/fisherfolk/day is harvested. This dramatically decreased in the 70's with 10 kg/fisherfolk/day as the advent of dynamite fishing was introduced. The 80's were not ideal with the popularity of fine mesh net and 1998 was the worst with average 2 kg/fisherfolk/day catch (White and Cruz-Trinidad, 1998) with a big question mark (?) lies on the future.

Realistic Solution (s) Now!

Whatever the solution(s), it has to be implemented now for the sake of the environment. One general idea is to reduce the stress on the ocean and rehabilitate! With this resource management approach, we can tackle two issues - rehabilitate damage reefs and provide feasible alternative/supplemental livelihood to the community affected. That is where the coral farming comes in with two motives at hand. One is ethical in nature – to rehabilitate for biodiversity conservation and ecosystem productivity and second is economics – creating consumptive (e.g. high fish yield) and non-consumptive benefits (e.g. coastal protection, tourism and high genetic pool).

Caw-oy Coral Farm

The project started last October 1998 to October 2000 and was initiated by Dr. Thomas Heeger (CIM) and Dr. Filipina B. Sotto (USC-MBS), under the University of San Carlos – Marine Biology Section as host. This was funded generously by GTZ, CHED-COD and the German Embassy (Manila). The farm was allocated with a 2-hectare area in Caw-oy, Olango Island, Cebu and declared as a protected area by virtue of Barangay Resolution No. 14 and Ordinance No. 7, Series of 1997 passed by the Caw-oy Barangay Council. About 275 Coral Nursery Units (CNU) were deployed and with approximately 22,000 coral fragments of 103 species (Heeger and Sotto, 2000). The coral farm has already rehabilitated two sites, one in Marigondon, Mactan (4,000 fragments) and one in Camotes Island, Cebu (2,000 fragments).

Coral Reef Rehabilitation Program (CRRP)

Presently, the project is supported by the International Marinelife Alliance (IMA) and at the same time launches its latest project the Coral Reef Rehabilitation Program (CRRP) which adapts the coral farming method for reef rehabilitation and proper reef management. It has two aims namely, to rehabilitate damage reefs into biologically diverse, productive and functioning system and to manage these resources properly.

Coral Farming Methodology

a.) Collection of coral fragments

Coral fragments are collected using pliers for branching type and hammer and chisel for massive, submassive, columnar, encrusting and foliose coral life forms. Collection is the most critical part, hence the need to properly educate and trained them the basics of coral reef ecosystem and its implication. Criteria are set to insure proper collection, such as; take only fragments from a healthy mother coral, do not exceed 20% of the whole size of the mother coral, deploy small pieces of corals to suitable hard substrate and collect only at the periphery of massive and submassive corals.

b.) Transfer of coral fragments by boat

Collected fragments are kept in plastic containers and water is change frequently. Boat trips usually last from 45 minutes to 1 hour and brought to the farm. Time element is crucial to the survival rate of coral fragments.

c.) Tying of coral fragments

The women are waiting in the farm and getting ready with their tools (pliers and plastic basins) and materials (Mactan stones and G.I. wires). The women then tie the coral fragments to the substrate carefully insuring tightness to allow faster attachment to the base. Finish products are thrown directly to the sea to minimize stress.

d.) Collection of tied coral fragments

Fisherfolk divers will collect the fixed coral fragments in the seafloor and transfer them to Coral Nursery Units (CNU). These CNUs are cleaned and maintained bi-weekly to insure survival. Coral fragments are either turnover or covered by sand or simply eaten up by natural predators. Dead ones are replaced, with their substrate re-used for the next cropping.

Threat to the coral fragments

The farm is by nature subject to different threats and one of this is starfish attack (*Acanthaster planci* or *Culcita* spp.), sedimentation from a nearby mangrove forest and coral bleaching.

Reef rehabilitation

This is the first aim in the coral farming. Prior to actual rehabilitation, there should be a rapid coral assessment using Line-Intercept Transect (LIT by English et al. 1997) to determine its feasibility. Criteria are set to favorable abiotic and biotic conditions such as, average working depth of 6-12 m with hard substrate, live coral cover should be at 20-25%. Considerations in reef rehabilitation should be followed e.g. do not place the fragment on top of a living coral, do not put it in sandy bottom, place it in between crevices and open spaces with hard substrate. Deploy two coral fragments per square meter area. Monitoring the survival rate is recommended if it is used for scientific purposes, otherwise it is not very necessary.

Coral Farm Ecotour

This activity is the second aim, which will also supplement their income. This activity consist of a informal lecture carried by a community member explaining things about the project, narrating their usual activities as well as their existing fishing practices. This will also highlight a coral farming demo, where the visitors can get a hands-on experience on the rehabilitation. Another component of the ecotour is an underwater coral trail, it is an interactive natural museum educating the scuba divers about the wonders of the corals and the reef itself. These consist of several signboards with information pertaining to the live exhibits.

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Asosiasi Koral, Kerang dan Ikan Hias Indonesia (AKKII/ Indonesian Coral, Shell and Ornamental Fish Association

AKKII, also knows as the Indonesian Coral, Shell and Ornamental Fish Association was established on the 1st of August 1990. As its name implies, the members of AKKII are exporters of the related commodity. At present AKKII have 19 members.

AKKII's established was due to the member's recognition that corals, shells and ornamental fish forms a part of Indonesia's natural resources. To ensure its future availability, limits on its utilization have to be set a sustainable level usually in a direct correlation between the resources population and availability in nature.

Within this framework, AKKII and its members are committed to the principles of sustainable utilization of what is available. At the same time, it also acknowledges that the existence of such resources should be useful.

Even though AKKII is an organization for businessmen; its activities are not oriented solely for the benefit of the members, but also members to act together with the common fishermen who are related in the chain of commerce. AKKII devotes its activities to the provision of assistance and guidance, either directly or indirectly on matters that aim to improve their prosperity.

Vision

To become an organization that upholds the principles of responsible, disciplined and sustainable management on the utilization of our natural resources in coral, shell and ornamental fish.

Mission

- Provide services for its members on the proper preparation and utilization of our corals, shells and ornamental fishes resources.
- Act as a bilateral bridge between the government, AKKII members and other related to the third parties.
- Execute regulations and other social functions.

Activities

Beside providing services to its members, AKKII is also focused on its involvement on the following divisions:

- Active in activities which are characterized as important to the survival our coral, shell and ornamental fish resources. One example is the propagation of corals by transplantation. Another is carrying our stock assessments of coral populations.
- Participate in discussions, seminar and trade shows, both locally and international.
- Create a social event that promotes the sustainable utilization of Coral, Shell and Ornamental Fish.

Cooperation with other parties

Inside the framework of sustainable utilization of our natural resources, AKKII emphasizes the importance of developing all forms of relationship and cooperation with parties both within and outside of Indonesia.

In acknowledging the book of regulations and criteria on sustainable utilization of coral, AKKII plays an active role in upholding those principles with parties and other related establish organizations.

Coral Collecting

Indonesian CITES Management Authority had recommend collecting area in Indonesia as follows:

1. South Sumatra/Babel : Belitung
2. Lampung : Legundi Island and Tanjung Putus Island
3. West Java : Labuhan, Binuangan, Pameungpuek and Cilamaya
4. DKI Jakarta : Panggang Island and Untung Jawa Island
5. Central Java : Jepara, Cilacap and Pemalang
6. East Java : Banyuwangi and Madura
7. Bali : Gilimanuk
8. South Sulawesi : Makassar
9. East Nusa Tenggara : Kupang
10. Maluku : Ambon

Coral reef is a renewable resource. Many species of stony corals grow slowly and depend on the environmental condition including disturbance to the growth of the corals. These factors must be taken into account in the harvesting and utilization.

In Order to guarantee sustainable utilization of coral reefs the following principles are adopted:

1. Corals are harvested outside the conservation areas and tourism areas;
2 . Corals are harvested with size limit in accordance with the growth rate and species;
3. Corals are harvested in harvest rotation systems in order to allow recovery;.
4. Corals are harvested below the regeneration rate of each species;
5. Corals can only be harvested in the sites whose stock or population has been assessed;
6. Monitoring and evaluation of the population to ensure sustainable utilization and conservation are undertaken.

Size limit of coral harvested:

- 60 % with size 5 – 10 cm
- 30 % with size 11 – 15 cm
- 10 % with size 16 – 25 cm

CORAL CULTURE USE TRANSPLANTATION METHOD AT PARI ISLAND, NORTH JAKARTA

Dedi Soedharma, Yuni Yarman, Sadarun, Ofri Johan

Abstract

The study program of stony coral transplantation was conducted at 2-10 m depth on the reef slope of Seribu Island from September 1998 to May 2000. The objective of this study was to develop fragmentation method using by the growth rate indicator for certain species of the coral.

The result of the coral transplantation was successful with the survival rate from 83 to 100%. *Acropora yongei* was the fastest growth rate (=4,890 cm/5 month) and the bud's number was found on *A. hyacinthus* (53 bud's/5 months). The second step of this study was done to transplant the stony coral at the windward, leeward and lagoon areas, which was carried out from October 1999 to May 2000. The result indicated that the fastest increasing of the length of stony coral was found at the leeward areas. The third step of this study was done to transplant the stony coral at the 3m and 10m areas, which was carried out from June 2000 to October 2000. The result indicated that the fastest increasing of the length of stony coral was found at the 3 m depth areas.

INTRODUCTION

Coral reefs have been utilized by Indonesian communities as protein sources (coral reef fisheries) for a long ago. The coral stone had been used as foundation of house in coastal area. According to the observation National Institute of Oceanology (LIPI),there is drastically decreasing on coral reef condition caused by fishing activities using by explosive materials and cyanide. Coral reef covering is around 7 % in excellent, 29% good condition, 40 % critical, while 24% moderate condition. Effort for rehabilitating has been doing through community awareness and stopping illegal fishing. Rehabilitating effort through moving a coral reef from natural stock to degradation area is a method in rehabilitating or creating a new habitat using fragmentation model which is cutting a small part of coral and putting at the ceramic or cement.

Harriott and Fisk (1988) reported that coral reef transplantation was a grafting or cutting live coral to be planted in other new area or other places which were degradation in condition as effort to rehabilitate or create a new habitat. Transplantation has a role in regenerating speed of coral reef and new colony appearing.

In the Phillipines, coral reef tranplantation had been applied for recovering coral reef ecosystem, which was degradation caused by fishing activities using explosive material. Auberson (1982) reported that coral reef tranplantation in Singopore was used to protect coral through moving the coral in new habitat because the previous habitat was reclaimed (Plucer - Rosario and Randall, 1987). Transplantation model was used also in Great Barrier Reef (Australia) for increasing a rehabilitation caused by attacking of coral predator {*Acanthaster planci*) (Harriott and Fisk, 1988).

This study was carried out by cooperating Bogor Agriculture University and national Institute of Oceanology and the Indonesian Coral, Shell and Ornamental Fish Association (AKKII).

METHODOLOGY

Experimental was done in Pari Island at 4-10 meter depth in the reef slope, from October 1998 to May 2000. A certain part of stony coral was laced at the substrates, nets, ceramics or cement that was

banded by nylon rope at the metal frame. The coral was not resistance out of water so it needs to be put in into the sea after binding. It was high mortality when in open air in long time. Harriot and Fisk (1988) reported that coral which was transplanted in the protected area maximum 1 hour long, more that 1 hour, it will die 50%; 3 hours, 70% will die.

Environmental parameters had been measured such as transparency, current, sediment rate, turbidity, nitrate and phosphate. Some steps of experiment were done:

1. Experimental growth on Acropora
2. Commercial coral reef experiment (coral export) from other places in Indonesia.
3. Transplantation experiment at 3 m and 10 m depth, grows the coral at difference position (vertical and horizontal)

RESULT AND DISCUSSION

1. Observation result using net

Observation result using by nets placed at the basis substrate from October 1998-March 1999 (5 months) was transplanted around 11 species Acropora from surround area. This choosing species was to observe a growth development for 5 months in new habitat.

Mucus duration from taking a small part for (fragmentation) at injures part that was covered mucus. Mucus is part of recovering that takes 3-5 days (Table 1).

Mucus	Name	Interval
3 days	*A. austeria*	3
	A. hyachinthus	3
4 days	*A. tenuis*	3 - 4
5 days	*formosa*	4-5
	A. nasuta	4-5
	A. divaricata	5
	A. yongei	5
	A. aspera	5
	A. digitifera	5
	A. valida	5
	A. glauca	5

From this observation can be seen that coral begins to grow from recovering time. Recovering period varied 5-13 days. Acropora austrea, A. hyacmthus and A. anstena are the fastest one comparing with other species as shown in Table 2.

Tabel 2. Recovery duration of coral transplantation

Recovery	Name	Interval
< 7 days (fast)	*A. tenuis*	5 – 6
	A. austeria	5 – 6
	A. hyachinthus	5 – 6
7 – 9 days (medium)	*A. formosa*	7 – 8
	A. nasuta	7
	A. divaricata	9
	A. yongei	9
> 10 days (slow)	*A. valida*	10
	A. digitifera	12
	A. aspera	13
	A. glauca	13

2 Growth Rate of Cora1

Growth observation was described to be 3 steps: height growth (length), encrusting to substrate, and encrusting to stalk. Height growth was around 2,01 - 4,91 / 5 months as shown at Table 3.

Table 3. Growth rate of coral transplantation

Height	Name	Interval
< 3 cm	*A. glauca*	2,01
	A. digitifera	2,11-2,43
3 – 4 cm	*A. divaricata*	3,19-3,22
	A. tenuis	3,26-3,33
	A. aspera	3,30-3,33
	A. hyachinthus	3,22-3,61
> 4 cm	*A. valida*	4,09-4,12
	A. formosa	4,38-4,44
	A. austeria	4,58-4,63
	A. nasuta	4,79-4,81
	A. yongei	4,88-4,91

Acropora glauca and A. digitifera were slow relatively comparing with others varied 2,01-2,43 cm/5 months, while other 4 species such as *A. valida, A. formosa, A. austeria, A. nasuta,* and *A. yongei* faster relatively varied 4,09-4,91 cm/5 months. Species that was relatively slow growth for export was around 106 species (AKKII,1999), kind of coral with polyp size small to large. The samples were collected from coastal places in Indonesia like Lampung, Seribu Island, Madura, South Sulawesi, etc.

At first time on replantation in the sea was to observed adaptive ability in Pari Island environmental. From the observations, most of coral (> 90%) can live well. The next study was focused to growth ability in field. Especially for coral with big polyp such as *Blastomussa, Cynarina, Catalaphyllia, Fungia,* etc. were tried to cut until can be known the species regenerate with human help.

3. Bud's regeneration

Growth of bud's number was a growth indicator of coral reef that was planted. During 5 months of planting, number of bud was around 6-53 buds in each 5 species of coral {*A. glauca, A. aspera, A. nasula*), 4 species of coral grows 20-40 buds and 2 species of coral (*A. lenuis, A. hyachinthus*) was around 42-53. Number of bud was shown in Table 4.

Table 4. Number of buds of coral *Acropora*

Height	Name	Interval (cm)
< 20	*A. glauca*	6
	A. aspera	7-8
	A. digitifera	9-12
	A. divaricata	11-12
	A. nasuta	17-22
20 – 40	*A. yongei*	21-23
	A. valida	24-26
	A. formosa	23-27
	A. austeria	24-31
> 40	*A. tenuis*	42-46
	A. hyachinthus	52-53

From the observation, it can be shown that development and growth ability of 11 species of the Acropora from nature habitat can adaptive easily and growth normally after transplanting. This condition was related to Maragos (1974) recommended that the transplantation must be from the same habitat especially water movement, depth, and turbidity.

Recently, it was tried a coral from other places in Indonesia such as Lampung, South Sulawesi, and Madura. The species of coral can adapt well and most of them live (90%). Transplantation effort done by placing on the substrate was possible many kinds of coral reef grows individually and can be farmed safely without cutting.

The highest mean linear extension growth rate of coral transplants was found on the leeward side (0.743 cm/month), on the windward side (0.308/month) and in the lagoon side (0.040 cm/month).

The highest survival rate was found on the windward side with 97,78%, on the leeward side with 91.1% and in the Lagoon with 35.6%. Species A. donei had the highest survival rate (91.1%) and is significantly different from A. acuminata (68.89%) and A. formosa 64.44% survival rate.

CONCLUSION

From the study in the field can be shown that species with small polyp like Acropora was easier and taster in growth through transplantation, while other species was capable in the environmental of Pari Island wish was difference with nature condition. The highest mean linear extension growth rate of coral transplants was found on the leeward side and the highest survival rate was found on the windward side. This study will be continued by transplanting a species with large polyp using the same method.

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Surveys of Coral Collection Sites in the Spermonde Archipelago, South Sulawesi

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SUMMARY: Indonesia is currently the world's largest exporter of stony corals for ornamental markets, with an annual trade of about 2 million pieces of stony coral and live rock. To date, Indonesia is the only country with a coral export fishery that is managed through an annual harvest quota established for each taxa in 10 provinces where harvest is permitted. Indonesia's guidelines for sustainable utilization of coral resources also stipulates best collection practices including size limits, rotation of collection sites, and sites closed to coral collection. While the quota for some taxa of corals appears to be sustainable, importing countries have expressed concern that other less abundant corals may have a quota that is too high, according to available scientific information on the biology, distribution and abundance of the taxa.

To resolve this dilemma and to provide guidance in the development of complementary management approaches, NOAA Fisheries in collaboration with TRAFFIC Europe is examining the stony coral fishery in Indonesia. The initial component of this project is focusing on specific taxa of corals that are currently under trade suspension in the European Union (EU)[1], which make up close to 50% of the total annual quota allocated by the CITES Authorities of Indonesia. The study includes an assessment of the distribution, abundance, population demography, habitat requirements and life history characteristics of the taxa in trade. We also examined patterns of utilization, including the numbers of collectors, locations of collection and the amount and type of harvest. The goals are to map the distribution of the harvested taxa and describe the condition of the resource, in order to determine ecologically sustainable collection guidelines. This report presents preliminary information from the Spermonde Archipelago, South Sulawesi, and recommendations on possible constraints that should be placed on current harvest levels.

