Marine Ornamental Animals
Collection, Culture and Conservation

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Eventhough the coral reefs cover less than 0.25% of the marine environment, they constitute the most biologically rich and productive system on earth and are often described as 'coral paradise' and 'rain forest of the seas'. Coral reefs support over 4,000 species of fish, about 800 species of reef building corals and a great number of other invertebrates and sponges. It is estimated that coral reefs provide supplies of materials and services worth about 375 billion US dollars each year. The ornamental animals are the highest value-added products that can be harvested from a coral reef.

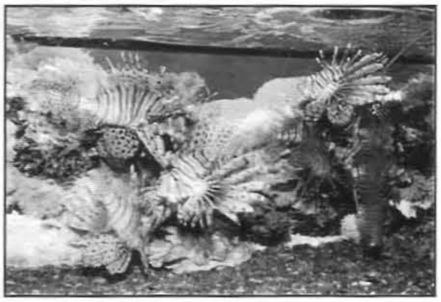
The annual global marine ornamental trade is estimated at US $ 200 – 330 million (Larkin and Degner, 2001). Unlike freshwater aquaria species where over 90% of the species are produced in farms, almost the entire ornamental species in the trade are collected from the coral reefs and adjacent habitats (Andrews, 1990). Hence the long term sustainability of the industry is a controversial aspect. The damaging techniques such as the use of sodium cyanide are non-selective methods used to capture fish and they adversely affect the health of the fish and also kill the non-target organisms (Erdmann *et al*, 2000). The over-harvesting of target organisms is another aspect of concern (Moore and Best, 2001). In addition, high level of mortality is associated with impact of shipping and poor husbandry practices (Oliver, 2003 ; Balboa, 2003). Hence it can be said that the three key aspects of concern in marine ornamental fish trade are collection, culture and conservation.

Marine Ornamental Trade : Global Scenario

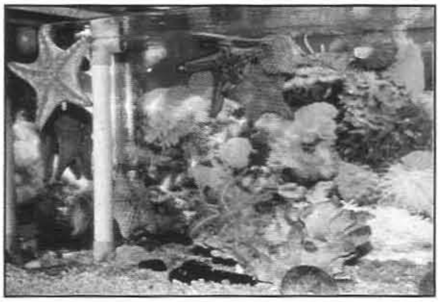
An overview of the global trade of marine ornamentals provides an insight into the magnitude of the trade and the conservation problems associated with it which point out the need for development of culture technologies for the long term sustenance of the trade. Based on the Global Marine Aquarium Database (GMAD) the annual global trade is between 20 million and 24 million numbers for marine ornamental fish, 11-12 million nos for corals and 9-10 million nos for other ornamental invertebrates. A total of 1471 species of fish are traded globally. Most of these species are associated with coral reefs although a relatively high number of species are associated with other habitats such as sea grass beds, mangroves and mud flats. According to the data provided by exporters, the Philippines, Indonesia, the Solomon Islands, Sri Lanka, Australia, Fiji, the Maldives and Palau together supplied more than 98% of the total number of fish exported .GMAD trade records from importers for the years 1997-2002 showed that the United States, the United Kingdom, the Netherlands, France and Germany were the most

Prime Ornamental species in Aquaria

a) Butterfly fish



b) Lion Fish



c) Miniature Reef in an aquarium with marine ornamental species

Clown fish broodstock development at CMFRI

Egg laying

Hatchery produced young ones of clown fish on sea anemone important countries of destination, comprising 99% of all imports of marine ornamental fish. Data on exporters revealed that Taiwan, Japan and Hong Kong are important importing areas (Collette *et al.*,2003).

Fishes

Among the most commonly traded families of fish, Pomacentridae dominates accounting for 43% of all fish traded. They are followed by species belonging to Pomacanthidae (8%), Acanthuridae(8%), Labridae (6%) Gobiidae(5%), Chaetodontidae (4%), Callionymidae(3%), Microdesmidae (2%), Serranidae (2%) and Blennidae(2%). For the years 1997-2002, the blue green damsel fish (*Chromis viridis*), the clown anemone fish (*Amphiprion ocellaris*), the whitetail Dascyllus (*Dascyllus aruanus*), the sapphire devil (*Chrysiptera cyanea*) and the three spot damsel (*Dascyllus trimaculatus*) are the most commonly traded species. These top species together accounted for 36% of all fish traded from 1997 to 2002.

