fishes) belong to the genus *Amphiprion*. They are associated with sea anemones, since they possess mucous coating over their body by which they are resisting to stinging of sea anemone. The major species of Pomacentrids in Indian waters include *Amphiprion sebae, A. ocellaris, A. percula, Chromis viridis, Pomacentrus pavo, P. cearuleus, Dascyllus auranus, D. trimaculatus, D. reticulatus, D. carneus, Neopomacentrus cyanomos, N. nemurus, Chrysiptera unimaculata, Abudefduf vaigiensis, A. septemfasciatus and A. bengalensis.*

Family Labridae

There are many colourful species of wrasses belonging to this family in the Indian rocky coasts and reef areas. The characteristic of wrasse is its swimming style, using only the pectoral fins to row itself along, but shooting suddenly ahead by body motion. The major genera of labrids available in our waters are *Gomphosus Halichoeres, Stethojulis, Thalassoma, Labroides, Cheilinus, Anampses, Coris,* and *Bodianus.* The major species include *Thalassoma lunare, Anampses caeruleopunctatus, Gomphosus caeruleus, Labroides dimidiatus, Halichoeres scapularis, H. marginatus, Stethojulis albovittata, S. strigiventer, Coris gaimardi, C. formosa, Cheilinus undulates* and *C. trilobatus.*

Family Scaridae

Parrot fishes of this family are of striking colours. Their name comes from the heavy parrot like beak, which is formed of their fused teeth. The common genera include *Scarus* and *Leptoscarus*. The major species include *Leptoscarus vaigiensis, Scarus sordidus, S. psittatus, S. ghobban* and *S. scaber.*

Family Pomacanthidae

The marine angelfishes are known for their grace and beauty. The major genera in our water include *Pomacanthus* and *Centropyge*. The common species are *Pomacanthus imperator, P. annularis, P. semicircualtus, Centropyge multispinis.*

Family Chaetodonidae

This family includes butterfly fishes and banner fishes. Butterfly fishes are small, swift and surprisingly well patterned and bright coloured fishes which are abundantly represented in the Indian Coast. The common species in our waters include *Chaetodon collaris, C. auriga, C. lunula, C. decussates, C. vagabundus, C. meyeri* and *C. trifasciatus.* The banner fishes are represented by genus *Heniochus. H. acuminatus* is very attractive in the aquarium. It has black and white stripes and yellow on the dorsal and tail fins.

Family Acanthuridae

Surgeonfishes of this family have oval body shape because of the identical rounded shapes of soft dorsal and pectoral fins. Their name is derived from the sharp knife like spine on each side of the caudal peduncle. The common genera in our water include *Acanthurus, Ctenochaetus, Zebrasoma* and *Naso.* The common species are *Ctenochaetus strigosus, Acanthurus triostegus, A. leucosternon, A. lineatus, A. nigricauda, Zebrasoma veliferum,, Naso unicornis* and *N. litturatus.*

Family Zanclidae

Zanclus canescens is the only species of this family. The snout is projected, tube-like and there are horns like protuberances over the eyes.

Family Scorpaenidae

Lionfishes of this family owe their name to the spreading pectoral and dorsal fins. It is the wild beauty in a marine aquarium. They are occasionally found in our rocky and coral seas. The common species in our waters are *Pterois volitans* and *Dendrochirus zebra.*

Family Syngnathidae

This family contains the sea horses and pipe fishes. In seahorses the head is bend down joining the body almost at right angle. Pipefishes are straight. Both have tubular snout and prehensile tail. Sea horses belong to the genus *Hypocampus*. They swim in upright position, stiff but gracefully. The female lays the eggs in the brood pouch of the male.