All of the taxa currently under trade suspension by the EU were observed in the Spermonde Archipelago, but these were not the dominant taxa present. In general, reefs were in good shape except for fish populations, with a high cover of coral (25-70% cover), a low level of coral disease and predation, and few signs of recent mortality. In reef environments, coral cover increased with distance from shore although inshore areas with close to 100% cover were identified; free-living corals were also observed in soft-bottom habitats at a low density in deeper water. Fish abundance and diversity were highest on offshore reefs, but commercially important fish species were rare at all sites. Although no outbreaks of predators [COT (Crown of Thorns) sea stars, *Drupella* gastropods] or major bleaching were observed, some areas were affected by blast fishing as indicated by large rubble fields and numerous dislodged and fragmented corals. Coral species richness varied among sites, with the highest diversity on fringing reefs (maximum of 52 genera on one reef) and the lowest diversity in deep, soft bottom habitats. Most scleractinian corals measured along transects were small to intermediate in size (7-23 cm diameter), with very few colonies over 50 cm in diameter. Of the 7 suspended taxa, each showed very specific habitat preferences (7 habitat types were identified); within preferred habitats they occurred at densities of 0 - 1.2 colonies per sq. m, with most at a density of < 0.2 colonies/m^2. Within the Spermonde Archipelago, the total abundance of each of the 7 suspended taxa was estimated to range from 8,000 colonies (*Blastomussa wellsi*) to 900,000 colonies (*E. glabrescens*), although one taxa under EU suspension, *B. merleti* was not observed during the surveys.

Coral collectors targeted specific sites for individual species of corals. Collection occurred on the reef slope or at the base of the reef (12-20 m depth), or in deeper soft-bottom habitats (30-40 m depth). Colonies were selectively harvested over a wide area, with minimal habitat impacts associated with collection. At the CV Dinar holding facility, 87% of the corals on hand were taxa under EU import suspension, and these ranged in size from 2-25 cm depending on the species.

An estimate of the total available resource (determined from the mean number of colonies per square meter multiplied by the estimated aerial extent of habitat occupied by that taxon) and the potential maximum annual harvest (determined from the quota) suggests that collectors may remove from 0.4% to 96% of the standing stock per year, depending on the target species. The quota allocated for *E. glabrescens and E. ancora*, appears to be within sustainable limits, as estimates suggest that <1% of the available resource is collected each year. The quota for *Nemenzophyllia turbida* may be sustainable if other similar habitats occur within the Spermonde Archipelago. The quota for colonies of *C. lacrymalis, T. geoffroyi*, *Plerogyra* spp. and *Hydnophora* spp. may be at or slightly above sustainable levels, with an annual harvest of 1.9-4.2% of the estimated resource. In contrast, *Blastomussa* spp., *C. jardinei* and *E. cristata* are currently being harvested at levels that may result in localized extinction within a few years (31%-96%). These surveys provide preliminary data on the potential available amount of coral resources using a very crude estimate of the area of each habitat type and results indicate that quotas should be reduced for at least three species to reflect field data. More field surveys and additional research on the biology of the target species are needed to verify sustainable harvest levels for other taxa, and to determine the impacts associated with the removal of corals at the present levels.

Introduction

Stony corals are harvested throughout Indonesia for building materials, aggregate for road construction, production of lime, the domestic ornamental industry, and also for international trade as curios, jewelry and aquarium specimens. Indonesia has been the world's largest coral exporter since the early 1990s. Currently, only live coral may be exported; trade in skeletons (recently killed and bleached coral) for curios was prohibited in 1998. While hundreds of individuals collect coral, only Asosiasi Kerang, Koral dan Ikan Hias Indonesia (AKKII , the Indonesian Coral, Shell and Ornamental Fish Exporters Association) members are allowed to legally export corals.

Indonesia has specific guidelines for the sustainable utilization of coral resources, which were developed in coordination with the Ministry of Forestry and Estate Crops (Director General of PKA). This includes a quota first developed in 1997, which is now broken down by species for each province. The quota allocated for 2001 includes over 925,000 live corals, 950,000 pieces of reef substrate with attached soft corals and 450 metric tons of live rock. Coral harvest for international trade is currently allowed in 10 provinces, but it must occur outside protected areas and tourism areas. In addition, coral is supposed to be taken at levels below the regeneration rate for each species, and at a specific size (e.g. 25 cm for fast growing species and 15 cm for slow growing corals). These guidelines also recommend that collection only occur in sites where population assessments have occurred and monitoring is undertaken to ensure sustainable utilization. Along with specific methods of coral removal, coral collection sites are under a minimum of a four year rotation period.

International trade in corals is regulated under an Appendix II listing in the Convention on the Trade in Endangered Species of Wild Fauna and Flora (CITES). Exporting countries must provide an export permit with each shipment that indicates that the collection and trade is legal, and the trade will not be detrimental to the survival of the species in the wild. In addition, an Appendix II listing gives an importing country the authority to implement more stringent requirements if they feel a species is being traded unsustainably. The EU countries recently adopted a regulation (Regulation (EC) No 338/97) on the protection of species of wild fauna and flora in trade that allows more stringent measures for EU Member States. This includes the obligation to issue an import permit as well as an export permit, and the authority to suspend imports if trade is believed to be to the detriment of the species.

In 1998, the Scientific Review Group (one body responsible for implementation of Regulation No 338/97) began to question the level of export quotas set by Indonesian authorities for live corals, and were particularly concerned about one taxon, *Catalaphyllia jardinei*. After additional analysis the EU adopted a temporary trade restriction for 7 coral species effective as of September 1999. Additional species of the suspended genera and one additional genus were added to the trade suspension in July 2000. The quota for these species was particularly high, and did not appear to be derived using knowledge pertaining to the status of populations, their distribution and abundance, or their biology. The EU requested additional information from Indonesia pertaining to these taxa, and can lift the trade suspension as soon as scientific data are available to verify that the level of trade is sustainable.

The purpose of this assessment was to test a monitoring approach for the stony coral fishery, use this approach to assess the status of coral collection areas, and determine whether alternative management measures are needed to ensure sustainable harvest. Based on recommendations at an International Coral Trade Workshop held in Jakarta (April 9-12, 2001), we developed a monitoring protocol to assess the status and trends in coral taxa targeted for trade as aquarium specimens and tested it in locations off the Spermonde Archipelago, South Sulawesi. This area was chosen as the site for coral surveys because this is one of the largest coral reef areas in Indonesia, and one of the largest coral collection areas. The results of this survey will form one component of an EU assessment of 7 taxa that have been suspended since 1999, and also will provide an initial step at determining a sustainable quota based on the condition and abundance of the resource.

Materials and methods

Surveys were conducted in 12 locations in the Spermonde Islands to examine the species richness, distribution, abundance, population dynamics and habitat requirements of key scleractinian coral taxa found there. The coral assessment team consisted of coral reef biologists (Borneman, Bruckner, Lovell and Suharsono), fisheries biologists (Field, Raymakers), industry representatives (coral collectors, AKKII members and a coral exporter), and students (Long and Yusuf). Areas examined were from 1-35 m depth, and included nearshore and offshore fringing reefs, submerged patch reefs and soft bottom habitats .

Fig. 1a. Location of study area. A. Sulawesi, Indonesia is the shaded area inside the box. B. Location of Spermonde Archipelago, off South Sulawesi, indicated by the shaded area.

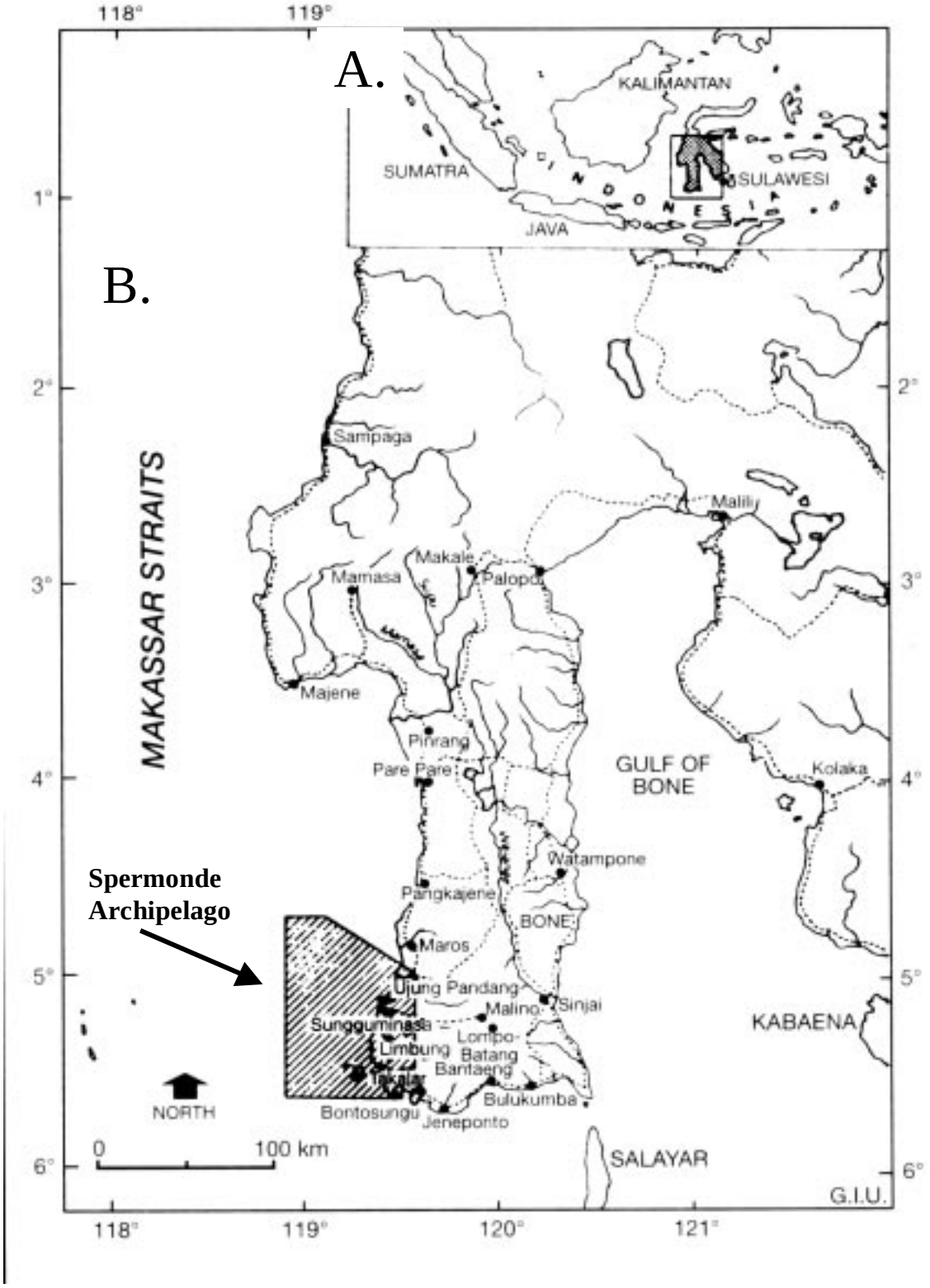
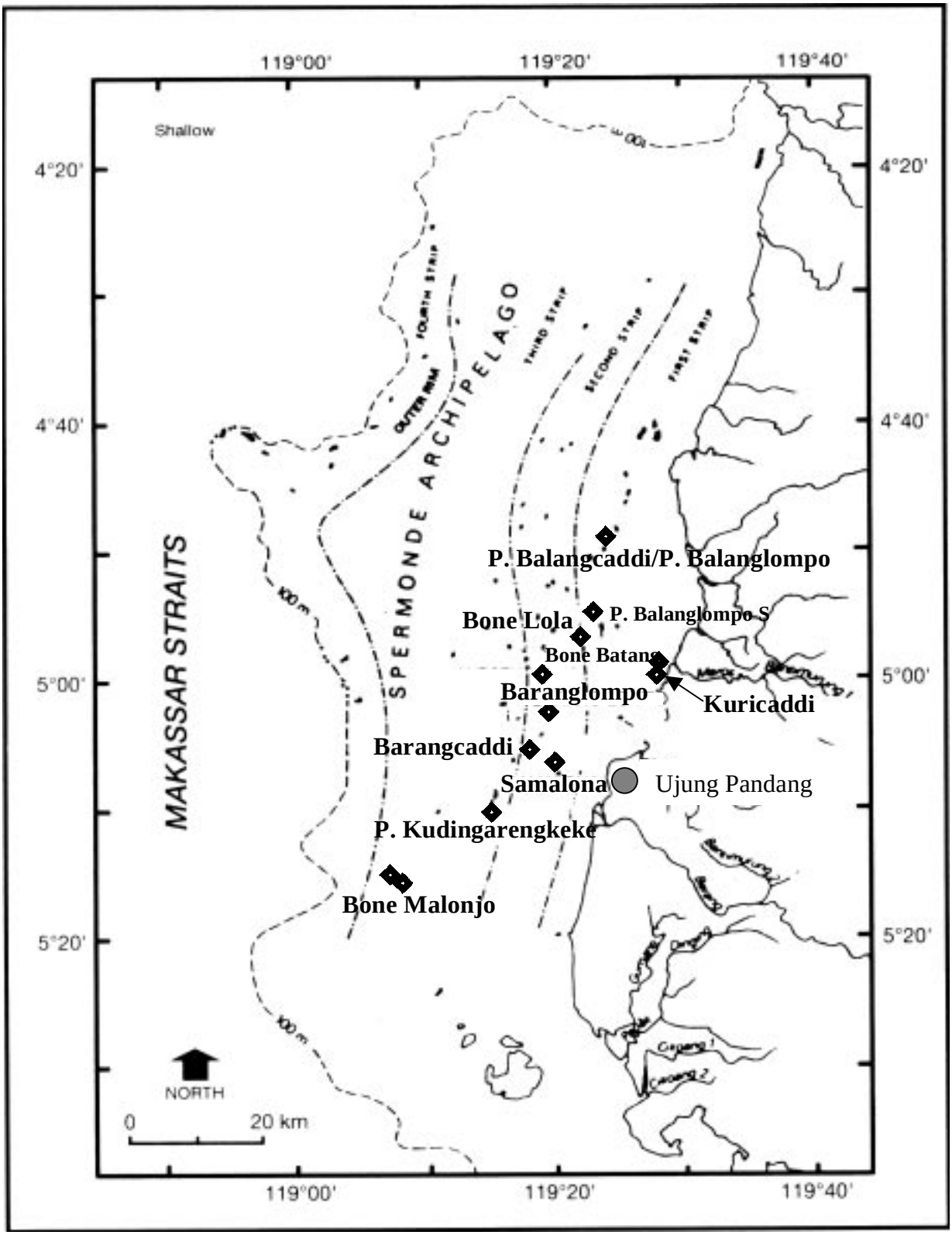


Fig. 1b. Location of study sites within the Spermonde Archipelago. Reas surveyed are indicated by a diamond. The Spermonde Archipelago was divided into four strips, based on exposure and distance from Sulawesi.



The four trained coral biologists performed transect surveys from 1-35 m depth to quantify coral cover and species richness, as well as the distribution, abundance and size of the major reef-building corals in trade. Other divers assisted with video photography, laying transects and other aspects of survey work. All corals were recorded to genus, except for certain easily identifiable taxa, which were recorded to species. In addition to the information collected on the habitat types, coral condition, and population demography, this trip allowed an assessment of collection and handling practices used by the coral fishers. The composition and sizes of harvested taxa was assessed at the CV Dinar holding facility in Baranglompo during one week in April. The numbers of each taxon was recorded, including corals observed during the first day, additional corals brought in during the week, and corals that were transferred to the export facility in Bali. A sub-sample of the taxa on hand were measured and weighed.

Using data on coral composition and size obtained from transects, and aerial extent of different habitat types within the Spermonde Archipelago (estimated from nautical charts), the potential harvest (using the quota established by Indonesia for this province, referred to as Sulsel Province) was calculated for the Spermonde Archipelago. The Spermonde Archipelago was divided into four zones, based on the distance from Sulawesi and physical parameters (according to Moll, 1983). Within these zones, seven different habitat types were identified. The extent of the different habitat types was calculated by estimating the spatial coverage of each for each zone.

Table 1. Site information for areas examined in Spermonde Islands. All coordinates were obtained from a GPS, except those indicated by an * , which were estimated from nautical charts.

Name	Coordinates	Depth	Habitat	Description
Pulau Balanglompo S 4/14/01*	05° 00' 00.0" S 119° 28' 00.0" E	4-16 m	shallow reef (inner belt)	submerged patch reef
Bone Lola 4/14/01	05° 03' 05.0" S 119° 21' 21.9" E	3-16 m	shallow reef (inner belt)	submerged patch reef
Bone Batang NW 4/15/01 *Nemenzophyllia* bed #1*	05° 00' 30.6" S 119° 18' 00.2" E	30-32 m	sand/silt high-ground (inner belt)	isolated, submerged low-relief patch reef
Bone Batang W 4/19/01 *Nemenzophyllia* bed # 2	05° 00' 50.8" S 119° 18' 20.2" E	30-35 m	sand/silt high-ground (inner belt)	isolated, submerged low-relief patch reef
P. Kuricaddi NW #1 4/15/01	05° 00' 26.0" S 119° 26' 38.0" E	1-3 m	mud/sand and silt with coral thickets (nearshore belt)	nearshore environment; river discharge
P. Kuricaddi #2 4/19/01	05° 00' 27.1" S 119° 26' 38.3" E	3-4 m	sand/silt with isolated rocks and coral heads (nearshore belt)	nearshore environment; river discharge
P. Balangcaddi/P. Balanglompo* 4/15/01	04° 55' 00.0" S 119° 25' 00.0" E	2-6 m	shallow algal flat and coral-dominated reef slope	submerged patch reef
Samalona reef 4/16/01 (dive 1)	05° 07' 22.3" S 119° 20' 32.4" E	3-9 m	shallow reef (inner belt)	fringing reef
Barangcaddi 4/16/01 (dive 2)	05° 05' 22.6" S 119° 19' 02.1" E	2-10 m	shallow reef (inner belt)	fringing reef
P. Kudingarengkeke SE 4/17/01 (#1)	05° 05' 34.7" S 119° 15' 12.5" E	10-20 m	reef slope (middle belt)	submerged patch reef
Bone Malonjo SE 4/18/01	05° 17’ 19.1" S 119° 06' 50.7"E	32-40 m	silt/sand, algae and cyanobacteria (middle belt)	macroalgal soft bottom community
Bone Malonjo 4/18/01 (#2)	05° 17' 16.4" S 119° 06' 44.7" E	23-28 m	gently sloping deep reef; sediment and hardground	submerged patch reef

The amount of available coral of each taxon was then extrapolated from 1) a mean abundance of each taxon based on information obtained in the twelve survey locations; 2) the percent of the total population that was within the size range targeted by collectors; and 3) the total area occupied by that taxon. For this preliminary analysis, estimates of the aerial extent of each habitat type are very crude, and may reflect a larger than actual area. For instance, the reef area used in calculations includes non-coral habitats such as the associated beach and cay.