During 1997-2002, *Amphiprion ocellaris*, *Chromis viridis*, *Labroides dimidiatus*, *Chrysiptera cyanea*, *Paracanthus hepatus*, and *Pseudanthias squamipinnis* are the most commonly imported species into the EU. Together, the species mentioned above and in the previous paragraphs make up 37% of all fish imported into the EU between 1997 and 2002. Similarly for the United States, the top species including *Dascyltus aruanus*, *Chrysiptera cyanea*, *Dascyllus trimaculatus* and *Labroides dimidiatus* accounted for 39% of all the species exported to the US (Collette *et al.*, 2003)

Corals

Corals include stony corals, soft corals and sea fans. Stony corals are marine colonial polyps, characterised by a calcareous skeleton, that often form reefs. Soft corals are species of the sub class Octocorallia which have no massive skeleton. Sea fans are supported by an internal axis. According to GMAD there are 61 species of soft corals and 140 species of stony corals in the trade.

Stony Corals: According to CITES data, the global live aqua material trade world-wide rose steadily from 1997-98 to 1998-99 with 9,34,463 live pieces and 11,42,242 live pieces. The trade decreased to 9,42,661 pieces in 2001.Since the late 1980 Indonesia has become the largest coral exporting country. Data from 1997 to 2001 show Indonesia, Fiji, the Solomon Islands and Tonga together contributed to more than 95 % of the live coral exports. The major importers of stony corals are the United States, Japan, Germany, France, China, Canada, the Netherlands and the United Kingdom, together importing 95 % of the total number of live corals being traded world wide.

Commonly traded genera, based on CITES export and import data 1999-2001, include *Acropora* (staghorn, cluster, blue tip, bush, cat's paw or bottle brush coral) *Catalaphyllia* (elegance coral), *Euphyllia* (anchor or hammer coral), *Galaxea* (galaxy coral), *Goniopora* (flower pot coral) *Heliofungia* (mushroom coral) *Lobophyllia* (lobed brain coral) *Pterogyra* (bubble or grape coral), *Turbinaria* (cup coral) and *Scleractinia*. GMAD also lists *Favia* and *Porites* as common in trade. With the exception of *Acropora*, most other genera are slow growing and some generally occur in low densities.

Soft Corals and Sea Fans: Most of the soft corals in the trade originate from the Indo-Pacific Ocean Zone. Although soft coral farming is simple, very few specimens are however of cultured origin. Despite high numbers of specimens being traded for use in aquaria, soft corals are not covered under CITES. GMAD data indicate that a total of 3,86,849 pieces of live soft corals were traded between 1988 and 2002. The United States is the world's largest soft coral importer receiving 67% of the total traded soft corals and Indonesia is the largest exporting country of soft corals. Based on GMAD (importers data /1988 – 2002) the most commonly traded soft coral genera globally are *Sarcophyton* (leather/ mushroom/toadstool coral), *Sinularia* (finger/leather/soft finger/digitate leather coral), *Xenia* (pulse coral), *Cladellia* (cauliflower/finger/colt/ blushing coral), *Clavularia* (clove polyp), *Anthelia* (waving hand polyp), *Lobophytum* (finger leather coral), *Nephthea* (broccoli coral), *Dendronephthya* (carnation/strawberry coral) and *Cespitularia* (blue xenia).

Eight genera of sea fans appear in GMAD trade records – *Ctenocella*, *Echinogorgia*, *Ellisella*, *Euplexaura*, *Gorgonia*, *Lophogorgi*, *Pseudopterogorgia* and *Rumphella*. The genus *Gorgonia* is the most well known and commonly traded sea fan.

Live Rock: Live rocks are pieces of coral rock to which live specimens of invertebrate species and coralline algae get attached and which are transported moist, but not in water. Typical inhabitants of live rocks are anemones, tunicates, bryozoans, octocorals, sponges, echinoids, molluscs, sebellarid and serpulid tube worms and calcareous algae. Besides the ornamental value of live rocks in aquaria, the organisms which live in live rock, through consumption of waste and production of oxygen, filter the water and prevent the build up of nitrate.