Family Ephippidae

The batfishes of this family grow very fast. When young they are most attractive, tend to lose some of their colour as they rapidly grow. The common species available along our coast are *Platax teira* and *P. orbicularis.*

Family Serranidae

Groupers of this family are widely distributed in the rocky Indian coast. Many colourful species of this family are of ornamental value. The common genera include *Cephalopholis* and *Epinephelus*. The common species are *Cephalopholis argus, Epinephelus merra, E. hexagonatus* and *E. tauvina.*

Family Balistidae

The triggerfishes and file fishes belong to this family. The trigger fishes are so named because of the locking device on the dorsal fin that triggers it into a stiff, erect spine, fixing the fish in position in a crevice in coral. In filefishes the dorsal fin consists of a single long spine. The common genera in this family include *Balistapus, Rhinecanthus, Oxymonocanthus* and *Pervagor*. The major species include *Rhinecanthus aculeatus, Balistapus undulatus, B. conspicillum, Oxymonocanthus longirostris* and *Pervagor melanocephalus.*

Family Apogonidae

The cardinal fishes of this family are small, red or brown coloured. The common genera in our waters include *Archamia, Pristiapagon, Ostorhynchus* and *Paramia.* The most common species are *Archamia fucata, Pristiapagon snyderi, Ostorhynchus savayensis* and *Paramia quinquelineata.*

Family Tetradontidae

It contains the puffer fishes and porcupine fishes. The puffer fishes have the ability to inflate their bodies with water and then turning upside down so that they float to the

surface. The common genera found in our Indian coast include *Arothron* and *Canthigaster*. The porcupine fishes can also inflate their body. They have long sharp spines over the body. When inflated, the body is round and spines protrude formidably. The common genus in our coast is *Diodon*. The major species of puffer fishes and porcupine fishes in our water are *Arothron stellatus* and *Canthigaster margaritatus* and *Diodon hystrix*.

Family Ostraciontidae

The boxfishes have hard outer cases that completely enclose their body. *Ostracion cubicus* is a common species.

Family Holocentridae

The squirrelfishes are brightly coloured fishes. Typically the body is red and the fins are yellow. The common genera include *Neoniphon, Holocentrus, Sargocentron* and *Myripristis*. The common species are *Neoniphon samara, Sargocentron diadema, Holocentrus laevis* and *Myripristis murdjan*.

Family Antennaridae

Frogfishes of this family are found in our coastal waters. The best known frog fish is the Sargassum fish *Hystrio hystrio*. It is seen wherever sargassum weed is found.The body is brownish yellow mottled with darker colour. The fish becomes perfectly concealed among the sargassum weed where it lives.

Family Muraenidae

Morey eels of this family are often attractively coloured. Many eels belonging to the genera *Gymnothorax* and *Muraena* are distributed in our reef areas and rocky coasts.

Family Theraponidae

The tiger fishes of this family have typically striped bodies. The three striped tiger fish *Therapon jarbua* is very common along Indian coast.

Families Gobidae and Blennidae

The gobies and blennies are attractive small bottom living fishes which are commonly found in tidal pools of rocky coast. The common genera of Gobies and Blennies in our waters include *Acentrogobius, Aspidonotus, Istiblennius* and *Salarias*.

Exploitation potential

A comprehensive study on the stock size and maximum possible yield from Lakshadweep was made by Murty (2002). The estimated stock sizes of the 20 families studied reveal that the damselfish are the most dominant accounting for 43.7% of the estimated total stock (137 lakhs) followed by parrotfish(15.3%), surgeonfish (13.3%), wrasses (11.0%), squirrelfish (2.5%), goatfish (1.7%), butterflyfish (1.1%), triggerfish (1%) and the remaining twelve families 10.4%.