Results:

Field Assessments

a. Habitat types and aerial extent

The Spermonde Archipelago has an estimated area of 16,000 square km and a total reef area of 4,290 square km. It extends approximately 60 km offshore, is bounded by a barrier reef 143 km in length, and has a maximum depth of 67 m (Tomascik et al. 1997). Within the archipelago are approximately 150 islands with fringing reefs, hundreds of submerged patch reefs, and extensive soft substrate habitats. To estimate the total available resource for each coral taxon, the Spermonde Archipelago was first divided into main four sections (referred to as Astrips@ by Moll, 1983), termed here nearshore, inner, middle and outer (Fig. 1 b). Each of these sections differs in the degree of wave exposure and sedimentation, which is primarily related to the distance from Sulawesi. Three sections encompass approximately an equal area (estimated to be 3200 square km each), while the middle section is about 6400 square km.

Seven major habitat types were identified in the Spermonde Archipelago. These include: 1) barrier reef (forms the outer rim of Spermonde); 2) fringing reefs (reefs associated with offshore coral cays); 3) submerged patch reefs (coral-dominated communities from 2-20 m depth, located 5-20 km off Sulawesi); 4) macroalgal soft bottom communities (deep areas located 20-60 km offshore with a sand/silt substrate colonized by red, green and brown algae and cyanobacteria mats); 5) isolated low-relief coral communities in unconsolidated sediment (deep areas with a sand/silt/mud substrate located 5-20 km offshore); 6) scattered coral/rock in unconsolidated fine sediments (up to 5 km offshore, less than 5 m deep, mud/silt/sand substrate, in areas affected by river discharge); and 7) grassbeds (associated with larger cays, primarily offshore). Surveys were performed in 5 of the 7 major habitat types.

Table 2. Estimates of the aerial coverage of habitats examined in the Spermonde Archipelago.

Habitat type	Section	% of section	Total area
Fringing reefs	inner and	15% and 5%	800 sq. km
Submerged patch reefs	nearshore and inner	15%	960 sq. km
Macroalgal soft bottom	middle	70%	4480 sq. km
Low-relief coral communities in unconsolidated sediment	inner	5%	160 sq. km
Scattered coral rock in unconsolidated sediment	nearshore	20%	640 sq. km

b. Coral composition and demography

A total of 67 genera of sceleractinian corals and four additional hard corals (*Millepora*, *Tubipora*, *Heliopora* and *Stylaster*) were recorded within belt transects conducted in 12 locations in the Spermonde Archipelago (Appendix 1). The number of genera in each location ranged from 5 to 52, with a maximum of 51 genera recorded along a single transect. Fringing and patch reefs from 5-20 m depth had a greater number of taxa and a higher cover by stony corals than shallow nearshore sites and deeper algal-dominated soft bottom habitats. Total cover of corals measured along transects in reef environments (10-20 m depth) ranged from 15-85%. In soft bottom habitats, coral cover was generally very low (<1%-5%). However, a shallow (1-3 m depth) site in very turbid water (near a rivermouth; P. Kuricaddi) was identified that had coral-dominated patches with close to 100% cover, and extensive monospecific assemblages of *Galaxea, Porites* and *Montipora*.

Most corals were small to medium in size with very few corals (1.5%) larger than 100 cm diameter. In reef environments, corals ranged in size from <1cm diameter to 330 cm, with 66% of all corals from 5-24 cm in diameter, which is equivalent to the size of allowable harvest in Indonesia (Fig. 2). In soft bottom habitats most corals were small (<15 cm), with the exception of large monospecific coral heads observed in shallow water.

c. Reefal areas
Submerged reefs included a reef between P. Balangcaddi/P.Balanglompo, *Bone Lola*, P. Baranglompo S, and P. Kudingarengkeke SE, and *Bone Malonjo* #2. Emergent fringing reefs included *Samalona* and *Barangcaddi*.

The reef between P. Balangcaddi/P.Balanglompo had a shallow algal flat dominated by *Sargassum* with isolated corals and rocks (1-2 m depth) and a very narrow band of corals concentrated along the reef slope (3-6 m depth). Reef areas had a mixed species assemblage with branching, massive and plating corals and large patches dominated by free-living fungiids . Acroporids were rare. This was reported to be an area dominated by *Catalaphyllia jardinei*, but *C. jardinei* colonies were aggregated in one small area, and the taxon was rare elsewhere. A few large *Euphyllia* and *Hydnophora* colonies were observed.

Bone Lola and P. Balanglompo S are nearshore submerged patch reefs with a high cover of living coral. These reefs have a shallow reef flat (3-5 m depth) and an extensive reef slope (5-16 m depth) that terminates in sand/silt. The coral community was represented mainly by massive and submassive corals (especially *Goniopora*), fungiids, *Euphyllia* spp. and *Galaxea*, with a notable absence of acroporids, few pocilloporids, and few large foliose or plating corals.

Samolona and Barangcaddi are fringing reefs in the inner section of Spermonde Archipelago. These had a shallow reef flat and a narrow reef slope that extended from 2-3 m depth to about 10 m. The reefs were dominated by plating and foliose corals like *Echinopora, Oxypora, Merulina* and *Pavona*; branching corals like *Acropora, Porites* and *Seriatopora*, and also faviids and fungiids.

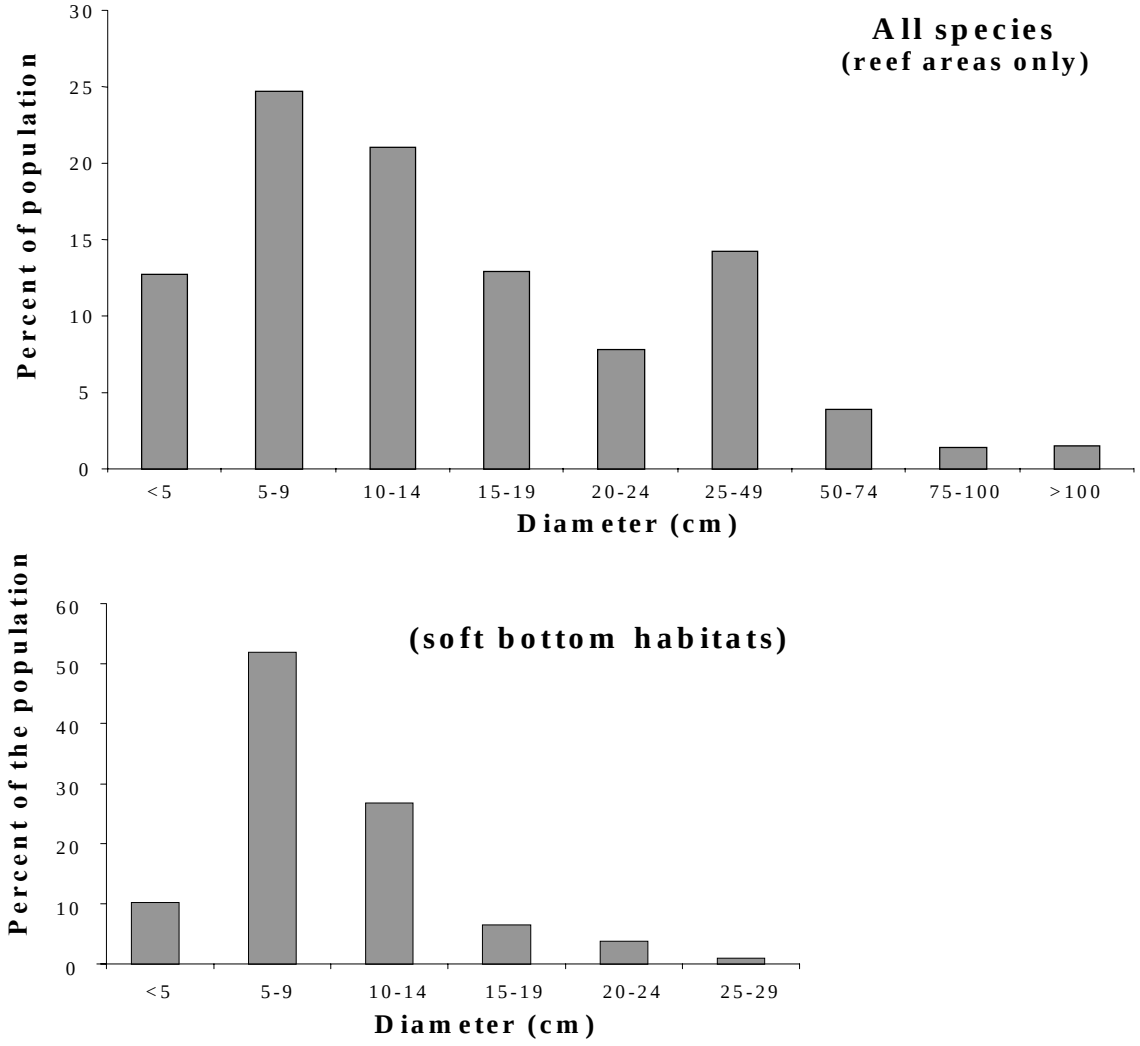
P. Kudingarengkeke SE was a submerged patch reef in the middle section of Spermonde. The reef extended from about 10 m depth to 20 m and lacked a typical reef flat community. This reef had the highest diversity of corals and highest cover, with massive, plating and branching taxa. Dominant taxa included *Euphyllia*, *Goniopora*, *Porites*, fungiids. faviids, *Lobophyllia*, *Galaxea* and *Seriatopora*, respectively. *Blastomussa* was observed and collected in this location.

A deep submerged offshore reef (Bone Malonjo) was surveyed in the middle section of Spermonde. Of all reef environments examined, this area had the lowest coral cover. Many of the corals were finely branched and delicate. *Acropora* and *Goniopora* were the most abundant taxa, followed by fungiids, and other plating and branching corals. *Blastomussa, Trachyphyllia, Cynarina* and *Hydnophora* were observed at a low density.

d. Soft bottom communities
Pulau Kuricaddi, the nearshore *Catalaphyllia/Trachyphyllia* beds (**habitat type 6**) consisted of a low-relief coral community with a sandy silt bottom in the nearshore section of Spermonde. In shallow water (1-3 m) there were large stands of *Galaxea* that extended about 1 m off the substrate, interspersed with patches of other taxa; a total of 23 genera were recorded. Dense coral assemblages were separated by meandering sediment channels that had isolated free-living colonies of *Trachyphyllia* (and *Wellsophyllia* which is lumped under *Trachyphyllia* because neither Cairns, 1999 or Veron 2000 recognize it as a separate genera). *Trachyphyllia* were also found as attached colonies on small boulders and coral heads. The amount of coral declined in deeper locations (3-4 m), as this was primarily a sandy/silt substrate with isolated boulders or mounds colonized by sponges, soft coral, columnar zooanthids, and isolated corals. *Trachyphyllia* and *Catalaphyllia* occurred at a low abundance in deeper areas, and had a mean size of 8.4 cm.

Bone Batang **(habitat type 5)** were small, isolated coral communities located in the inner section of Spermonde at 30-35 m depth. Coral areas were elevated about 1-2 m off the surrounding unconsolidated silt/sand substrate. One of the patches was 37.5 m wide by 30-50 m long, with dense coral cover (>15 colonies/m^2) occurring in an area of roughly 1300 square meters. The second patch was larger, but corals were much less dense (<5 colonies/m^2). The community was dominated by *Nemenzophyllia, Goniopora* and *Lobophyllia* respectively, but 5 other genera of corals were also found. Other organisms included corallimorphs, colonial anemones (*Zoanthus* and *Palythoa*), octocorals (*Sinularia, Neptheidae Sarcophyton, Clavularia* and *Pachyclavularia*) and barrel sponges (*Xestospongia*).

Fig. 2. Size frequency distribution of corals observed within transect areas in Spermonde Archipelago. A. Sizes of corals inhabiting reef environments. All genera of corals occurring within transects are pooled. B. Sizes of corals found in soft-bottom habitats. Only corals that are currently under EU suspension identified in soft-bottom habitats were measured (*Nemenzophyllia, Trachyphyllia, Cataphyllia, Cynarina,* and *Euphyllia*).



Bone Malonjo SE is a macroalgal soft bottom community (**habitat type 4**) that occupies an extensive area in the middle section from 30-40 m depth. In addition to soft corals and tunicates, six genera of free-living corals (*Trachyphyllia*, *Goniopora*, *Herpolitha*, *Euphyllia*, *Cynarina* and *Wellsophyllia*) were identified here, at a mean abundance of 2 colonies/m^2.

Table 3. Population dynamics of scleractinian corals in Spermonde Archipelago, Sulawesi. All species examined along transects are pooled. * For these reefs only the suspended taxa were measured.

Site	Habitat	depth	No. genera	Mean diameter (cm)	No. corals/m2
Bone Batang (NW*)* *	soft-bottom	30	8	13.5	4.7
Bone Batang (W*)* *	soft -bottom	32	5	15.2	15.5
P. Kuricaddi NW # 1*	soft -bottom	1-3	23	8.4	0.3
P. Kuricaddi # 2*	soft-bottom	3-4	8	9.8	0.2
Pulua Baranglompo S	patch reef	15	27	23.4	4.0
Samalona reef	fringing reef	9	39	18.6	7.5
Bone Lola	patch reef	15	31	19.8	5.8
Barangcaddi	fringing reef	5-10	51	14.4	6.8
Bone Malonjo SE #1	soft-bottom	35	6	7.5	2.0
Bone Malonjo	patch reef	26	20	8.6	3.0
P. Kudingarengkeke SE	patch reef	15-20	53	18.9	9.4

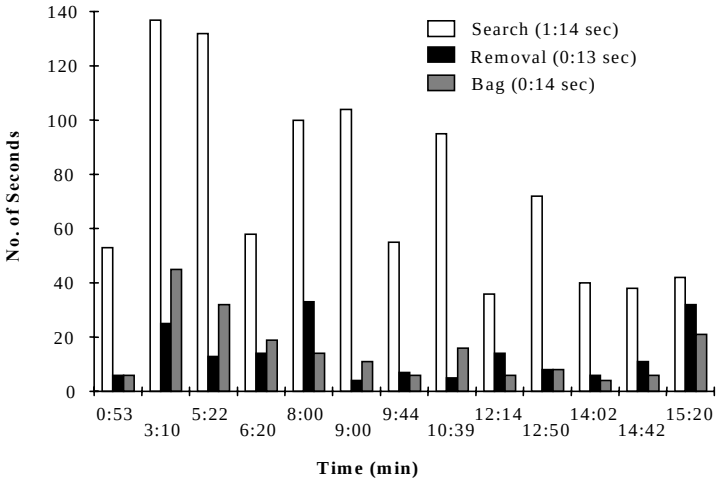
Coral collecting activities

The majority of the collection activities observed in the Spermonde Islands occurred on the reef slope or the base of the reef, and in deep water soft bottom habitats. Collectors did not appear to target shallow reef flat communities dominated by branching taxa. In all cases, corals were selectively harvested over large areas. Some corals such as *Euphyllia* spp. were obtained from several different reefs, while other collection areas appeared to be very specific for certain species, such as areas targeted for *Catalaphyllia*, *Nememzophyllia*, and *Blastomussa*. Certain species such as *Trachyphyllia* were collected from a very characteristic, deep water, soft-bottom algal flat, which covered a large portion of the more remote, offshore locations in the Spermonde Archipelago.

Collectors used hookah (surface supplied air), and often dove relatively deep (35-40 m depth), without using watches or following dive tables. Typically, several divers (4-6) operated out of one boat, with a single diver collecting at any given time. In more remote, offshore locations, the collectors were primarily interested in obtaining sea cucumbers (trepang) that have a much greater value than corals, while certain taxa of corals in high demand were collected secondarily (e.g., *Trachyphyllia* and *Catalaphyllia*). In reef environments, collectors use a hammer and small chisel to remove the target coral, causing minimal damage to the surrounding reef or associated corals. In soft bottom habitats, corals are free-living and no tools were used.

By following a collector underwater for the duration of a dive, an assessment of the catch per unit effort was made for one reef. The collector spent the majority of the time near the base of the reef, in 18-20 m depth, and was able to find 25 corals within 30 minutes. Corals were placed in small collecting bags underwater, immediately after removal. The collector spent on average 1 min 40 sec searching for an appropriate coral, 13 sec to remove the coral and 14 sec to place it in a bag. The duration of individual activities over a 15 min period are shown in Fig. 3. At the end of each dive, the collector sorted the corals in the boat. Other divers did not bag each coral when under water. Instead, the collector removed corals, amassed them on the bottom, and at the end of the dive brought them to the surface in a small basket. Corals were often placed indirect sunlight, out of water, for 5-10 minutes before being transferred to a small styrofoam box. Each coral was kept separate from others by a piece of plastic. Very little water was placed in the collection buckets, and these may be held on the boat for many hours before being brought to the holding facility (because of the large distance between collection areas and the holding facility).