Live rock is traded either as 'cured' or 'uncured'. On collection from the ocean, the rocks harbour a large variety of sea life some of which, such as certain species of anemones and mantis shrimp are common pests on them. Uncured rock is the rock that has been collected and directly exported. 'Cured rock' is material that has been placed under a fine spray of high salinity water for several hours or days prior to export. The objective is to keep the coralline algae alive but kill and wash out less hardy, unwanted organisms, which would foul tank water.

According to CITES importers data, the United States, the EU, the Republic of Korea, Hong Kong and Canada together imported a total of 38,97,654 pieces of live *Scleractinia* spp. in which the largest component was live rock. Fiji is the world's primary supplier of live rock with data showing that in 2001 more than 800 tonnes of live rocks were harvested from its reefs, about 95% of which were destined for the United States. It is evident that large scale removal of live rock , the result of hundreds of years of accretion , can destroy reef habitat, undermining the structure of coral reefs and leading to increased erosion as well as reduced biodiversity.

Other Invertebrates

Many invertebrates other than corals are popular in the aquarium trade. According to GMAD, 516 species of invertebrates are being traded for aquarium. Mexico, Indonesia, Singapore, Fiji, Sri Lanka, the Philippines and Vanuatu are the main exporters. The main destination countries are the United States, the United Kingdom, the Netherlands, France, Germany, Italy and Canada. The main species in the trade are *Lysmata* spp., *Heteractis* spp., *Stenopus* spp., *Turbo* spp., *Tridacna* spp., and *Trochus* spp.. These traded invertebrates comprise species that feed on algae, parasites or dead tissue and dead animals. These species are particularly important in controlling algae growth and parasites. The removal of cleaner species from their natural habitats may not only lead to a reduction in diversity but also affect the balanced functioning of the ecosystem.

Giant Clams: Giant clams represent an increasingly large proportion of the exports of live invertebrates for aquarium trade. Although additional lighting is required in order to maintain giant clams, they play an important role in removing nitrates, nitrites and ammonia from aquarium. Belonging to the family Tridachnidae and composed of two genera of *Tridachna* (7 species) and *Hippopus* (2 species), the giant clams are the largest bivalves in the world. The more brightly coloured *T.maxima*, *T.crocea* and *T.derasa* are more popular ones in the marine ornamental trade. Unsustainable exploitation of giant clam species has led to the local extinctions of some species such as *T.gigas* in some areas (Hestinga *et al*, 1984). Those that are under unsustainable exploitation are species of giant clams listed in CITES, Appendix II.

Issues associated with Wild Collection

Destructive collection practices, the introduction of alien species, overexploitation, the lack of scientific information on many species collected and threat of extinction of target species are the major problems of the marine ornamental fish trade. Destructive fishing techniques include the use of sodium cyanide and other chemicals to stun and catch fish. Eventhough cyanide only stuns the fishes, high post-capture mortality has been recorded. It may destroy the coral reef habitat by poisoning and killing non-target animals, including corals . During collection of coral pieces for the coral trade, many more colonies happen to get damaged or broken than are actually harvested. Corals are also broken for easy access to capture fish. This is more common with species that branch out and scatter in which small species such as *Dascyllus* and *Chromis* often take refuge(Edwards and Shepherd, 1992). Collection of live rock has been considered as potentially destructive as it may lead to increased erosion and loss of an important fisheries habitat.

When exploitation is at a lower level in comparison to the resource available, there will not be any negative impact on reef fish populations. A study of the situation of fishery in Cook Islands showed that the total catch per unit effort remained constant between 1990 and 1994 (Bertram,1996). In Australia, due to the permit system, the current aquarium fishery is at sustainable level (Queensland Fisheries Management Authority,1999). But Australia is a rare case as the Great Barrier Reef is the largest reef system in the world. It is well known that not all fish are equally available and not all are equally attractive to the industry, and the most common fish need not be those favoured by the hobbyists. As a result, the effect of collection of ornamentals should be measured with respect to their potential to deplete particular species or locations. Several countries in Asia and South America have begun to implement restrictions on collection of certain ornamental fish species (Corbin and Young,1995; Friedlander,2001, Ogawa and Brown,2001). Although no marine species collected for the aquarium trade have been driven to global extinction, studies carried out in Sri Lanka, Kenya, the Philippines, Indonesia, Hawaii and Australia have reported localized depletion of a number of target aquarium fish species like butterflyfish and angelfish due to heavy collection pressure(Lubbock and Polunin, 1975; Rubec, 1987; Vallejo, 1997; Soegiarto and Polunin, 1982, Tissot and Hallacher 1999). The only systematic study assessing the effects of harvesting of fish for the aquarium trade on resource populations was carried out in Hawaii (Tissot, 1999). The study reported that eight of the ten species most targeted by collectors showed decline in abundance at exploited sites relative to control sites.