Among the damselfishes, *Chromis caeruleus* has the maximum projected yield in numbers (43,81,000) followed by *Dascyllus aruanus* (2,22,000), *Chromis chrysurus* (1,65,000), *Abudefduf lacrymatus* (1,35,000) and *Dascyllus trimaculatus* (1,02,000). The parrotfishes with maximum abundance are *Scarus psittacus* (10,033,000) followed by *S.bataviensis*. The abundant surgeonfishes are *Acanthurus triostegus* (5,69,000) followed by *A.lineatus*. Among wrasses, *Halichoeres hortulanus* has the maximum annual projected yield (2,65,000) followed by *Stethojulis albovittata* (98,000). The abundant goatfish species was Mulloidichthys. *Samoensis* (41,000), followed by *Parupeneus macronemus* (39,000).Among squirrel fishes the maximum abundant species are *Neoniphon summara* (39,000) and *Myripristis murdjan* (30,000). The most abundant butterflyfish species are *Chaetodon auriga* (33,000) *and C.trifasciatus* (17,500). The Moorish idol *Zanclus canecens* has the estimated annual yield of 20,000 numbers. Among Triggerfishes, *Rhinecanthus aculeatus* is the common species (24,000). Of the various Angelfishes, *Centropyge multispinis* is most abundant (24,000). Among Filefishes, *Oxymonocanthus longirostrisi* has an estimated yield of 8,000 numbers. The Rock cod *Epinephelus merra* has an estimated annual yield of 13,000. The projected annual yield of the Cardinalfish *Pristiapogon snyderi*, is 38,000. The Pufferfish, Lionfish and Boxfish were dominated by *Canthigaster margaritatus, Pterois volitans* and *Ostracion cubicus* (Murthy, 2002).

Estimated stock size (number) and maximum possible yield of ornamental fishes of Lakshaweep (Murty, 2002).

Sl. No.	*Group*	*Stock size*	*Maximum yield*
1	Surgeonfish	18,17,418	7,82,195
2	Triggerfish	1,34,171	27,271
3	Butterflyfish	1,47,955	1,01,802
4	Wrasses	15,10,673	5,36,990
5	Squirrelfish	3,37,636	89,369
6	Goatfish	2,30,943	1,21,866
7	Damselfish	59,92,984	54,22,447
8	Parrotfish	21,01,167	12,65,071
9	Rock cod	83,573	27,082
10	Lizardfish	13,469	4,226
11	Cardinalfish	85,637	58,006
12	Filefish	13,841	9,376
13	Sandsmelt	13,841	9,376
14	Boxfish	13,841	9,376
15	Angels	27,682	18,752
16	Scorpeonfish	14,449	9,787
17	Rabbitfish	52,147	35,332
18	Pufferfish	74,974	50,783
19	Moorish idol	29,261	19820
	Total	1,26,95,635	85,98,927

Trade

The trade of marine ornamentals has been expanding in recent years and has grown into a multimillion dollar enterprise mainly due to the emergence of modern aquarium gadgets and technologies for setting and maintenance of miniature reef aquaria. The marine ornamentals include fishes, stony corals, soft corals, sea fans, ornamental shrimps, sebellids, giant clams, ornamental echinoderms and live rocks. The ornamental animals are the highest valued product that can be harvested from a coralreef.

The global marine ornamental trade is estimated at US$ 200-330 million (Larkin & Degnar, 2001). The ornamental trade is operated throughout the tropics. Philippines, Indonesia, Solomon Islands, Sri Lanka, Australia, Fiji, Maldives and Palau supplied more than 98% of the total number of marine ornamental fish exported in the recent years.

An overview of the global trade of marine ornamentals has been given by Collete *et al.*, (2003). Based on the Global Marine Aquarium Data base (GMAD), the annual global trade is between 20 million to 24 million numbers for marine ornamental fish, 1 to 12 million numbers for corals and 9 to 10 million for other ornamental invertebrates. A total of 1,471 species of fish are traded globally. Most of these species are associated with coral reef, although some of them are associated with other habitats such as seagrass beds, mangrove and mud flats.

ISSUES ASSOCIATED WITH TRADE

Destructive collection practices

Since the trade is dependent upon wild collection, the destructive collection practices, the introduction of alien species, over exploitation, the lack of scientific information on many species collected and threat to extinction of target species are the major problems. Destructive collection practices such as the use of sodium cyanide may destroy the coral reef habitat by poisoning and killing non target animals, including corals. During collection, many colonies of the branched corals are also broken for easy access to capture fish which take refuge in coral colonies. Collection of live rock is considered as potentially destructive as it may lead to increase erosion and loss of important fisheries habitat.