Fig. 3 Coral collection activities in Spermonde Archipelago. Activities were broken down into time spent searching (white bars), time to remove the coral (black bars) and time to place it into a bag (gray bars). A typical fifteen minute block of time is shown.



Corals are held in shallow, flow-through seawater tanks on Baranglompo, until being transferred to the CV Dinar facility in Bali. During one week in April, a relatively small number of taxa were brought into the holding facility (Table 4). Individual taxon were kept in separate tanks, and were organized in rows to ensure that adjacent colonies were not in direct contact. Certain taxa of corals (e.g., *Catalaphyllia*) were held for one to two days, and then transported to the export facility. Other taxa (*Nemenzophyllia*) were kept at the holding facility for the entire week. Several corals died (especially *Catalaphyllia*) while at the holding facility, and a few others had partial tissue loss or began to bleach within days of collection. The very low water flow in these tanks may compromise the health of certain sensitive corals if held for more than a few days, but in general most of the corals appeared to be in excellent health.

Quota setting

Since 1997 Indonesia has used a system of harvest and export quotas for each taxon of corals in international trade. The quota is broken down by species with a separate harvest quota for each of 10 provinces where collection is permitted. The harvest quota for the taxa under EU suspension is presented for 1998-2001 in Table 5. From 14-42% of the total catch quota for the 7 taxa is allocated to Sulsel Province, with the remainder divided among 6-8 other provinces.

Biological and ecological information of taxa under EU suspension

a. Euphyllia:

There are nine species of *Euphyllia* recognized by Cairns (1999) and eight species recognized by Veron (2000). The genus occurs most often in reefal areas, particularly along the reef slope in moderately turbid environments with low wave exposure. *Euphyllia* was identified on most submerged patch reefs and fringing reefs examined in Spermonde from 5-20 m depth. We identified six species, but two of these were relatively uncommon (*E. paradivisa* and *E. paraancora*) and were lumped under *E. divisa* and *E. ancora*, respectively. *Euphyllia divisa* was also observed at a low abundance (0.3-0.6 colonies/square meter) in deeper, soft bottom habitats, occurring from 30-35 m depth in an area dominated by *Nemenzophyllia*, *Goniopora* and *Lobophyllia*. It was rare or absent from shallow fringing reef environments, especially in offshore locations dominated by branching pocilloporids and acroporids.

This coral is harvested whole when small, and also is fragmented from larger corals. On the reefs examined, all species of *Euphyllia* had a mean size of 18 cm; 60% of the population was of the appropriate size for collection as whole colonies (e.g. 15 cm or less in diameter), with very few colonies larger than 50 cm (6.4%) (Fig. 4). However, on one reef (Samalona) four colonies of *E. ancora* that were 2-3 m in diameter were observed within one transect. The most common species observed along transects was *E. glabrescens* (70%), followed by *E. ancora* (24%) and *E. divisa* (5.2%); *E. cristata* was rare (0.3%). *Euphyllia ancora* and *E. glabrescens* occurred from 5-20 m depth, while *E. divisa* was found more frequently in shallow areas (5-15 m).

The genus (all species) made up about 16% of the total trade in live coral in 1998. For 2001, the quota allocated for these species in Spermonde ranged from 6000-9000 colonies, with the highest harvest allowed for the rarest species, *E. cristata* (Table 5). Although this species was not observed in the holding facilities at Baranglompo, the other three species were ones, including *E. divisa,* for which no quota has been allocated. The density of *Euphyllia* ranged from 0 to 1.2 colonies

per square meter,with the highest number of colonies observed on submerged patch reefs in the inner section (Table 6). Using an average density for fringing reefs and an average for submerged patch reefs (all surveys are pooled), an estimated 900,000 colonies of *E. glabrescens*, 750,000 colonies of *E. ancora* (*E. parancora* is included in the total) and 72,000 colonies of *E. divisa* (*E. paradivisa* is included in the total) occur in fringing reef (total area of 800 sq. km) and submerged patch reef environments (total area of 960 sq. km) of the Spermonde Archipelago. Since specimens for international trade can be fragmented from larger colonies, only those colonies that are less than 5 cm in diameter would be unavailable for harvest, which is approximately 15% of the population (Fig. 4a). Thus, annual harvest of *E. glabrescens* and *E. ancora* amounts to about 0.9% of the available stock. In contrast, survey data for *E. cristata* suggests that less than 10,000 colonies exists in the Spermonde Archipelago, and the potential annual harvest based on the allocated quota would reflect 90% of the available population .

Table 4. Composition of corals at the CV Dinar holding facility in Baranglompo, Sulawesi during one week in April, 2001.

Taxa	Numbers of animals	percent of total	average diameter (cm) ± SE	average weight (grams)
Blastomussa spp.	13	1.3%	5.0 ± 0.8	38 ± 13.1
Cynarina lacrymalis	4	0.3%	5.7 ± 1.0	95 ± 18.1
Catalaphyllia jardinei	250	27.1%	8.8 ± 1.8	177 ± 69.1
Euphyllia ancora	40	4.2%	12.0 ± 1.6	179 ± 22.4
Euphyllia divisa	25	2.6%	7.7 ± 0.3	114 ± 10.6
Euphyllia glabrescens	48	5.1%	8.1 ± 0.5	107 ± 6.2
Nemenzophyllia turbida	260	28.2%	18.2 ± 2.8	125 ± 9.6
Plerogyra spp.	110	11.9%	9.6 ± 0.4	246 ± 26.3
Trachyphyllia geoffroyi	60	6.4%	6.4 ± 0.3	80 ± 9.2
Favia/Favites spp.	50	5.3%	not measured	not measured
Goniopora spp.	15	1.4%	not measured	not measured
Heliofungia actiformis	10	1.0%	not measured	not measured
Lobophyllia	50	5.3%	not measured	not measured
All taxa	935	100%	9.9 ± 0.4	148 ± 8.0

b. Nemenzophyllia turbida

Nemenzophyllia is a monospecific genus recognized by Veron (2000) and Cairns (1999); other authors may place it in the genus *Plerogyra* as one recently described species, *Plerogyra discus* (Veron 2000) is very similar to Nemenzophyllia. This taxon is considered uncommon, but it was found in large aggregates in two soft bottom habitats near Baranglompo (about 15 km from Makassar) in 30-35 m depth. The density of *Nemenzophyllia* varied from 2.2-7.9 colonies per square meter, with a much higher number recorded in site 2 (Table 6). Overall this taxon occurred at a density of 5 colonies per square meter in a surveyed area of 120 sq meters. Since this type of habitat covers an estimated 160 sq km, up to 800,000 colonies of *Nemenzophyllia* occur in the Spermonde Archipelago. All sizes are available for collection, as specimens for international trade can be fragmented from large colonies. Thus, the quota allocated for Spermonde (3000 colonies per year) is about 0.4% of the available stock (Table 7). Although, we estimated that up to 160 sq km of *Nemenzophyllia* habitat occur in Spermonde, it is possible that this is an overestimate; additional studies are needed to determine whether these patches are unique or whether they are fairly common at these depths.

c. Trachyphyllia geoffroyi

Trachyphyllia is a monospecific genera recognized by Veron (2000) and Cairns (1999). A similar coral *Wellsophyllia radiata* has a separate quota, but this taxon is not recognized by Cairns (1999) or Veron (2000) and is considered synonymous with *Trachyphyllia*. Colonies attach to hard substrata when young, but are most often free-living in sand and silt habitats and grass beds. In Spermonde, it was identified in shallow, nearshore environments (1-4 m depth) near P. Kuricaddi at a density of 0.28 colonies per sq. meter; this type of habitat extends over an estimated 260 sq km. It was also observed in deep, offshore algal flats (30-40 m depth) at a density of 0.1 colonies per square meter (Table 6). Although the density is low, this is the most extensive habitat type in the Spermonde Archipelago, covering an estimated 4480 sq km. Thus, in the nearshore habitat, an estimated 179,000 colonies occur, while 448,000 colonies occur in offshore algal flats. Colonies ranged from 2-19 cm (maximum diameter), with a mean size of 8.4 cm (Fig. 5). Over 83% of the population was within the size range preferred by collectors (5-15 cm). However, these corals may have an upper size limit making virtually all but the juveniles (colonies less than 3 cm in diameter) exploitable. Based on a total of 627,000 colonies, 520,000 of these are within the size range being harvested. With a quota of 11,000 for Spermonde, 1.9% of the available resource is currently harvested each year (Table 7). However, colonies observed on nearshore reefs were very drab in color, unlike those observed at the holding facility. This suggests that the taxa is being collected primarily in offshore locations. If this is the case, collectors may remove up to 2.9% of the population each year from deep algal flats.

d. Plerogyra

There are four species of *Plerogyra* recognized by Cairns (1999) and three species recognized by Veron (2000); one of the species listed by Cairns (1999) may be synonymous with *Nemenzophyllia (P. turbida)* and one species listed in Veron 2000 *(P. discus)* is very similar to *Nemenzophyllia*. Two species are reported to be somewhat common (*P. simplex* and *P. sinuosa*), while the third is rare. In the Spermonde Archipelago, isolated colonies of *Plerogyra* were observed on all fringing and submerged patch reefs along transects performed at 5-20 m depth. A slightly higher abundance of colonies were recorded on fringing reefs than on patch reefs. With a mean density of 0.083 colonies per square meter on submerged patch reefs, this habitat has an estimated 79,000 colonies. On fringing reefs, a mean density of 0.19 colonies per sq m was recorded, with a total estimated abundance of 148,000 colonies (Table 6).

Colonies ranged in size from 2-80 cm (Fig. 6). About 63% were the appropriate size for collection (5-20 cm); 7% of the population was less than 5 cm in diameter and 30% were from 20-80 cm. Overall, about 143,000 colonies are available in the Spermonde Archipelago for collection. Based on an allocated quota of 6,000, collectors are harvesting 4.2% of the available stock each year (Table 7).

e. Blastomussa

There are two species, *B. merleti* and *B. wellsi* recognized by Cairns (1999) and Veron (2000). These corals are reported to occur in reef environments, along the reef slope and under overhangs, but are generally thought to be rare; however, *B. wellsi* is not reported to occur in Indonesia. Very few colonies of this taxon were observed in Spermonde Archipelago, and all were colonies of *B. wellsi*. Isolated colonies of *Blastomussa* were recorded in one transect performed on P. Kudingarengkeke (18-22 m depth), an offshore submerged reef, and one individual was identified outside a transect area on another reef. Colonies observed within transects were very small (2-4 cm diameter) and occurred at a mean density of 0.05 colonies per sq. m (Table 6). Based on a very specific and limited habitat preferred by these taxa, only about 160 sq km of habitat is occupied by these species (deeper part of the reef slope of fringing reefs and submerged patch reefs). Thus, only 8000 colonies of B. wellsi are estimated to occur in Spermonde and it is unclear if *B. merleti* occurs here. With a quota of 2,500 for *Blastomussa* spp., collectors harvest up to 31% of the total stock each year.

f. Catalaphyllia jardinei

Catalaphyllia is a monospecific genus recognized by Cairns (1999) and Veron (2000). In Spermonde, it is reported to occur in nearshore environments influenced by river discharge and in offshore grassbed habitats. During the present surveys, *Catalaphyllia* was identified at a low abundance (0.05 colonies per sq m) on one reef in shallow water (3-6 m depth), but colonies appeared to be highly aggregated and were larger than those generally targeted for the aquarium trade. A few colonies were also observed in a shallow, nearshore location (2-4 m depth) close to a river mouth (0.03 colonies/m^2), and isolated colonies were identified in a deep (32 m) *Nemenzophyllia* patch outside of the transect area (Table 6). The taxon was not observed in two grass beds examined during this survey where they were reported to us to occur commonly. The entire area was surveyed by manta tow, with no additional colonies found. Based on the rare occurrence of this taxon, and the small amount of habitat occupied (primarily areas affected by river discharge), no more than 10,400 colonies remain in nearshore or inner habitats. Based on an annual quota of 10,000, over 95% of the population would be removed in one year (Table 7). However, according to collectors, most of the collection for

Table 5. Harvest quota established by the CITES Management and Scientific Authorities of Indonesia. Data are presented for 1998-2001, including the quota allocated to Sulawesi Selatan (Sulsel) province and the total number of provinces where collection is allowed. In 1998 a single quota was provided for all species within each genera; quotas for individual species were first allocated in 1999. * *Wellsophyllia* has been included under *Trachyphyllia*.

Year	2001 Total	2001 Sulsel	No. of provinces	2000	1999	1998
Catalaphyllia jardinei		10,000 (17.9%)	8	65,000	75,000	99,750
Euphyllia spp.	135,000	22,000 (16.3%)	9	140,000	140,000	138,000
E. divisa	0	0	0	0	80,000	-
E. ancora	40,000	6,000 (15.0%)	9	40,000	0	-
E. glabrescens	40,000	7,000 (17.5%)	9	40,000	60,000	-
E. cristata	55,000	9,000 (16.4%)	9	60,000	0	-
Blastomussa spp.	6,000	2,500 (41.7%)	7	8,000	9,000	9,500
B. wellsi	0	0	0	8,000	9,000	-
B. merleti	6,000	2,500 (41.7%)	7	0	0	-
Plerogyra spp.	36,000	6,000 (16.7%)	9	35,000	40,000	50,000
P. simplex	0	0	0	0	40,000	
P. sinuosa	36,000	6,000 (16.7%)	9	35,000	0	
Nemenzophyllia turbida	15,000	3,000 (20%)	8	18,000	20,000	20,000
*Trachyphyllia geoffroyi**	85,000	11,000 (13.8%)	9	90,000	99,000	80,000
Cynarina lacrymalis	10,000	2,500 (25.0%)	8	10,000	11,000	8,000
Hydnophora spp.	22,000	4,000 (18.2%)	9	22,500	21,600	17,500

Catalaphyllia in the Spermonde Archipelago is now in more remote, offshore locations, approximately a one day boat trip from Makassar. It is possible that this coral was once common in nearshore soft bottom habitats and on the patch reefs we examined, but it has been overexploited.

g. Cynarina lacrymalis

Cynarina is a monospecific genus recognized by Cairns (1999) and Veron (2000). It was found attached to hard substrates on the reef slope from 15-20 m depth, and on a deeper (25-30 m depth) offshore reef, and also was free-living in deep (30-35 m) soft bottom habitats. The taxon was observed in the middle section and was absent from the nearshore and inner sections. It was extremely rare (a total of 8 individuals were observed) and 80% were too small for harvest (1-3 cm diameter). Based on densities ranging from 0 to 0.1 individuals per square meter, an estimated 9,600 colonies occur on submerged patch reefs, and 22,400 colonies occur on fringing reefs (table 6). In addition, up to 134,000 colonies may be found throughout the deeper algal flats in the middle section. However, this may be an overestimate, as 3 colonies occurred along a single 30 m transect and none were observed in the second transect or the surrounding area. Assuming that a maximum of 166,000 colonies occur within the Spermonde Archipelago, and 30% are too small to harvest, 116,200 are available. Thus, the annual harvest amounts to 2.2% of the available resource (Table 7).

Table 6. Density (number per square meter) of the 7 suspended coral taxa identified within transect areas in the Spermonde Archipelago. Species listed are as follows: E.g. = *E. glabrescens*; E. a. = *E. ancora*; E.d. = *E. divisa*; Plero= *Plerogyra*, all species; Hydno= *Hydnophora* all species; Trach= *T. geofforyi*; Cat= *C. jardinei*; Blast= *Blastomussa wellsi*, all species and Cy= *C. lacrymalis.* * Only surveyed reef for one taxon, *Catalalphyllia jardinei*.

Site	area	E.g.	E.a.	E.d.	Plero	Hydno	Trach	Cat	Blast	Cy
Pulua Balanglompo	90 m^2	0.74	0.20	0	0.07	0.02	0	0	0	0
Kudingarengkeke	65 m^2	0.79	0.34	0.17	0.06	0.08	0.02	0	0.05	0.02
P. Kuricaddi #2	100 m^2	0	0.01	0	0	0	0.2	0.03	0	0
P. Kuricaddi #1	160 m^2	0.03	0	0	0	0.1	0.4	0	0	0
Bone Malonjo SE	30 m^2	0	0	0.03	0	0	0.1	0	0	0.05
Bone Lola	90 m^2	1.2	0.12	0	0.19	0.13	0.02	0	0	0
Bone Malonjo #2	60 m^2	0	0	0	0.02	0.07	0.07	0	0.02	0.02
Samalona	90 m^2	0.05	0.25	0	0.03	0.23	0	0	0	0.07
Barangcaddi	90 m^2	0.01	0.02	0	0.07	0.14	0	0	0	0
P. Balanglompo*	600 m^2	-	-	-	-	-	-	0.05	-	-

h. *Hydnophora*

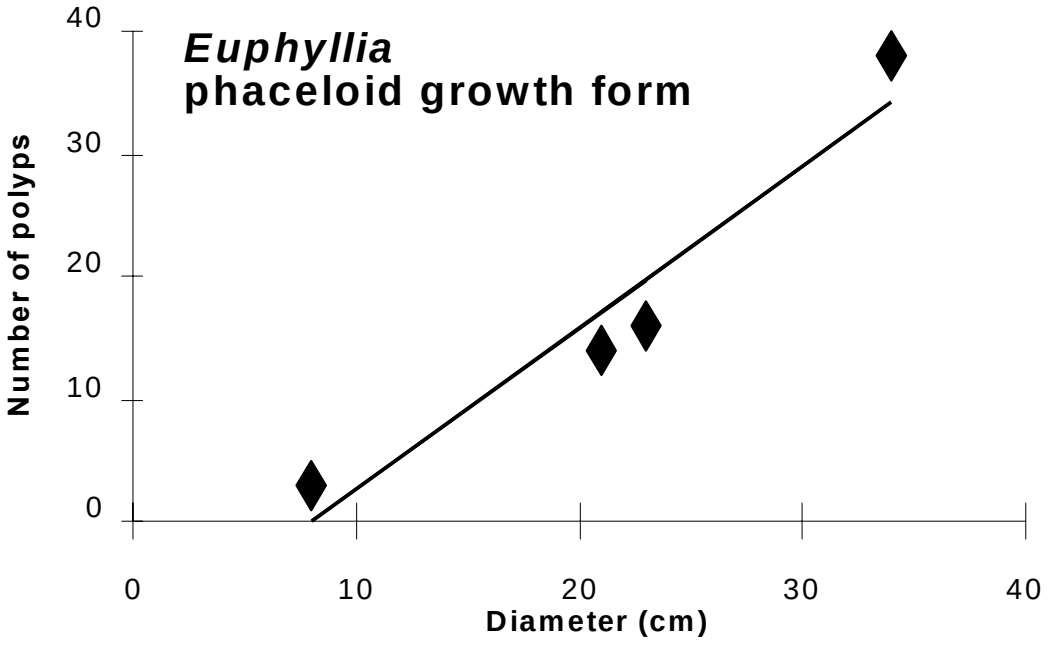
There are six species of *Hydnophora* recognized by Cairns (1999) and Veron (2000). Two species were identified at a low abundance (a total of 46 colonies were observed), but this taxa was identified on all submerged and fringing reefs examined at a mean density of 0.1 colonies per sq. m (Table 6). Assuming a total reef area of 1760 sq. km, an estimated 176,000 colonies occur in Spermonde Archipelago.