A larger part of the trade of ornamentals is centred on individual species. The vulnerability of the species to collection will depend on a number of life history parameters like growth, reproduction and recruitment (Harriott, 2003). Eventhough reef fish exhibit a wide variety of mating strategies the larvae are distributed through wave and wind driven ocean currents(Hutchings, 2002). This makes replenishment of reefs with new fish larvae highly dependent on these currents and hence the availability of fish for sustainable aquarium collection is highly variable.

The effects of fishing are significantly different for species that are hermaphroditic or change sex compared with species that do not change sex. A fishery selectively removing larger animals first will mean that animals will have to start changing sex at smaller sizes , possibly reducing the fitness of individuals and thus making hermaphroditic stocks more vulnerable to overfishing.

Trade in ornamental marine fishes is characterised by extreme selective harvesting. For many species, juveniles are preferred by aquarium fish collectors due to their distinctive colouration and ease of maintenance . Consistent harvesting of juveniles may leave only limited number of young ones to reach adult size and to replenish the adult stock.

Eventhough most coral reef fishes have broad distribution, a few species are endemics. Some species are naturally rare, occurring only in very restricted locations or naturally occur in lower numbers , eventhough they may be widely distributed(Wood, 2001). ☞

Other species may be abundant at different sites, but their distribution is limited to specific habitats. The more wide spread/ or abundant a species is, the less vulnerable it is to exploitation. Increased rarity often implies higher prices and hence vulnerable to overexploitation.

Males of many coral reef fishes tend to be preferred due to their distinctive colouration. Selective harvesting for males of particular populations on a regular basis may lead to reproductive failure and ultimate population collapse due to heavily biased sex ratios in remaining population.

There are many factors that lead to post harvesting mortality, such as physical damage and use of chemicals during collection, poor handling practice and disease. Even when collected in an environmentally sound manner, aquarium organisms often suffer from poor handling and transport practices resulting in stress and poor health of fishes. Research on the marine ornamental trade between Sri Lanka and the UK demonstrated that in the mid 1980s about 15% of fish died during and immediately after collection, another 10% died during transit and a further 5% in holding facilities (Wood, 1985). As a result of such mortality, more fishes are required to be collected than would be necessary to meet the market demand.

Culture

One way to reduce the pressure on coral reef ecosystems brought about by an increasing demand for marine ornamentals is to develop and improve technologies to culture desirable animals for trade (Parks *et al* , 2003).

Corals: Mariculture can be an environmentally sound way to increase the supply of hard and soft corals, and has proved successful for a large number of species. In addition, cultured coral is acknowledged as adapting better to aquarium conditions than wild caught coral (Borneman, 2000).According to CITES, only 0.3 % of the total global trade in live corals is from mariculture.

Aquaculture of stony and soft corals refers to coral propagation by fragmenting a large colony into smaller pieces, or pruning the tips of larger colonies, and subsequently attaching the fragments to a new substrate using superglue or suspending them in water on a nylon line.These fragments are then left to grow in holding tanks or placed back into the sea until they have reached a marketable size. Most branching corals can be easily propagated from small trimmings clipped from a parent colony and in about an year, a five to ten fold increase in biomass can be obtained. Soft coral fragments can grow to a marketable size within 4 to 12 months (Ellis Sharron , 1999) and stony corals like *Acropora* within four to six months (ICLARM 1998).

More than 75 species of corals can be captive bred , but only fast growing corals appear to be economically profitable (Bruckner, 2000). Hence propagation in species of stony coral is mainly targeted at the fast growing branching species such as *Acropora* , *Pocillopora* , *Seriatopora* and *Stylopora*. The most popular species in the trade such as *Blastomussa* , *Pterogyra, Trachyphyllia* and *Goniopora* are slow growing and are difficult to propagate.