Conservation and management

A critical analysis of current global trade of the marine ornamentals from wild collections reveals many ecological concerns which require policy interventions. The major aspect that should receive top most priority is for taking appropriate action to ensure that the development of the trade should not threaten the sustainability of the coral reef ecosystem. The following measures are suggested.

i. Regulation for collection from the wild

The destructive collection practices such as use of cyanide should be banned by legislation and enforced. Results from a recent study demonstrated that colonies of commonly traded species of corals and soft corals to varying concentrations of cyanide

over different periods of time caused mortality in all corals. *Acropora,* the genus which is specifically targeted by fishers for collection of fish as they tend to hide amongst its branches, is most vulnerable to cyanide exposure, showing rapid signs of stress and bleaching (Cervino, *et al.,* 2003). Another aspect of concern is the impact of exploitation on population due to selective harvesting of species, which are of high demand in the trade. Here also policy intervention through legislation has to play a key role.

Several countries in Asia and South America have begun to implement collection restrictions on 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 targeted aquarium species due to heavy collection pressure. Studies have also shown that removal of larger quantities of cleaner wrasses and cleaner shrimps, which play key roles in reef health, creates negative impacts on reef diversity. The third aspect of concern is the exploitation of species, which are not suited for aquarium. This also needs to be avoided by legislation.

The fourth aspect, which demands regulations, is regarding the post harvest mortality. Research on marine ornamental trade between Sri Lanka and the United Kingdom demonstrated that in mid-1980s about 50% fish died during and immediately after collection, another 10% during transport and 5% in holding facilities (Wood, 1985). As a result of such mortally more fish often need to be collected for meeting the market demand. Where organisms are collected, stored and handled by adequately trained individuals and transported in suitable containers, fish mortality have been very low. The post harvest conditioning facilities should include modern gadgets such as UV lighting system, protein skimmers and carbon filters.

ii. Introduction of certification for wild collected species

Marine Aquarium Council (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 coordinating efforts to ensure that the international trade in ornamental marine organisms is sustainable. MAC certification covers both practices and products (Bunting *et al.,* 2003).

Industry operators can be certified through an evaluation for compliance with the appropriate MAC standard for the certification of practices. For certification of products MAC certified marine ornamentals must be harvested from a certified collection area and passed from are certified operations to another. MAC–certified marine organisms bear the "MAC-certified" label on the tanks and boxes in which they are kept and shipped.

iii. Development of hatchery technologies for selected species

The ultimate answer to a long-term sustainable trade of marine ornamentals can be achieved only through the development of culture technologies. It is well accepted as

an environmentally sound way to increase the supply of marine ornamentals by reducing the pressure on wild population and producing juvenile and market sized fish of wide variety of fish year round. In addition hatchery produced fish are hardier and fair better in captivity and survive longer (Oliver, 2003). Even though techniques are available for culture of corals, according to CITES data only 0.3% of the total global trade in live coral is from mariculture. Most branching corals can be easily propagated from small trimmings clipped from a parent colony and in about a year a five-to ten-fold increase in biomass can be obtained. Soft coral fragments can grow to marketable size within 4-12 months and stony corals like *Acropora* within 4–6 months. More than 75 species corals are bred under captivity, but fast growing corals appeared to be economically profitable.

The list of marine ornamental fishes reared in captivity today contains more than 100 species. The maximum number of species reared is from the family *Pomacentridae.* Attempts for spawning and rearing in closed systems have proved technically challenging for most species except Pomacentrids like *Amphiprion* spp. and the existing mariculture projects have been developed on a relatively small scale. The great obstacle to successful tank breeding of ornamental reef fish is rearing larvae beyond the 6th to 8th day of development, a time typically associated with failure to initiate larval feeding.

Artificial seed production techniques are available for giant clams and hence giant clam culture has increased considerably. Now there are successful giant calm hatcheries for aquarium trade, in most tropical pacific nations and island groups. The culture of ornamental invertebrates other than giant clams and cleaner shrimps is constrained due to lack of information on key life history characteristics.

iv. Other management strategies

a. 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.

b. 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.

c. 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.

d. 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 40-50 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 will guard these against destructive uses.

e. 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.