Colonies ranged in size from 4-105 cm and had a mean size of 18 cm. About 80% of the population is within the allowable size for harvest (5-25 cm in diameter), with 2% smaller than 5 cm and 18% larger. Thus 140,800 colonies are available for collection. With an annual quota of 4,000 collectors may remove 2.8% of the available population each year (Table 7).

Table 7. Estimated abundance of each taxa and potential amount of harvest in the Spermonde Archipelago, South Sulawesi. Density estimates are the number of colonies observed within the preferred habitats for each taxa (mean value obtained by pooling data from similar habitat types); for species that occurred in multiple habitat types, values are presented for each habitat. The total percent of colonies within the size range preferred by collectors is indicated as the percent of stock available. *** the quota is actually for *B. merleti*, but only *B. wellsi* was observed on the reefs examined and also at the holding facility.

Coral	Density (#/m^2)	Area (km^2)	Total no.	% of stock available	Quota for Sulsel	% of harvest
B. wellsi	0.05	160	8,000	100%	2,500***	31.0%
B. merleti	0		0			
C. jardinei	0.03-0.05	260	10,400	100%	10,000	96.2%
C. lacrymalis	0-0.1	6,240	166,000	70%	2,500	2.2%
E. ancora	0.1-0.2	1,760	750,000	85%	6,000	0.9%
E. cristata	0-0.01	1,760	10,000	85%	7,000	90.0%
E. divisa	0-0.17	1,760	72,000	85%	0	????
E. glabrescens	0.03-0.9	1,760	900,000	85%	9,000	0.9%
Hydnophora	0.1	1,760	176,000	80%	4,000	2.8%
N. turbida	5.0	160	800,000	100%	3,000	0.4%
Plerogyra	0.08-0.19	1,760	227,000	63%	6,000	4.2%
T. geoffroyi	0.1-0.28	4,740	627,000	83%	11,000	1.9%

Fig. 4. Size frequency distribution of *Euphyllia* on reefs in the Spermonde Archipelago. A. Comparison of the maximum colony diameter and the number of polyps. B. Proportion of the population in each size class. Colonies ranged in size from <5 cm to 330 cm.



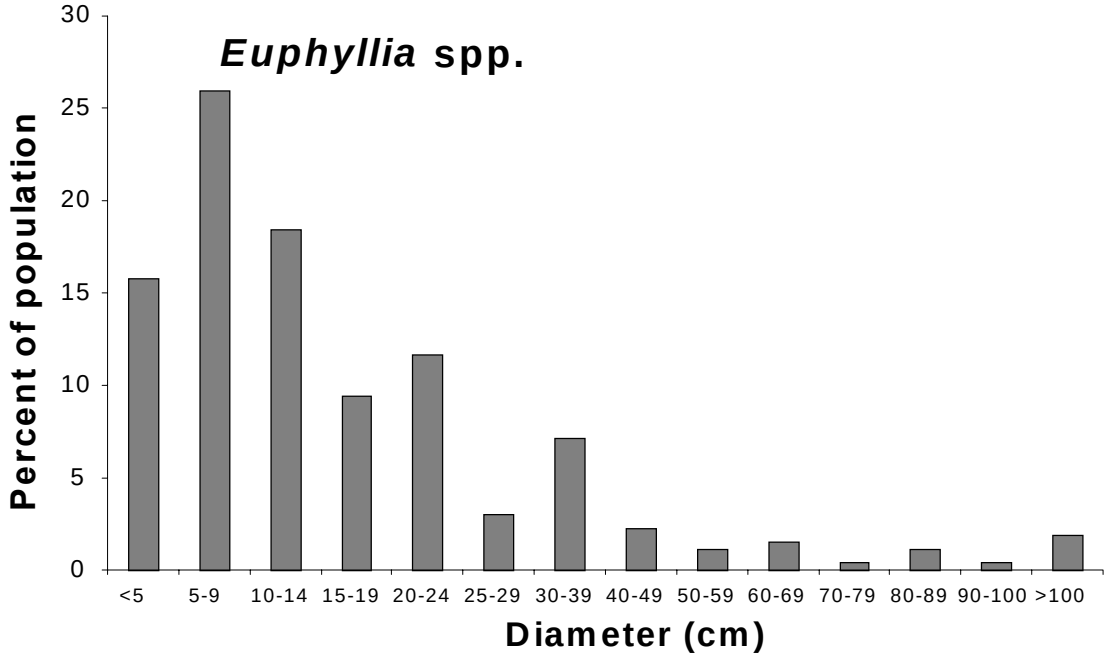
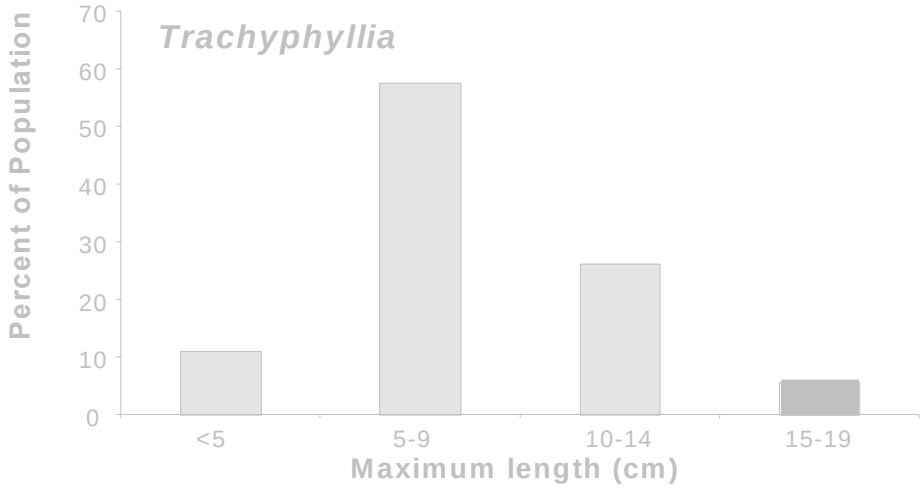
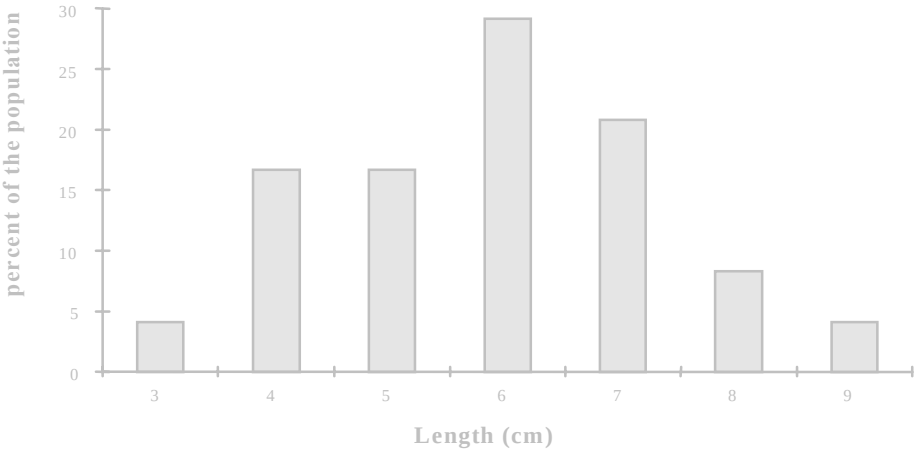


Fig. 5. Population demography of *Trachyphyllia geoffroyi* in the Spermonde Archipelago. A. Size frequency distribution of colonies identified within transects on fringing reefs and submerged patch reefs. Colonies of a suitable size for collection are indicated by the gray bars. B. Size frequency distribution of colonies observed at the CV Dinar holding facility in Baranglompong.





Discussion:

Reef condition: There is considerable historic data available for the coral reefs of the Spermonde Archipelago, including information on live cover and species diversity. The Spermonde Archipelago is regarded as one of the most diverse coral areas in Indonesia, and some areas on the outer reefs have 70-100% coral cover (COREMAP, 1996). However, coral cover is significantly less on reefs closer to the mainland of Sulawesi, and repeat surveys conducted in the same area suggest progressively degraded. For instance, recent surveys of a reef near Baranglompo (Bone Batang), 15.2 km from Makassar, reported a decline in cover from 46.5% in 1996 to 42% in 1998. Another study reported a cover of 74.4% at Kapoposan (at the edge of the shelf in a protected area), 54.2% at 3 m depth in Baranglompo, 47% at Samalona and the lowest cover (18.2%) near the harbor of Makassar (Edinger et al., 2000). In addition to threats posed by land-based pollution from Makassar, destructive fishing is likely to be the greatest threat affecting these reefs, with an estimated 40% of the income in the Spermonde Archipelago coming from bomb and cyanide fishing (COREMAP, 1996).

In the areas examined during this study, coral cover and diversity was high and corals were generally in excellent condition. Areas affected by blastfishing were identified, but these were primarily in shallow water. In most locations commercially important fish appeared to be largely absent, including groupers, snappers, cod, and humphead wrasse. Also in low numbers were many of the smaller reef fish targeted for the aquarium trade. Reefs did not appear to be negatively affected by macroalgae and there was a high number of coral recruits. In general, reefs were dominated by small to medium-sized corals and very few large colonies were observed. Species composition differed most notably between fringing reefs and submerged patch reefs, especially with respect to branching pocilloporids and acroporids which were largely absent from patch reef communities examined. In addition, unusual and/or uncommon corals were observed in deeper soft bottom communities, including *Nemenzophyllia*, *Trachyphyllia*, *Catalaphyllia* and an undescribed species of *Lobophyllia*.

Potential problems arising from collection: The collection of corals for ornamental purposes is often selective in nature. In most situations, it is likely that a few individuals of a species will not be collected because they are not the preferred color morph, shape, or size, or they have experienced partial mortality, and these may serve as a future source of reproductive propagules to rebuild populations. This is evident in nearshore soft-bottom locations of Spermonde, where *Trachyphyllia* was relatively abundant, but colonies were not particularly colorful. However, selective harvest of certain preferred species may lead to localized extinctions, especially if the targeted coral has a patchy distribution or occurs at a low abundance. Some preferred taxa occurred in isolated patches (e.g. *Nemenzophyllia*) that did not cover a large area; the potential for recovery may be reduced following intensive collection, because these corals are found in deep water environments where current patterns may be unfavorable for recruitment from other reefs. In addition, many taxa such as *Cynarina* were found at a very low abundance, and further removal may affect subsequent reproductive potential, as corals are sessile organisms that broadcast their gametes into the water column, and they may need to occur at a certain density to ensure successful fertilization. Also, very little known about reproductive strategies/life history of the corals in question here.

In coral exporting countries such as Fiji, the Solomon Islands and Vietnam a large percentage of the coral consists of branching species collected primarily on reef flats in shallow water. These types of coral tend to be the dominant corals found on Pacific reefs, and they are fast growing, and exhibit high rates of recruitment and asexual spread. These taxa were identified at high abundance on fringing reefs located mid-shelf in the Spermonde Archipelago, but were notably absent from patch reefs in inner and nearshore locations. Despite demand for the corals in importing nations and their abundance in Indonesian waters, they do not appear to be a prime target of collectors in Spermonde as the quota is very low and they were not observed at the holding facility. In fact, the bulk of corals exported from Indonesia are either massive species, species with large fleshy polyps, or other corals that are generally presumed to have slower growth rates and are less common. Most notable are the 7 taxa for which imports into the EU have been suspended, which appeared to be the dominant component of the trade from the Spermonde Archipelago.

Quota setting. The quota for coral harvest is currently established using available information on reef accretion rates, rates of coral growth, condition of reefs from sites where monitoring has occurred, and estimates of reef area. Initially, a total quota was established at 1,000,000 colonies between 15-25 cm diameter, which represented 0.00035% of the total coral reef area in good to excellent condition. The quota was based on the assumption that reef accretion ranges from 1 to 1.5 cm per year, growth rates are from 2.5-30 cm per year and harvest occurs only on about 30% of the reefs in Indonesia, specifically those in good to excellent condition (Suharsono,1999). The quota is subdivided among individual taxa (to the species level, or in some cases to genus) for each of 10 provinces.

Indonesia represents the only country that has developed a quota for the trade of corals, and claims to be harvesting corals based on sustainable utilization principles developed by the Indonesian government. However, several potential problems with this quota were identified during this study. First, the quota was determined using an estimate of total reef area for reefs in good to excellent condition, but collection typically occurs in reefs and other environments that are not dived by tourists, and in many cases represent turbid areas that are in moderate to poor condition due to anthropogenic stresses. In addition, two of the dominant taxa exported from Indonesia (*Trachyphyllia* and *Catalaphyllia*) are not collected from reef environments; they are collected from soft-bottom habitats. Second, the quota is loosely based on limited information available on the biology of the target species and their distribution and abundance in Indonesia. In general, there is a lack of scientific information on the basic biology of these species, and very few reef surveys have been conducted in collection areas that would provide the information needed to verify the established quota. This preliminary assessment of coral abundance and population demography for the Spermonde Archipelago identified several taxa which are relatively rare, and their abundance appears to be significantly lower than the quota would dictate.

An analysis of the available CITES data and the quota allocated by the CITES Authorities of Indonesia illustrates several other potential problems with corals in trade from Indonesia. Perhaps most notable is the discrepancy between export and import data. In some cases export data suggests that Indonesia is trading in corals at levels higher than those permitted by the quota. However, permits often list the total amount of coral that can be exported, and this may be considerably higher than the actual volume contained in the shipment. In addition, the 2001 quota issued by Indonesia differs in several respects from that published on the CITES web site. On the CITES website, several species recognized by Indonesia (and in some cases by coral taxonomists) have been omitted, including *W. radiata* and *N. turbida*, and some taxa are listed at lower numbers than those provided by Indonesia. In addition, some of the species currently under trade suspension in the EU were not listed on the quota in 2000 and 2001, but were presumably in trade and were observed at the holding facility. This includes *E. divisa* and *P. simplex*. The quota established for some taxa was modified in 2000 or 2001, which resulted in the removal of some of the species of concern in the EU, but these were replaced with closely related species in the same genera not previously listed in the quota (e.g. *E. divisa* is no longer listed, but has been replaced by *E. cristata* and *E. ancora; P. simplex has been replaced by P. sinuosa;* a quota was established only for *B. merleti* in 1999 and only *B. wellsi* in 2000 and 2001, even though *B. wellsi* is not reported to occur in Indonesia). Finally, the quota for several species under the EU trade suspension was reduced in 2000 and/or 2001 to levels below the 1999 quota, but it is unclear whether this is because those taxa have become more difficult to find, the demand has declined, the 1999 quota was found to be unsustainable, or it was in response to the EU trade suspension.

Determination of a sustainable quota: A quota is one mechanism for ensuring that a resource is utilized sustainably, but it must be based on science. The quota should reflect the total amount of each taxon coming out of the water, and not the amount of coral that is exported, as this does not reflect the numbers that died during collection and subsequent handling. In addition, the quota should be established for each geographic collection area, based on the condition of the reef, the abundance of the targeted coral, the extent of other reef uses, and impacts from natural and anthropogenic disturbances that may affect survival of targeted taxa. The quota must also take into account life history strategies, such as rates of growth, recruitment rates, and population demography. Various quantitative data, such as the abundance, size frequency distribution, growth rates, mortality and recruitment, in combination with the total area occupied by a targeted species and the area under collection pressure, can provide an initial estimate of the potential yield of each taxa under different levels of collection.

A classical fisheries model was modified for precious corals by Grigg (1984) and was also applied to stony corals to estimate the maximum sustainable yield for *Pocillopora verrucosa* in the Philippines (Ross, 1984). This model involved a calculation of the biomass that could be harvested, based on an assessment of the standing crop in the harvested area, the growth rate, and the instantaneous rate of recruitment and natural mortality. For sustainable harvest, the model requires that the corals obtain a minimum size (age) to allow for reproduction, which in the case of *Pocillopora* was estimated to be 18 cm (6 years). This type of model may be suitable for branching corals, especially those harvested for curios, as these taxa are generally harvested at a large size. However, it may not be applicable to the bulk of corals collected in Indonesia, as branching taxa make up a very small portion overall. In addition, the average size of most corals collected in the Spermonde Archipelago for aquarium displays, as measured in this study, were considerably smaller in size, and may be pre-reproductive.