Soft corals such as *Clavularia* , *Sarcophyton* , *Sinularia* , *Alcyonium* and *Cladiella* are suitable for aquarium propagation , due to their ability to heal wounds and regenerate tissue rapidly. The most commonly used practice for soft coral propagation is to simply remove , underwater , a piece of tissue from the parent colony using sharp scissors or a scalpel. Freshly cut specimens should be left exposed to fresh seawater motion or dipped in fine sand , for one or two weeks. They can be subsequently tied or glued to appropriate substrate harvested within four to twelve months. *Cladiella* spp. and other zooxanthellate species that are sensitive to fragmentation are almost impossible to propagate (Fabricius & Alderslade ,2001; Ellis Sharron,1999).

Fish: At present almost all the marine ornamentals are wild caught and tank reared species and contribute only 1-2 % of the trade. However, there is an increasing pressure over reliable and commercially viable captive breeding techniques for the long term sustenance of the trade.

Culture of marine ornamental fish is well accepted as an environmentally sound way to increase the supply of such organisms by reducing the pressure on wild populations and producing juvenile and market size fish of a wide variety of species year round. In addition, hatchery produced fish are hardier which fare better in captivity and survive longer (Oliver,2003).

The list of marine ornamental fishes reared in captivity today the world over contains more than 84 species. The maximum number of species reared are from the family Pomacentridae(26 species). The tropical marine anemone fishes (Pomacentridae) are important in the trade and are popular as a subject of research. Over the last twenty years mariculture centres and scientific laboratories have started rearing these fishes in large quantities. The species that can be reliably reared in large quantities include only a dozen anemone fishes, seven species of gobiids(Gobiidae), five species of cardinal fishes (Apogonidae) and eight species of Pseudochromids (Pseudochromidae). The other species reared belong to families Blennidae(one species), Callionymidae (one species), Ephippidae (one species), Gobiesocidae(one species), Pomacanthidae (6 species), Pomadasydae (2 species), Serranidae (3 species), Syngnanthidae (8 species), Tetraodontidae (one species) and Labridae (one species).

While culture has been done successfully for a few species, it is hoped that much of the market demand for the more popular ornamental fishes such as clown fish , yellow tangs and angel fish may eventually be satisfied by cultured fish (Ziemann,2001) . At present , most marine ornamental aquaculture remains comparatively problematic, both from technical and socio-economic point of view (Rosamond *et al*, 2000). Attempts at spawning, rearing and mating repeatedly in closed system have proved technically challenging for most species except Pomacentrids like *Amphiprion* spp and existing mariculture projects have been developed on a relatively small scale (Sadovy & Vincent, 2002).Blennies , Gobies and members of the family Pomacentridae are relatively easy to rear in captivity as they attach or deposit their eggs. Species such as clownfish can be conditioned to spawn voluntarily by manipulation of day length and water temperature. Most other fish species such as angel fishes and butterflies are known as broadcast spawners, as they spread their eggs freely in the water column , and therefore more difficult to culture in captivity. They also usually require hormone treatment to induce spawning. The greater obstacle to successful tank breeding of ornamental reef fish is rearing larvae beyond the sixth to eighth day of development, a time typically associated with failure to initiate larval feeding(Ogawa & Brown, 2001).This is often due to larval feeds being too large or not meeting the nutritional requirements of fish larvae. Once the larvae transform to small juveniles, they are weaned on to semi-natural diets and various prepared rations can be transported and sold. Besides technical challenges, the high price commanded by some cultured aquarium fishes compared to those wild caught often undermine their economic viability.

A relatively recent type of mariculture whereby fish larvae are captured by means of light traps or crest nets is of much interest (Doherty ,1987, Fisher &Bellwood ,2002). Considering that the vast majority of fish larvae die after having settled onto the reef (10 % survival rate) , removing them prior to the high mortality rate would guarantee minimal fishing impact . Species farmed this way and exported from French Polynesia to France showed promising growth rates. They were more gregarious , accepted a wider variety of food and were less sensitive to stress than wild caught individuals of the same species (Dufour,2002).

Invertebrates: Since technical constraints regarding the spawning of mature giant clams and raising of larvae and juveniles have been overcome, of late, there has been an increasing interest in giant clam culture Successful giant clam hatcheries have accordingly come up for aquarium trade in several tropical Pacific nations and Island groups. However, the production of ornamental invertebrates other than clams and also quality shrimps is constrained due to lack of information on key life history characteristics.