As a first step in developing a model applicable to Indonesia, we assessed the abundance and diameter of stony corals identified along transects, calculated the maximum area occupied by each taxa, and estimated the total number of colonies found within the Spermonde Archipelago. By comparing the estimated abundance to the maximum allowable harvest (as set by the quota for this province), collectors were estimated to remove from <1% of the resource to up to 96% depending on the taxa. Based on an analysis of the taxa under EU suspension, the quota for *Blastomussa*, *Euphyllia cristata* and *Catalaphyllia jardinei* appears to be too high, as these corals were particularly rare. Unless large beds of these occur within this Archipelago that were not identified in the surveys, it is recommended that no collection for these species occurs. Other taxa, including *Hydnophora* spp., *Cynarina lacrymalis*, *Trachyphyllia geoffroyi* and *Plerogyra* spp. are being collected at relatively high numbers relative to their abundance and it may be advisable to lower the quota until additional surveys are conducted that provide more information on their distribution and abundance. In contrast, *E. glabrescens* and *E. divisa* appear to be much more abundant than previously reported, and the collection of these species at present levels is likely to be sustainable. *Nemenzophyllia turbida* was also extremely abundant in the two deep water habitats identified in this survey. However, because *N. turbida* was found in a very specific deep-water soft bottom habitat, additional surveys need to be undertaken to verify that more than two *N. turbida* patches occur in the inner belt of Spermonde and monitoring of the

two known *N. turbida* areas should be completed on an annual basis to ensure that these assemblages are not being overexploited. In addition, overexploitation of individual patches is very likely, as 1) the patches were relatively small; and 2) *Nemenzophyllia* was highly aggregated in some parts of individual patches, and was absent from other parts of the patch, even though both areas contained similar numbers of co-occuring genera.

Finally, it is recommended that a more detailed analysis of the aerial coverage of different habitat types in Spermonde Archipelago, and the distribution and abundance of targeted corals within these habitats be conducted. Many of the species targeted in the coral fishery in Indonesia appear to have a patchy distribution and the collectors tend to target particular habitats or reefs to obtain a certain coral. Thus, it is possible that collectors may continue to harvest one species from an individual area until it becomes so rare that collection effort far exceeds the value of the coral. Upon identification of specific collection areas that contain certain targeted corals that do not have a widespread distribution (such as the small *Nemenzophyllia* patches observed in Spermonde), these areas must be monitored on an annual basis to ensure that collectors only remove a portion of the population. If the population declines below some level (which will differ for each taxa based on its biology and abundance), it is imperative that the area remain off limits to collection until the taxa recovers to its former abundance.

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Conclusion: Sustainable Management Guidelines for Stony Coral Fisheries

Andrew W. Bruckner

Introduction

Coral reef ecosystems occur in over 100 countries worldwide, most of which are developing countries whose peoples are dependent on reefs as the basis of their livelihood. Coral reefs are renowned for their high diversity and productivity, and they provide important sources of food, jobs, chemicals, medicines, revenue from tourism and fishing, and shoreline protection against tropical storms. Despite numerous economic and environmental benefits, reefs are being destroyed at an alarming rate from increasing human impacts precipitated by population growth, urbanization and industrialization. As human populations continue to expand in coastal areas, increasing pressure is placed on coral reefs to supply a growing local and international demand for food, ornamental organisms, and traditional medicines (Bruckner 2000). Because of their high value in international trade, many species are being collected at unsustainable rates and fishers often use destructive fishing practices. While the harvest of stony corals for international trade may seem to represent a small issue in terms of global volume, it can be a potentially significant extractive use at a localized scale. Coral fishers may cause considerable habitat damage, including breakage of undesirable corals and generation of rubble. Also, many of the most popular aquarium corals are uncommon, have a patchy distribution, exhibit slow growth, and are characterized by slow rates of annual recruitment and adult mortality, making them vulnerable to overexploitation and localized extinctions (Ross 1984). Repercussions of an unsustainable coral fishery may extend beyond the target species, affecting the diversity and abundance of associated invertebrates and fish, and possibly triggering overgrowth of benthic habitats by macroalgae. These changes may cause any socio-economic benefits associated with the coral fishery to sharply decline or be lost altogether.

Stony coral resources

Stony corals are the major reef framework constructors in tropical and sub-tropical environments. They provide topographic complexity, critical habitat, refuge, and feeding grounds for thousands of fish and invertebrates, including many commercially important species. Corals of commercial value can be divided into five groups: stony corals, semi-precious corals (black coral), precious corals (pink, gold and bamboo corals), shallow-water gorgonians, and alcyonarians. This paper focuses on stony corals, including all taxa in the order Scleractinia, organ pipe coral (*Tubipora musica*), blue coral (*Heliopora coerulea*), fire coral (*Millepora* spp.) and lace corals (*Stylaster* spp. and *Distichopora* spp.). All of the species under consideration are listed on Appendix II of the Convention on Trade in Endangered Species of Wild Fauna and Flora (CITES). These species can be in international trade, provided that the collection is legal, the exporting country determines that the trade is not detrimental to the survival of the species in the wild and its role in the ecosystem, and shipments contain appropriate CITES permits issued by the exporting country.

Domestic use of coral

Stony corals are mined from reefs in East Africa, Fiji, India, Indonesia, Malaysia, Maldives, the Philippines, Sri Lanka, Vietnam and other countries for use in road construction, buildings, jetties, seawalls, land reclamation, and as a source of lime for soil improvement, cement, ceramics, and the betel nut industry. Corals mined from construction include genera with dense calcium carbonate skeletons, especially *Porites*, *Goniastrea*, *Platygyra*, *Acropora* and *Favia*, with limited collection of a few other species that coexist on shallow reef flats (Bentley 1998; Brown and Dunne 1988). The worldwide volume of coral extracted for construction materials is difficult to estimate, but in Bali, Indonesia alone it amounted to 150,000 cubic meters during the 1970s and 1980s (Bentley 1998). In most countries coral is also collected for local curio, souvenir and aquaria markets. Collection for local markets may be widespread and involve a high diversity of species, but it accounts for a relatively small proportion of the total coral harvest.

Corals in international trade

Corals are harvested to supply international markets with souvenirs and curios, animals for home and public aquarium displays, jewelry, carvings, human bone replacement, traditional medicines, and biomedical purposes. A small component of the trade is also for scientific research and to supply captive-breeding facilities. Over 95% of all stony coral in trade originates in the Indo-Pacific (Green and Shirley 1999). Indonesia is currently the largest exporter of live coral

followed by Fiji, with smaller amounts from Vietnam, Solomon Islands, Vanuatu, Tonga, and the Marshall Islands. Dead coral is currently supplied mainly by Fiji and Vietnam, although a number of other countries have supplied coral for curio markets over the last decade. The United States has consistently imported 60-80% of all live coral, 95% of the live rock, and more than half of the curio coral (Bruckner 2001). Imports of stony corals to the United States alone averaged about $1.0 million annually from 1975-1980 (Wells 1981). By 1997 exporting nations generated about $5 million from the coral trade, with a retail value of $50 million (Green and Shirley 1999).Corals for use as curios and souvenirs consist of a relatively small number of genera with ornate skeletal structures. The preferred taxa include branching corals such as *Acropora*, *Pocillopora* and *Stylophora*, mushroom corals (*Fungia* spp.), and two octocorals, *Heliopora* and *Tubipora*. Colonies are removed when alive, and may be up to one meter or more in diameter. They are collected primarily in shallow water by snorkeling or wading, using a hammer and small chisel for small colonies and long iron bars for large colonies. Specimens are bleached, cleaned and dried prior to export, and some may be dyed. They are sold intact as raw coral skeletons or are manufactured into carvings, jewelry, inlays for picture frames, furniture and other items. CITES trade records from 1985-1997 indicate that over 900,000 kg and 16 million items of coral (coral skeletons) were in international trade (Bruckner 2001). The trade in skeletons remained fairly constant between 1993-1998, but volumes have increased substantially due to a growing trade from Vietnam and other locations. Corals harvested for curios are a non-perishable product that can be taken from remote locations and transported to export facilities without time constraints.

Coral in trade as live specimens for aquarium displays consist of over 50 genera with branching, massive and plating morphologies, most of which are traded at a small size (5-15 cm). The five most common taxa in the live trade in order of importance are *Euphyllia*, *Goniopora*, *Trachyphyllia*, *Catalaphyllia*, and *Acropora;* with the exception of *Acropora* spp., all of these corals were much less common in the trade prior to 1990 (Bruckner 2001). The volume of trade in live coral has increased sharply in the last decade, from about 50,000 colonies in 1989 to nearly 800,000 colonies in 1999. Collection is carried out by local fishers operating out of small boats, who free dive or use surface-supplied air (i.e. hookah apparatus). Colonies are removed from depths of up to 50 m, in reef environments and soft-bottom communities. A small number of species are also collected on shallow reef flats by wading. Because only certain coral sizes and colors are preferred, fishers often cover large areas of reef or other habitats to obtain the desired animals. The harvest is highly selective, and particular environments are often targeted for single species (Bruckner 2001b). Areas of collection are generally limited to those located relatively near to airports or large holding facilities to maximize survivability.

Another component of the trade consists of material reported on CITES permits as *Scleractinia* which includes live rock, reef substrate, and coral gravel. Live rock is any hard reef substrate (limestone skeletal material of algal or coral origin) that supports an assemblage of living marine organisms, including coralline algae. Live rock may be chipped from the reef substrate in shallow water, or it may consist of loose pieces of coral rubble collected from the reef crest or fore reef environments. The product is exported with minimal preparation and cleaning, or it is transported to a holding facility and cured through several washes to remove unsuitable organisms. Fiji has emerged as the world's largest supplier of live rock, with exports doubling or tripling each year since 1993 (Bruckner 2001). A total global volume of over 1.5 million kg of live rock was in trade in 1999. Reef substrate consists of small (generally up to 5-10 cm diameter) pieces of reef rock with an attached soft coral, colonial anemone or other benthic invertebrate. The organisms of value are the attached invertebrates, but the underlying reef substrate must be removed to minimize damage to the target species. Trade in reef substrate from all exporting countries was close to 1 million pieces in 1999. This is likely to increase in coming years, as Indonesia established an annual export quota of 950,000 pieces of reef substrate in 2001, and they represent one of several substrate exporting countries.

Potential environmental impacts of coral collection

There are over 650 zooxanthellate stony coral species found on tropical and subtropical reefs worldwide. Corals harvested for international trade constitute a fraction of the volume of corals that are mined for construction materials, but collection involves a much larger diversity of species and include taxa with a wide variation in morphology, size and life histories. Unsustainable coral harvest to supply international markets can contribute to changes in species composition and abundance, and may lead to severe localized depletions. Breakage of corals during collection causes generation of rubble that can cause further damage to surrounding corals through abrasion, and rubble may inhibit coral recruitment due to its unstable nature. In addition, coral collection may cause reductions of live coral cover and loss of rugosity, with cascading impacts on reef fish abundance and diversity, including species utilized in artisanal and export fisheries (Dulvy et al. 1995). While other factors (including coral mining) have resulted in much more significant losses of corals, extraction of corals for international trade may magnify the impacts of other natural and anthropogenic stressors, and possibly prevent recovery following unusual environmental disturbances. Some of the most common corals in demand for the curio trade are ornate, small-polyp (SPS) branching corals that grow rapidly (up to 20 cm per year), are widespread, and exhibit high rates of recruitment. Even though most branching corals targeted for curio collection in the Indo-Pacific are very

successful colonizers,they are susceptible to breakage by wave action. In addition, these species are often the preferred foods of corallivores such as *Acanthaster* sea stars and *Drupella* snails. Many shallow water reefs are dominated by species utilized as curios, and these experienced widespread coral mortality during a major bleaching event in 1998 (Wilkinson 2000). Furthermore, corals harvested for curio markets are typically sexually mature, and extensive collection may have negative impacts on reproduction. Because collection primarily involves large colonies, the removal of these corals may affect reef topography and available habitat for reef fishes and motile invertebrates. Nine of the ten most popular live aquarium corals have a massive growth form, large colorful polyps and prominent tentacles (LPS). Many of these are uncommon or patchily distributed, and may grow slowly (<1 cm per year), but colonies often achieve a large size and can persist for centuries. The live trade is dominated by colonies that are fairly small in size, and non-reproductive. Collection pressure that targets juvenile long-lived corals may lead to growth overfishing, which is of particular concern for LPS corals that recruit infrequently but have a low rate of natural mortality. In addition, many of these species occur in deep, turbid environments. If these areas are denuded of coral due to intense collection pressure, recruitment from other reefs may not occur if currents are unfavorable, resulting ultimately in a reef with low coral cover and diversity.

Corals living in shallow, exposed environments are often fractured or dislodged during storms, and some colonies may die as a result of disease, predation or other factors. Coral skeletons are rapidly colonized by algae and encrusting invertebrates and become incorporated into the reef substrate. This substrate is essential for the reef because it provides a site for future settlement and attachment of reef-building corals and other benthic organisms crucial for continued reef growth. It also provides important habitat for fish and motile invertebrates, and it contributes to the structure and total biomass of reefs. This material is collected and sold as live rock. Its removal results in the net loss of substrate that requires decades to centuries or longer to replace. In addition, many commensal (symbiotic), sessile organisms essential for the health of the reef are removed along with the rock (Maragos 1992). Intensive harvest of live rock from one location may lead to increased erosion and flooding of coastal areas. Reef degradation is of particular concern to low islands like Tonga that are most affected by rising sea level.

Benefits and justification for the coral fishery

Some stony corals represent a valuable renewable resource. Corals have been highly valued as raw material for construction and for ornamental uses since antiquity, with the first uses dating back to 25,000 B.C. (Grigg 1989). In addition to significant cultural and economic values, a sustainably managed coral fishery can serve as a tool to promote local coral reef conservation and increase worldwide awareness of the importance of reef ecosystems.

The coral fishery is currently difficult to manage in a sustainable manner due to conflicting destructive uses such as coral mining and blast fishing, increased non-extractive human impacts, and limited information on species in trade and the status of the resource. However, with proper management practices it is possible to sustainably harvest some species of curio and aquarium corals. Because many of the species targeted for curios are predominantly harvested from shallow water, deep-water populations may serve as a refugia and a source for replenishment for some of these species (Lovell 2001). In areas where space is limiting, removal of dominant, fast growing branching corals may increase coral diversity through creation of additional space and reduced competition (Ross 1984).

Existing management measures

In an attempt to protect coral reef resources, a number of countries have implemented severe restrictions on coral harvest. At one extreme, this involves a complete prohibition on collection, sale and export of coral, such as that implemented in the Philippines since the late 1970s in response to catastrophic losses of live coral from destructive fishing, overharvesting, and other impacts (Mulliken and Nash 1993). Mozambique temporarily closed their fishery to allow recovery following a severe bleaching event in 1998, with a reevaluation of the fishery slated for 2002. Commercial harvest of stony corals has also been prohibited in most federal, state and territorial waters in the United States due to their pivotal ecological role and importance as essential fish habitat.

Importing countries can also take broader measures to address unsustainable trade in wildlife listed under CITES. For instance, the European Union allows coral imports from most countries, but they have prohibited the import of particular species from Indonesia because they feel the export quotas do not reflect sustainable harvest based on the known distribution and abundance of those species.

Prohibitions on coral harvest may be appropriate for some locations, for certain vulnerable species, to protect ecosystem biodiversity or function, or to allow recovery following an unusual disturbance event. However, the closure of established coral fisheries based solely on political interests and not sound science may have severe negative implications for developing countries dependent on these resources. Closure may result in an increase in illegal commerce

in stony corals. In addition, individuals whose livelihood depends on revenue generated from the coral fishery may resort to more destructive practices, including blast fishing for subsistence or cyanide fishing to supply the live reef food fish trade.

Due to the high number of species and low population numbers of most reef species, a very precautionary approach to extractive use must be taken. The fishery could be managed through the development of policies which allow operation of the industry in a competitive environment, while promoting a sound emphasis on sustainability of the resource and other fisheries resources that are likely to be impacted (Lovell 2001). Effective management measures must be carefully considered to provide the best protection for the cost, and ensure that implementation of some practices will not create new ecological stress. Solutions to achieve sustainable management can be implemented through local management actions in concert with national and regional agreements and international policies. To ensure compliance by the coral fishers, management plans should be developed through consultation with all user groups. To ensure that coral resources and the habitats they come from are conserved and managed, different aspects must be considered.
The following recommendations were largely developed from discussions at the International Coral Trade Workshop (NMFS 2001), with examples of existing management approaches in Indonesia, Australia and the United States. I have also included my own recommendations based upon independent coral reef studies, discussions with other scientists, and best management practices from other coral reef fisheries. Recommendations include:

- Provisions for licensing, training and certifying fishers; limiting entry into the fishery; and specifications for reporting, compiling and analyzing fishery data.
- Setting limits on the volume, size and taxa of corals collected.
- Establishment of defined collection sites for individual collectors and cooperatives and no-take areas that include the same type of habitats utilized by collectors.
- Rotation of collection sites and introduction of closed seasons or periods.
- Use of acceptable gear and collection methods.
- Assessments and monitoring of collection sites and control sites to evaluate the status of the resource and harvest impacts.
- Responsibilities and requirements of collectors, middlemen, and exporters.
- Sustainable financing schemes to ensure sufficient funds are recovered from license, collection and export fees to pay for effective management and monitoring.

Key considerations for sustainable management

A sustainable management approach for the coral fishery requires that 1) the resource is harvested in such a way that it is protected from overexploitation; 2) collection is ecologically sustainable; 3) damage to associated species is minimal; and 4) the structure and function of the reefs are not altered. Of critical importance, collectors must preserve the ecological integrity of reefs when removing coral, not simply the physical reef structure (Dustan 1999). Once the upper ecological and sustainable limits of removal are determined from sound science and monitoring, the allocations, rights and responsibilities of collectors and exporters should be addressed. Effective management will maximize social and economic benefits, within these ecological limits, to promote equitable sharing of benefits arising from utilization of the resources.

An ecosystem-based management approach that promotes conservation and sustainable use is the most effective strategy for integrated management of marine environments and the living resources within those environments. Management is based on the application of scientific methods that focus on the structure, processes, functions and interactions among organisms and their environment, and the role that humans play in these processes. Unlike traditional, single species fisheries management that strives to maximize yields of a target species, this approach seeks to minimize impacts to the ecosystem while maintaining ecological sustainability, and thus ensuring economic sustainability. Consideration must be given to the harvested species and all uses and impacts that may affect those species, as well as the effect that collection has on associated species, habitat structure and habitat quality.

Unfortunately, much of the information needed to make appropriate decisions for effective management of a coral fishery at an ecosystem level is currently unavailable. Monitoring of coral collection sites is virtually non-existent, and baseline assessments have been completed in few sites. Many of the preferred target species for aquaria may be locally abundant but patchily distributed. Also, the favored habitat for these species is deep, turbid water (10-40 m depth), further complicating the ability to obtain distributional data. In addition to the absence of detailed information on the population dynamics and habitat requirements, we have an incomplete understanding of the biology of these species or their ability to recover from collection or other impacts. Due to these limitations, it is critical that managers adopt a precautionary approach until additional information, especially from quarterly take figures and regular monitoring, is available to support increased sustainable take.

Methods to regulate the coral fishery

To achieve a sustainable fishery, regulations should be adopted for all levels of the fishery, including: 1) defined activities that can occur in the collection areas to ensure sustainable harvest; 2) activities that can be carried out by the commercial fisher; and 3) requirements that will affect the person who buys the coral from the fisher. Management approaches may vary among countries, depending on existing local and national regulations. For instance, marine tenure arrangements in Fiji, Solomon Islands, Vanuatu and Tonga recognize community ownership of marine resources. These communities may have the ability to prevent non-community participation in the fishery, and also may be able to impose agreed standards or protocols on community members involved in the fishery. In addition to local and national requirements, regulations must meet international standards of CITES mandated by the Appendix II listing of stony corals. Without addressing all components of the fishery, managers will not be able to provide adequate protection for the corals, associated species and habitats, or ensure maximum long-term benefits for the community.

Balancing ecosystem needs with community objectives

Effective habitat management is a critical tool for a sustainable stony coral fishery, with protective measures established for coral reefs and associated habitats — sea grass beds, mangrove communities, lagoonal habitats, and deep water soft-bottom communities utilized by certain high value coral species such as *Trachyphyllia*, *Catalaphyllia* and *Nemenzophyllia*. An effective tool utilized in Australia and other countries involves the zoning of benthic environments for specific uses. Zoning measures include ecological areas or reserves where no collection is allowed, buffer zones around these no-take marine protected areas (MPAs), and areas where specific activities can be undertaken. Coral collection sites should be separate from areas subject to other uses such as fishing and recreational diving to reduce conflicts among different users. Zoning can also minimize risk associated with other stresses by spatially separating collection sites. The establishment of defined collection and no-take sites also allows managers and scientists to focus their monitoring and research to specific areas, and to compare collection sites with areas that are undisturbed by extractive uses. To increase capacity for compliance and enforcement, it is important to establish zones for specific uses through consultation with all user groups.

Introduction of spatial and temporal closures

Sites closed to collection (no-take MPAs), rotation of collection sites, and short-term closures can be useful tools to promote effective management of stony coral fisheries. These measures may help prevent overexploitation, allow recovery from over-use, and protect the stock at a vulnerable time in its life history or from an unusual perturbation.

No-take reserves provide numerous benefits for coral reef ecosystems. For instance, they maintain biodiversity and provide a refuge for vulnerable species, prevent habitat damage, facilitate recovery from catastrophic human and natural disturbances, and provide undisturbed spawning grounds for fishery species. Reserves help maintain adult breeding populations of fished species by allowing individuals to live longer, grow larger and produce more offspring. As the number, density and biomass of individuals within a reserve increases, spillover into adjacent fishing grounds will occur through emigration and larval dispersal, thereby assisting in rebuilding depleted stocks and reestablishing a natural ecosystem balance (Bohnsack et al. in press). The degree to which reserves are likely to enhance recruitment to fishing grounds is equivalent to the fraction of the total biomass of a population which they contain (Roberts and Hawkins 2000).

The extent of recruitment from no-take reserves to collection sites is dependent on 1) the size of the reserve; 2) how close they are to collection sites; 3) population dynamics, density and life history of target coral populations within the reserve; and 4) ability of recruits to disperse to surrounding collection sites. For most commercially important reef fish, fishery biologists recommended setting aside a minimum of 20-30% of representative coral reefs and associated habitats as no-take reserves (Bohnsack et al. in press). For stony corals, no-take reserves should encompass a much larger area, however, due to their unique life histories, their sessile nature, and a high demand for rare or uncommon species and juvenile life stages. First, many of the LPS corals are long-lived, slow growing and recruit sporadically, and these will take longer to become reestablished following collection. Second, corals are permanently fixed to the bottom and successful spawning relies on high population densities. Individuals need to be sufficiently close that eggs and sperm can fuse before the sperm lose their short-lived motility. In fished areas, many species of corals, especially those that are uncommon, are likely to be much further apart than in reserves. Thus, a small portion of the population biomass that is densely packed within a reserve can account for a large proportion of the species' reproduction, and the ability to provide recruits that colonize sites open to collection. Most species targeted for aquaria are removed before they reach the size of sexual maturity, which may lead to very little reproduction within collection sites. As a precautionary approach, at minimum 50% of all representative habitats should be set aside as no-take areas to ensure protection for a sufficient

portion of the total stock that may contribute to the re-colonization in fished areas (Barbara Best pers. communication). The concept of "rotation of collection sites" must be carefully examined scientifically and experimentally to determine whether rotation is compatible with sustainable management. Rotation of collection sites can reduce pressure on a particular area, minimize habitat damage, and allow a greater number of corals to mature and reproduce before being removed from the population. However, if collection in one area is truly sustainable for the long-term, that area should continue to provide the target species at the established level indefinitely without the need for rotation.

- If a collection site must be rotated so that it can "recover" from overexploitation or degradation due to collection, collection has exceeded sustainable take and the role of collected species in the ecosystem has been diminished.
- Cycling collection areas between periods of exploitation and recovery may disrupt natural succession processes. In particular, rotation may favor those species which are more opportunistic colonizers (i.e. species that take advantage of reef patches opened up by collection) or "weedy" species which are more rapid growers.
- The concept of rotation may undermine marine tenure rights and responsibilities. Rights-based fisheries, along with concomitant responsibilities, is the best motivator for an individual or cooperative to strive for sustainable management and long-term use of a resource. If individuals or coops are allowed to rotate out of an area into a new area, that motivation is lost. Particularly over a short time-frame, an area may be overexploited and the collectors will be allowed to move on without any consequences nor responsibility for their actions.

Resource managers must also consider collection pressure and other impacts that affect coral resources when establishing collection sites and limits on collection within these sites. Temporary closures of collection sites before, during, or shortly after annual mass spawning events may enhance recruitment success. Managers should also have the authority to temporarily close a site zoned for collection in response to natural or anthropogenic disturbances that affects the harvested resource. For instance, collectors should avoid areas that have been impacted by a bleaching event, a crown-of-thorns (*Acanthaster*) sea star outbreak, or disease epizootic to allow recovery of that area. Collectors may also need to restrict collection activities during unusual environmental events, such as an El Niño (ENSO) event that is associated with unusually high sea water temperatures, as coral health may be compromised and corals are unable to survive additional stresses associated with collection and handling. Such closures may last for years, with associated displacement of a community's fishery.

Coral fishery participants

In many countries, the number of people participating in the coral fishery are not identified, licensed or limited in any way. Licensing of collectors is paramount and should include a limitation on the number of fishery participants and the amount of coral that can be collected by each fisher. The number of people that the coral fishery can support is also dependent on socio-economic and cultural requirements of the collectors and dependent communities.

The ideal situation for a stony coral fishery is one that allows only one collector or a cooperative in each area that is zoned for collection. This rights/responsibility-base approach offers the greatest incentive for sustainable use, as individual collectors would be responsible for maintaining his or her collection site.

For each new entry into the fishery, management agencies must develop and provide detailed information to fishers on the regulations for harvesting corals, including:

- Maps illustrating demarcated areas for coral collection and areas closed to harvesting.
- A list of approved species that can be collected from each collection site. If a species is not on the approved list for management and monitoring, it can not be collected.
- Size limits and quotas for each approved taxon in that site.
- Techniques to minimize injury and mortality of target corals during collection.
- Detailed reporting requirements of fishers.
- Safety standards for divers and reporting on diver health.

Guidance for determining sustainable harvest level

The amount of coral that can be removed from a site must be based on the carrying capacity of the ecosystem, while the decision to establish collection sites and the allocation of those sites depends upon the social objectives of the community. Given current limitations, allowable levels of take should be precautionary until scientific data becomes available that supports increased sustainable collection. A precautionary approach may include a "freezing" harvest levels at some average value of export for the last several years while monitoring programs are developed. An estimate of sustainable yield requires an examination of each collection area, the taxa targeted in the area, and available life-history information on those taxa (Table 2). The development of a database that compiles research and field monitoring data, and fishery dependent statistics such as catch, effort and location, will facilitate this process.

Table 1. Consequences of unsustainable coral and live rock collection practices

Impact	Description
Effect on target population	Overexploitation, localized extinctions, and reduced recruitment.
Habitat impacts	Reduced coral cover, diversity and rugosity.
	Loss or destruction of habitat and decreased abundance, biomass and diversity of reef fish, invertebrates and other species.
Ecosystem impacts	Increased erosion of the reef structure, associated islands and coastal environments, with increased flooding during storm surges.
Socioeconomic impacts	Conflicts with other uses and user groups, including traditional and cultural uses, fishing and tourism.

Development of species-based quotas

An approach often used to regulate wildlife trade involves a quota system that defines the maximum amount of collection or maximum export level. In some cases, these quotas primarily reflect the demand for a species, and are based only to a limited extent on the status of the resource or its sustainable yield. Quotas should reflect the amount of sustainable harvest and not the amount of trade, with a separate quota developed for each site based on the abundance and condition of each coral species, and the ecological sustainability of that site. Other considerations include 1) the size classes within the target population, and the size classes being considered for harvesting; 2) the size of the collection site, which should be small enough for reliable monitoring and management; and 3) the presence and condition of neighboring, no-collection areas that may serve as a source for larval replenishment and as control sites for monitoring. Because of the multi-species nature of the coral fishery, setting of non-specific quotas may increase conservation problems as fishers are likely to concentrate on the high priced species, which are typically less common and more likely to be overexploited. A separate quota must be developed for each species, determined from the coral's growth rate, rate of instantaneous mortality, recruitment success, and other life history parameters (Grigg 1984). Finally, species that are inappropriate for the trade, or for which there is no baseline assessment and no monitoring protocol and data, should have a quota of zero. Inappropriate species 1) are rare or endangered in the proposed country or region of collection; 2) have an important ecological role or provide habitat for other species; and 3) are difficult to maintain in captivity.

Table 2. Preliminary assessment for development of a sustainable stony coral fishery

Information needs	**Management Considerations**
Type of coral utilized by the fishery	Target species, growth form and size.
Life history of target species	Growth rates, rate of natural mortality, recruitment rates, size class at maturity.
Collection sites and no-take replenishment sites	Nature and size of habitat suitable for coral growth; size, depth and zone of collection area and size and condition of adjacent replenishment areas; historical and current uses and existing natural and anthropogenic threats.
Existing protection	A review of existing laws and regulations to conserve coral resources and ecosystems.
Environmental Impact Statement	Assessment of potential collection sites prior to opening them to collection to provide initial baseline information of the standing crop (population size and density), and existing threats, impacts and uses.

Table 3. Provisions for sustainable management of the stony coral fishery in Australia. Adapted from AFCFWG (1999).

Regulation	**Description**
Type of harvest	Commercial harvest only; no recreational harvest. Dominant taxa: *Pocillopora*, *Acropora* and *Fungia* primarily for curios, with recent increases in other taxa and live rock to supply domestic aquaria; 45-60 metric tons harvested each year from 1994-1997. Total allowable catch exceeds actual harvest by 60-88% each year; harvest is 1-2% of the standing stock.
Collection areas	50 authorized Acoral areas@ each with 200-500 meters of reef front to a depth of 6 m; average size of each coral area is 25,000 m^2.
Quota	Total allowable catch (TAC) of 4 metric tons of coral per year for each lease area with no distinction in amount of harvest for individual species.
Participants	14 collectors in 1983; 27-55 fishers with authority to harvest coral from 1990-1998. Not all areas are targeted for collection each year and not all fishers are active; each participant may acquire collection rights in up to 5 areas.

Table 4. Application of a fishery population dynamics model to the shallow water reef building coral *Pocillopora verrucosa* to determine sustainable yield.

Data requirements	Measures of distribution and abundance, growth data (weight/size increase per unit time), rate of instantaneous mortality, recruitment rates and age at reproductive maturity. Mortality and recruitment are determined by analysis of age frequency distribution of a portion of an unfished population.
Principle to maximize yield	Harvest must not occur until the colony reaches a specific size (age). Maximum production occurs at the point where losses due to natural mortality overtake gains from growth.
Assumptions	For simplicity, the model assumes a steady state - the yield of a single cohort over its lifespan is equal to the yield of all age classes present in a single year. Variations in annual recruitment rates can be incorporated by introducing year specific estimates of certain population parameters.
Application	Not appropriate for the live trade, as colonies are often collected before they reach reproductive maturity and some species are collected as fragments of whole colonies.

A quota system was first introduced in Australia in 1991, with a total allowable take established for each area zoned for collection (AFCFWG 1999). Coral areas are located in shallow environments (<6 m) dominated by *Acropora* or *Pocillopora*. Quotas were established when almost all harvested coral consisted of branching species for curios. The current management arrangement appears to be ecologically sustainable for the established species, although more comprehensive monitoring is planned (Table 3). Collected coral is only for domestic use, as Australia does not allow coral to be exported.

However, due to an increased demand for live aquarium species in Australia, a number of issues have emerged regarding measuring the coral and monitoring commercial quotas. First, the current quota is based on a total allowable weight that can be removed on an annual basis, with no distinction among individual species. This approach will not be effective for live corals, as they are sold as individual pieces. Second, the aquarium trade involves collection of many diverse taxa that often occur in areas deeper than those authorized for collection, and are found at a much lower density.

Indonesia currently allows export of live coral, live rock and reef substrate, with no export of coral skeletons or manufactured items. The proposed management plan includes the following provisions:

- Annual quota is assigned to the Indonesian Coral, Shell, and Fish Association (AKKII) whose members are the only people in Indonesia authorized to export coral. Quota for 2001 is 950,000 live corals, with separate quotas for each species divided among 10 provinces. Maximum size limit of 15 cm for slow-growing corals and 25 cm for fast growing taxa. An export of 450 metric tons of live rock and 950,000 pieces of reef substrate is also allowed.
- Annual quota is based on reef accretion rates (assumed to be 10-15 mm/year); coral growth rates (linear skeletal extension rates of 2.5-30 cm/year); condition of monitoring sites [421 stations from 43 locations assessed as being in excellent condition (6%), good condition (24%), fair condition (24%) and poor condition (40%)]; and estimates of total reef area in the country (85,700 Km^2). Using these figures, it is assumed that a quota of 1 million corals is 0.00035% of the total reef area in good to excellent condition.
- Fishers are not nationally licensed or regulated, but permits to utilize corals may be given to Indonesian citizens living in the district surrounding the harvest area.
- Collection is only supposed to occur in sites that are in good to excellent condition and where population assessments and monitoring are undertaken. However, collection sites are not defined, but must be outside conservation areas and marine tourism sites. Collection is only allowed in 10 provinces.
- Corals will be harvested in harvest rotation systems.

Several concerns have been expressed regarding the management of the fishery in Indonesia, and the calculation of the annual and species quotas. Species quotas do not appear to be based on the population dynamics or life history of the species, as some of the highest quotas are issued for rare species, while common species are traded at lower levels (Bentley 1998). Also, collection occurs in marginal reef environments and non-coral reef environments which is contrary to assumptions used to develop the quota, and assessments or monitoring of collection sites have not been completed, with the exception of a few recent surveys (Bruckner 2001b).

In the U.S., and throughout most of the Caribbean, coral collection is prohibited as it is considered essential fish habitat and essential reef components. The U.S. does allow a limited harvest of black coral in state waters of Hawaii, and selective harvest of precious corals in federal waters off Hawaii. The amount of harvest was determined from a mathematical model based on the classic fisheries population dynamics model of Beverton and Holt, and uses data on population dynamics obtained from the collection sites and known information on species biology (Grigg 1984; Table 4). The black coral fishery appears to have been sustainable over a 23 year period.

Collection guidelines

A coral fishery will benefit from the establishment of specific collection guidelines that minimize habitat impacts and maximize survivorship of targeted species. A code of practice should be established by the industry in partnership with local governments and environmental groups and must include training in appropriate collection, handling and diver safety techniques. One method to encourage voluntary compliance is to train and certify fishers in the use of national and international standards of best practice, such as those being implemented by the Marine Aquarium Council (MAC).

Monitoring approaches

Monitoring of collection sites and comparable control (no-take) areas is critical, as it will provide important data on the abundance and population dynamics of the species and impacts associated with collection. Monitoring data provides managers with the ability to make sound management decisions and appropriate adjustments in response to changes in species abundance, ecosystem characteristics, or overexploitation. The monitoring protocol should be a practical and rapid technique that can be used by scientists and resource managers with minimal training, and is easily repeatable by any individual with expertise in corals. Monitoring should be conducted with sufficient frequency to properly evaluate the impact of the trade and detect changes in the abundance or condition of taxa of interest, but not so frequently that it is inefficient, too costly or destructive. One recommendation is that monitoring should be conducted regularly over a period of two years, with a reassessment of existing management approaches after that time (Lovell 2001). A two-year period will allow interpretation of the population dynamics of the target species and natural variability in abundance, obvious damage associated with collection or other impacts, and extent of recruitment of harvested taxa.