Conservation Management

Management of marine ornamental fisheries has to be undertaken in such a way that their fisheries are biologically sustainable, do not conflict with other resource uses and keep post harvest mortalities to the minimum. Habitat damage and negative impact on the ecosystem have to be avoided. Collection of species that are unsuitable for aquaria could be avoided.

The establishment of marine reserves where the collection of marine ornamentals is made illegal is one of the effective conservation measures. Setting up quotas and size limits ,and restricting access to the ornamental fishery through the use of permits can also reduce exploitation pressure. Governments and industry play an important role in supporting conservation initiatives and promoting best practices in this regard. The consumer can also be involved in the conservation programme. Third party certification of the trade, whereby the consumer is empowered to assist in the reduction of the environmental impacts of the trade by selectively purchasing products produced in an environmentally friendly manner, has been recommended as a possibility for improved conservation management.

Marine Aquarium Council (MAC) and Certification

MAC has developed a certification scheme that will track an animal from collector to hobbyist. Established in 1996, the goals of MAC are to develop standards for quality products and sustainable practices and a system to certify compliance with these standards, and create consumer demand for certified products. With a network of 2600 stakeholders in more than 60 countries, it is recognized as the lead organization for developing and co-ordinating efforts to ensure that the international trade in ornamental marine organisms is sustainable. MAC certification covers both practices and products.(Bunting *et al,* 2003)

Certificates of compliance with the appropriate MAC standard for the certification of practices can be issued through an avaluation of the compliance status. For certification of products MAC certified marine ornamentals must be harvested from a certified collection area for passing from one certified operation to another. MAC – certified marine organisms bear the "MAC-certified" label on the tanks and boxes in which they are kept and shipped.

The MAC core standards outline the requirements of third party certificates of quality and sustainability in the marine aquarium industry from reef to retail supply chain, as outlined hereunder.

(i) *The Ecosystem and Fishery Management Core Standard :* This addresses *in – situ* habitat, stock and species management and conservation by verifying that the collection area is managed according to principles that ensure ecosystem health and sustainable use of the marine aquarium fishery.

(ii) *The Collection, Fishing and Holding Core Standard :* This addresses harvesting of fish, coral, live rock and other coral reef organisms, handling prior to export, holding and packaging and transport to ensure the health of the collection area, sustainable use of the marine aquarium fishery and optimal health of the harvested organisms.

(iii) *The Handling, Husbandry and Transport Core Standard :* This addresses the handling of marine live species during export, import and retail to ensure their optimal health, their segregation from uncertified organisms and proper documentation to show that they pass only from one MAC-certified industry operator to another.

The core standards are accompanied by best practice guidance documents that provide advice to the industry operators on how they might be able to comply with the standards.

Another important aspect of this certification programme is the ☞

establishment of a monitoring system within collection areas to ensure early detection of any changes in the fish population resulting from collection for the trade. Reef Check, a non-profit community based coral reef education and monitoring organization, developed this monitoring system entitled 'Marine Aquarium Trade Coral Reef Monitoring Protocol in conjunction with MAC.

Management Strategies

Marine ornamental fisheries, if managed sustainably and integrated with other resource uses, have the potential to provide many people in source countries with a stable means of income. When addressing issues relating to the management of ornamental fisheries, it is necessary to involve all the concerned parties such as collectors, wholesalers, governments, hobbyists, scientists and members of industries who might have a resource conflict with aquarium fish collectors. One of the most promising and effective strategies is to allow local communities to manage and control their fisheries. It is also important to highlight the need for further research on the biology, population dynamics, recruitment and conservation importance of species involved in the marine ornamental trade, with a particular focus on rare or endemic species and species that show poor survival in aquarium conditions. A survey of the distribution and abundance of the target species, including an assessment of the exploitable area, is also crucial when attempting to set quotas or develop management plan for resources harvested for the aquarium trade. The following general strategies are suggested.

(i) ***Limited Access to the Fishery:*** A licensing system, whereby collection effort is regulated through a limited number of permits being issued each year, offers a good way of monitoring the industry (Wood, 2001). The number of permits to be issued should be based on scientific studies estimating the resource base and sustainable harvest quotas, subject to review on a regular basis.