The monitoring program should be specific enough to determine the composition, abundance and population dynamics for each taxon in trade. Because of the high diversity of scleractinian corals found on Indo-Pacific reefs, and considerable expertise required to properly identify these to species, monitoring should focus at minimum on identification of coral genera, except for monospecific taxa, readily identifiable species, and species that are particularly rare or vulnerable to overexploitation. If the species can not be monitored, it should not be approved for collection.

Determination of the baseline abundance of target stocks can be achieved through implementation of a variety of monitoring approaches at a range of scales. At the largest scale, countries need to determine the total area of reefs within territorial waters and the amount of that reef that will be open for harvest and other uses. Satellite and aerial remote sensing offers a quick and powerful tool for calculating such parameters and for development of maps that show the boundaries of collection sites and the total area open for collection. At a local scale, on the short-to-medium time frame, stock assessment teams or individuals need to accompany collectors to determine the extent (patch size and frequency) of habitats being exploited for target species. Suitable methodologies include manta tows and timed swims for covering large areas and where the target species is abundant, transect approaches to obtain quantitative data on population dynamics, and free search methods to identify the presence and abundance of rare species. Since the goals are accurate density estimates and size frequency distribution data, the distribution and natural abundance of the species of interest will help determine which methods are most appropriate.

The monitoring protocol should be detailed enough to:

- Determine the status of the resource.
- Assess changes in biodiversity, standing stock, mortality, recruitment, and condition to the resource, including collection impacts and other factors contributing to coral decline/loss.
- Establish an initial quota and provide information needed to adjust the quota if a particular taxon becomes rare or overexploited.
- Assess, quantitatively, whether a management response is warranted due to changes in the quarterly audits submitted by collectors.

Responsibility of importing countries and consumers

The development of a sustainable management approach is primarily the responsibility of the exporting country, but it will require assistance from importing countries, the industry and hobbyists. Hobbyists should only purchase corals that exhibit a high survivability in captivity, with a level of required care and handling that matches the expertise of the hobbyist; beginners should purchase animals that are the least challenging to maintain. Avoid purchasing corals known to be rare or with life history characteristics that make them vulnerable to overexploitation, and species whose collection is detrimental to the health of coral reef ecosystems. Ideally, consumers should choose branching species that grow fast and can be propagated by fragmentation, or corals from environmentally-sound mariculture farms. Hobbyists, retailers and suppliers should pay attention to emerging environmental issues that may affect reef health, such as a bleaching event, and avoid purchasing affected corals from the countries impacted by severe global or regional threats. When selecting appropriate corals, ask local retailers questions on the source of their coral and whether the coral was collected in a sustainable, environmentally friendly manner or from mariculture. One assurance for a quality product may be achieved through the support of eco-labeling programs like that established by MAC. Importing countries have a responsibility as well to ensure that coral reef species were taken from areas under sustainable management and were not taken with the use of destructive practices.

Table 5. Recommended coral collection guidelines for live coral and curio coral.

Parameter	Collection guidelines
Type of coral	Species with a high local abundance, fast growth and high rates of recruitment. Focus efforts on branching species. Only collect slow-growing genera (massive corals) from areas where their ability to grow into adult colonies is prevented, or from areas where fast growing corals are overgrowing them. Only remove the number and type of species that are requested by the middleman or exporter.
Size limit	Maximum size is dependent on the biology of the species and its use; for live coral the minimum and maximum size also reflects survivability during handling and transport. Indonesia has established a maximum diameter of 15 cm from slow-growing taxa (e.g., massive corals and solitary or free-living corals) and 25 cm for fast-growing corals (e.g., branching corals) (Suharsono, 1999). Lovell (2001) recommended a maximum size of 45 cm for curio coral (*Acropora* and *Pocillopora*). MAC core standards recommend collection of corals in small size classes, with show-piece corals consisting of no more than 1% of total exports by weight.
Unit of collection	Remove whole colonies only, unless fragments can be removed from larger colonies without impact to parent colony or reef. When fragmenting a branching colony, only a small percentage should be removed, with no addition collection from the parent colony until healing or re-growth from previous collection has occurred.
Maximum harvest quota	Maximum amount of collection developed for each species within individual collection sites, based on its biology and abundance, with consideration of the desired size and reproductive status. A zero quota for rare species, ecologically important species, species for which no baseline and no monitoring data is kept and sustainability is not ensured, and species difficult to keep in captivity.
Location of collection	1) Target areas with dense coral growth, removing species that may die due to competition with or shading by neighboring corals; 2) no collection of isolated corals greater than 0.5 meters away from any other live coral; there is little chance of the coral being overgrown, and it is likely to reach maturity; 3) avoid reef crest environments, as aquarists cannot duplicate necessary environments, such as wave energy, and excessive mortality may occur; 4) select sites that are at a minimum distance from the holding facility or export facility to avoid long transport and unnecessary stress. Vaughan and Lovell (in press) recommend that collection is prohibited in areas with less than 30% live cover.
Amount of collection in each collection site	Remove corals in a selective manner, spreading out harvest over largest area possible, but within defined collection sites; ensure that a limited number of corals of each species are collected from the site, such that adult colonies remain and may provide a source for replenishment.
Depth of collection	Follow safe diving practices, and limit collection to depths less than 20 m. Due to monitoring limitations and lack of baseline data for deeper environments, limit collection in deep water as a precautionary measure and for diver safety.
Duration of collection	Collect coral from one site for no more than 2 years, with a rotation of sites to allow recovery of the resource. Enforce periodic closure, especially following an unusual disturbance or environmental event.
Method of removal	Only use tools that remove appropriate coral species with minimal injury to the target coral, surrounding corals and the reef structure. Collectors should use fins when collecting, as this causes less damage than walking on the reef.
Injury or breakage of non-target corals	Place corals and other reef organisms that are inadvertently broken or dislodged during collection near the point of breakage, positioned carefully within the reef framework to stabilize the colony, with live polyps facing upward.
Handling	Minimize handling; avoid touching live polyps; maintain corals in clean sea water of ambient temperature with frequent water changes; avoid placing separate corals in direct contact, preferably one specimen per bag; minimize exposure to sunlight and air; transfer to holding facility as soon as possible.
Reporting	Collectors should maintain a logbook that shows the numbers, types and sizes of coral collected. For each coral this should include the location, habitat and depth of collection. Also record routine information for the collection site, including evidence of bleaching, disease and physical damage. Management authorities should require an audit and submission of logbooks on a quarterly basis.

Table 6. Summary of key points to include in a management plan for the stony coral fishery.

Background information	1) Data on the coral collection site and coral resources within that site, including the history of exploitation, a summary of preexisting threats and existing management measures; and 2) information on the target species and proposed use.
Provisions to assess and monitor collection sites	1)Determine the total area of coral reef habitat and the abundance and cover of the targeted coral taxa within the proposed collection area before harvesting begins (for a new entry); 2) assess the current condition of the resource (for preexisting collection sites); 3)monitor the population dynamics of the target species and impacts of coral collection; and 4) use monitoring information to develop and modify established quotas as appropriate to continue sustainable harvest.
Zoning of coral reefs and associated habitats	Separate coral reef uses through zoning. Include: 1) areas off limit to collection; 2) defined areas for other extractive and non-extractive uses; and 2)defined collection sites with a rotational harvest that spreads out collection over a large area and minimizes the duration of collection in any given site.
Spatial and temporal closures	Establish no-take areas that include a substantial portion of all representative habitats and high densities of reproductively-mature target species. Include provisions for temporary closures during key periods in the life history or during unusual environmental events.
Harvest quota	An annual quota for each species allowed in trade developed for each collection site from 1) the life history strategies of the coral; 2) its distribution and abundance and resilience based upon ecological requirements or specialization and susceptibility to threats; 3) its suitability for the trade; and 4) its status within the collection site. A list of species that can not be collected.
Collector obligations	Licensing and training for all collectors, and a system of fees to cover monitoring costs. Training should cover fishery legislation, management guidelines, size and species that can be collected, collection and handling techniques, and reporting requirements. Logbooks that provide information on the location, amount and type of collection should be submitted quarterly. Licenses should be revoked for failure to comply.
Collection guidelines	Specific non-destructive harvest guidelines that illustrate where and how to remove the coral to minimize impacts, proper handling and transport techniques, and training in these techniques.
Export requirements	Exporters should submit weekly, detailed information on the number and size of each species exported and the source of this coral.
Methods to minimize impacts	A management plan should include recommendations for reef enhancement in collection areas and a restoration plan for resource recovery in degraded areas.

Conclusion

There are many basic constraints to establishing a sustainable coral fishery, especially to address live corals collected for home aquaria, offices and restaurants. Constraints include a lack of understanding of reef processes, interdependent relationships among associated species, and regional and local connectivity among reefs and habitats. Data requirements for successful management rely on an understanding of the biology, life history and habitat requirements of each species, and the population dynamics of those species within each collection site. The stony coral fishery is supported by a large diversity of corals that are collected at different sizes and in varying quantities depending on their use, value and demand. Environmental impacts associated with collection are difficult to measure on the short-term, due to natural variation in coral reefs, limited knowledge of local retention of coral larvae, and the inability of a heavily utilized species to recolonize. Much more needs to be learned about the resource and its dynamics, including reproduction of target species, recruitment and subsequent growth rates. Because this type of information may be prohibitively expensive to obtain, resource managers must adopt a precautionary approach and progressively work towards achieving a more thorough understanding of the resource and its sustainable yield. This can be accomplished through expanded research on the species distribution, abundance and life history, implementation of monitoring programs in collection and control areas, establishment of extensive no-take areas, and quarterly reports from the collectors on effort and amount of take per species.

A sustainable coral fishery can be measured by long-term stability of targeted species, protection of coral reef habitat, avoidance of detrimental cascading ecosystem impacts. A sustainable fishery will ensure social and economic security for communities dependent on the resources. One clear indication of sustainability is the ability of collectors to continue collecting corals at the same level within existing, permanent collection areas. The development of a sustainable stony coral fishery requires financial and technical support of industry and governments in exporting and importing countries to develop appropriate management measures, commitment of local fishers to protect the resource, and demand by the hobbyist and suppliers for sustainably and environmentally-friendly harvested stony corals.

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Appendix I: Workshop Agenda

April 9, 2001, MONDAY:

8:00am Registration

8:20-8:35 Welcome, introductions, workshop overview
Roberta ChewDOS, Bureau of Oceans, Environment and Science
Ir. Yuni Yarman, Chairman, AKKII

8:35-8:40 Opening remark by the Director General of Forest Protection and Nature Conservation, Government of Indonesia, ***Mr. Ir Wahyudi Wardojo***

8:40-9:00 Keynote speech by the Minister of Marine Affairs and Fisheries, Government of Indonesia
Honorable ***Sarwono Kusumaatmadja***

9:00-9:15 Coffee and snacks

Session I. Coral trade: overview, concerns, international requirements and alternatives
Facilitator: Andy Bruckner

9:20-9:35 National policy of sustainable coral reef utilization in Indonesia
Dr. Rokhmin Dahuri, Director General of Coastal, Beaches and Small Island Affairs

9:35-9:55 Background on coral trade: commodities in trade and trends
Dr. Andrew Bruckner, NOAA/NMFS, USA

9:55-10:10 Environmental concerns associated with the stony coral trade
Dr. Edmund Green, UNEPs WCMC, UK

10:10-10:25 Management and enforcement of coral imports into the U.S.
John Field, US Fish and Wildlife Service, CITES Scientific Authority

10:25-10:40 CITES regulations; permit process; making a non-detriment finding; coral reporting procedures ***Dr. Vin Fleming,*** CITES Scientific Authority, EU

10:45-11:15 EU trade restrictions on stony corals from Indonesia; background, EU concerns, taxa of stony corals involved ***Caroline Raymakers,*** TRAFFIC Europe

11:15-11:30 Certification of marine ornamentals
Dr. Paul Holthus, Executive Director, Marine Aquarium Council (MAC), USA

11:30-11:50 Community-based Coral Reef Rehabilitation Program in the Philippines
Joey Gatus, IMA Philippines

11:50-12:10 Coral mariculture in Indonesia
Ir. Yuni Yarman & ***Prof. Dr. Dedi Sudharma***

12:10-1:10 Lunch

Session IIa. Status of the trade in stony corals and current management regimes
Facilitator: Roberta Chew

1:10 Introductory overview:
Roberta Chew, DOS, Bureau of Oceans, Environment and Science

1:15-1:40 **Fiji**
Ed Lovell, Biological Consultants, Fiji;

1:40-2:00 **Vietnam**
Dr. Vo Si Tuan, Institute of Oceanography and
Prof. ***Dr. Nguyen Chu Hoi,*** Haiphong Institute of Oceanology

2:00-2:15 **Solomon Islands**
Moses Biliki , CITES Management Authority
Peter Ramohia, Ministry of Fisheries and Marine Resources

2:15-2:30 **Vanuatu**
William Naviti, Ministry of Agriculture, Forestry and Fisheries
Trinison Tari, CITES Management Authority

2:30-2:45 **Tonga**
Anitimoni Petelo, Ministry of Fisheries

2:45-3:00 Coffee

Session IIb. Status of the trade in stony corals, current management regimes and options for sustainability Facilitator: John Field

3:00-4:05 **Indonesia**
a) Management measures and CITES trade controls for the stony coral trade
Mr. ***Ir Wahyudi Wardojo***, Director General of Forest Protection and Nature Conservation
b) Overview of Indonesian Coral Trade: importance to coastal communities, health and safety issues, user conflicts and illegal trade concerns
Arief Wicaksono, Director, IMA and ***Imran Amin***, Telapak
c) Sustainable harvest of stony corals: quota establishment, methods of coral collection and status of corals in trade ***Dr. Suharsono,*** CITES Scientific Authority, LIPI

4:10-4:40 The status of the ornamental coral trade in **Australia:** collectors, collection areas and management strategies for coral resources in Queensland
Sian Breen, Queensland Fisheries Service; ***Randall Owens***, Great Barrier Reef Marine Park Authority

4:40-4:55 Linkages between the MAC Draft certification scheme, international requirements and existing and new management measures ***David Vosseler,*** MAC, USA

April 10, 2001, TUESDAY

Session IIb. Status of the trade in stony corals, current management regimes and options for sustainability. Facilitator: John Field

4:55-5:30 Discussion and questions: Government oversight, EU trade restrictions, CITES responsibilities, 3rd Party certification

6:30 PM Evening reception. Appetizers, cocktails and dinner. Sponsored by NOAA and AKKII

Session III. Development of guidelines for best harvest practices, a sustainable management approach, and techniques to monitor coral resources. Facilitator: John Field

8:45-9:05 Factors to be considered in the sustainable management of corals
Dr. ***Vicki Harriott***, CRC Reef Research Centre, James Cook Univ (Australia)

9:05-9:20 Factors to include in best practices for coral collection
Ferdinand Cruz, IMA (Philippines)

9:20-9:35 Factors to consider in a monitoring protocol for the coral trade (overview)
Dr. Gregor Hodgson ReefCheck (USA)

9:35-10:00 Discussion

10:00 Coffee

10:15-10:30 Linkages between the MAC Draft certification scheme, international requirements and existing and new management measures ***David Vosseler,*** MAC, USA

10:30-10:45 Introductions; assignment to individual groups. ***Roberta Chew*** DOS, Bureau of Oceans

10:45-12:00 Coral trade working groups begin their discussion
a) management regimes for coral extraction, Facilitator: ***Sian Breen/ Randall Owens***
b) coral collection guidelines, Facilitator: ***Ferdinand Cruz/ Eric Borneman***
c) monitoring of coral resources, Facilitator: ***Gregor Hodgson/ Vicki Harriott***

Session IIIa. Coral identification

10:00-11:30 Coral identification and use of the NOAA coral identification manual. Session for quarantine officers and wildlife inspectors *Andrew Bruckner*, NMFS

12:00-1:00 Lunch

1:00-6:00 **Field trip** to coral collection facilities in Jakarta: **CV Dinar and Golden Marindo**
a) Workshop participants examine coral transport, handling and quarantine, and export procedures ***Wesen Wirawam***, AKKII, Indonesia
b) Group 2 participants receive training in coral identification
Ed Lovell, Fiji; ***Eric Borneman***, USA; ***Andy Bruckner***, USA

April 11, 2001, WEDNESDAY

8:30-10:00 Coral trade working groups reconvene

10:00-10:15 Coffee break

10:15-12:00 working groups continue

12:00-1:00 Lunch

1:00-3:00 working groups continue

3:00-3:15 coffee

3:15-4:45 working groups continue

4:45-5:00 Summary of management WG progress
Sian Breen Queensland Fisheries, and ***Randall Owens,*** GBRMPA, Australia

5:05-5:20 Summary of monitoring WG progress
Dr. Gregor Hodgson ReefCheck, USA

5:25-5:40 Summary of collection guidelines WG progress
Ferdinand Cruz IMA, Philippines

5:40-6:00 Questions and discussion

6:00 Dinner

7:30 PM Informal discussion on the EU trade suspension.
Indonesia (***Dr. Rokhmin Dahuri*** and ***Dr. Ir. Alex Retraubun***, Ministry of Marine Affairs and Fisheries; ***Dr. Samedi***, CITES Management Authority; ***Dr. Suharsono***, CITES Scientific Authority, plus AKKII, WWF, IMA and Telapak),
EU (***Caroline Raymakers***, TRAFFIC Europe; *Vin Fleming*, CITES SA, UK)
US (***Andrew Bruckner***, NOAA, *Roberta Chew*, DOS, ***John Field***, USFWS)

April 12, 2001, THURSDAY

8:30-3:00 Working groups draft preferred alternatives for a management approach, harvest guidelines and monitoring protocol

3:00-4:00 Summary of recommendations for managing coral resources
Sian Breen/ Randall Owens, Australia

4:00-4:45 Summary of recommendations for coral collection ***Eric Borneman***, USA

4:50-5:10 Summary of protocol for monitoring trade-related impacts, ***Dr. Gregor Hodgson,*** USA

5:10-5:30 Discussion and Conclusions

5:30-5:45 Closing remarks

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