(ii) ***Quotas:*** Limiting the number of fish being exported from any source country is another way of reducing or limiting collection pressure. Quotas are only likely to be effective if based on rigorous scientific research and implemented at species-specific level. Although relatively simple and can be easily enforced, general quotas are not advisable as they may simply encourage collectors to focus collection on the most valuable species, hence not ensuring protection of overall stock and least so of vulnerable species.

(iii) ***Size Limits:*** Size limits are another useful tool in managing aquarium fisheries. The marine ornamental fish trade tends to be highly selective in favour of juveniles due to their distinctive colouration, low transport cost for exporters and optimal size to fit in a home aquarium. Young ones of some popular species are easily stressed and hence may suffer high mortality during holding and transport. Setting minimum size limits would help to ensure that stock is not unnecessarily wasted. Maximum size limits are equally important to ensure that sufficient numbers of breeding adults remain on the reef.

(iv) ***Marine Reserves:*** The creation and effective management of areas where fishing is prohibited can prove to be a valuable tool for managing aquarium fisheries. Australia has effectively implemented this strategy for collection of corals. There are no-take areas and selected collection areas. It is reported that despite collectors harvesting 40 to 50 tonnes of coral per year for twenty years, no noticeable impact on the resource has been observed (Bruckner,2000). Marine reserves will be more successful by a community based management. By giving community members a sense of ownership of their resources, they can be motivated to guard these against destructive uses.

(v) ***Temporary Closures:*** This approach is commonly used to protect species during reproductive phases to ensure that there is sufficient recruitment to sustain the population. Although not in operation specifically for the aquarium trade at present, such closed seasons could allow juvenile fish to grow to a size unsuitable for aquarium collection, thus making sure that a healthy stock of adult fish is maintained on the reefs, which would contribute to recruitment. The temporary closures are only likely to be effective if implemented at the right time and right location.

Development of Marine Aquarium Fisheries in the Indian Context

India is bestowed with vast marine aquarium resources in its island ecosystems of Lakshadweep and Andaman-Nicobar Islands besides many areas of mainland. A comprehensive assessment of the biodiversity of marine ornamental animals from our reef areas has not yet been made. This should deserve primary attention. Secondly , till date no marine ornamental fisheries policy has been formulated. For this reason an organised trade of marine ornamentals has not yet been initiated in the country. In this context, it has to be admitted that a good deal of illegal collection of marine ornamentals is in vogue in many of our reef ecosystems. The crude and indiscriminate methods employed for the collection have been inflicting lot of damage to our reef habitat and biodiversity. In addition, the lack of knowledge on appropriate husbandry practices leads to large scale mortality of the animals collected.

In this situation, it is time to develop an organised marine aquarium fisheries in India by developing proper policies and management to ensure their sustainability. A few entrepreneurs can be licensed to collect suitable species from selected areas by ecofriendly collection methods. Availability of necessary infrastructure for conditioning and maintaining the harvested species should be one of the pre-requisites for issuing license for entrepreneurs. The Central Marine Fisheries Research Institute and National Bureau of Fish Genetic Resources can combinedly develop a certification system in line with the standards developed by the Marine Aquarium Council. The Marine Products Export Development Authority can take the lead to develop an export trade for the certified varieties. The impact of exploitation has to be closely monitored by scientific agencies and the required management measures have to be implemented as and when required.

The culture of marine ornamental species has been receiving much attention in recent years. During the past few years the Central Marine Fisheries research Institute has intensified its research on breeding, seed production and culture of marine ornamental fishes. One of the milestones in this programme is the recent success in the hatchery production of clownfish (Gopakumar *et al.*, 2001; Ignatius *et al.*, 2001; Madhu and Rema Madhu, 2002)). Another significant achievement is the seed production of sea horse. Experimental success was also obtained in the hatchery rearing of three species of damsel fishes(Gopakumar *et al*, 2002). Intensified research and development in this area can lead to development of culture technologies for many more species of demand in the trade. It is felt that in the near future, India can emerge as a leading source country for a sustainable marine ornamental trade by evolving suitable aquarium fisheries policies for collecting ornamentals from the wild as well as by developing culture technologies for hatchery rearing.

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