Indian scenario

India is bestowed with vast marine ornamental resources in our island ecosystems of Lakshadweep and Andaman and Nicobar Islands besides many areas of mainland. However, a comprehensive study on the biodiversity of coral reef fishes and their stock estimates is not available. Hence there is an immediate need to bring out a compendium on the diversity and abundance of coral reef fishes in India.

It may appear from the vast biodiversity of ornamental fishes in our waters that a lucrative trade can be developed from the wild collections. But it is evident from the global scenario of the ornamental trade that even though the trade is very lucrative and is expanding rapidly, the problems involved are complex and require appropriate management strategies. If managed properly, the aquarium industry could support long-term conservation and sustainable use of coral reefs.

In India, till date no organized trade of marine ornamentals has been initiated. But it is a fact that a great deal of illegal collection of marine ornamentals is in vogue in many parts of our reef ecosystem and this is a matter of great concern due to the indiscriminate nature of exploitation and ecohostile methods of collection which damage the reef ecosystem. In addition to this, lack of knowledge on appropriate post harvest husbandry practices leads to large scale mortality of the collected animals. It is time to evolve a marine ornamental fisheries policy in the country for developing an organized trade of marine ornamentals.

In India, the Central Marine Fisheries Research Institute has been focusing on breeding and seed production of marine ornamental fishes during the past few years. One of the milestones is the recent success in the hatchery technology of clownfish and sea horse. Experimental success was obtained on the broodstock development and larval rearing of five species of damselfishes. It is felt that research on breeding and seed production of marine ornamentals has to be intensified in future years. The culture of marine ornamental fish can prove to be more economically feasible than that of marine food fish culture. This is because even though the market for ornamental fish is much smaller than that of food fish, the price per unit is far higher in the case of aquarium fish. Hence in future, hatchery reared fish will become a significant part of marine ornamental fish trade.

It is time to develop an organized marine aquarium fishery in India by formulating certain policies and management to ensure its sustainability. In the near future, India can emerge as a lead country for a sustainable marine ornamental trade by evolving suitable aquarium fisheries policies for wild collection as well as by developing culture technologies for selected species.

The establishment of an oceanarium in the country will be of much significance for education, research and conservation of the marine ornamental biodiversity. In the oceanarium the marine flora and fauna are kept and maintained in large tanks with walk-through acrylic tunnel and in aquarium tanks. The oceanarium can accommodate touch lagoon, reef aquaria and display of different coral reef habitats and their biodiversity. It can also undertake educative and scientific programmes on the ecology, biodiversity and conservation of marine ornamental animals.

References

Bruckner, A. 2000. New threat to coral reefs: trade in coral organisms. *Issues in Science and Technology Online. www.nap.edu/issues/17.1/bruckner.htm.*

Bunting, B., Holthus, P. and Spalding, S. 2003. The marine aquarium industry and reef conservation. In: *Marine Ornamental Species- Collection, Culture and Conservation* (eds. J. Cato and C. Brown) Iowa State Press, Ames, USA, pp. 109-124.

Cervino, J., Hayes, R., Honovich, M., Gorea, T., Johns, S. and Rubec, P. 2003. Changes in zooxanthellae diversity, morphology and miotic index in hermatypic corals and anemones exposed to cyanide. *Mar. Poll. Bull.*, **46**: 573-586.

Colette, Wabnitz, Michelle Taylor, Edmund Green and Tries Razak. 2003. From Ocean to Aquarium: The global trade in Marine Ornamental Species, *UNEP World Conservation Monitoring Centre,UK*, p. 65.

Corbin, J. and Young, L. 1995. Growing the aquarium products industry for Hawaii. Department of Land and Natural Resources Aquaculture Development Programme, Hawaii., p. 35.

Friedlander, A. 2001. Essential fish habitat and the effective design of marine reserves; application for marine ornamental fishes. *Aquarium Science and Conservation*, **3**: 135-150.

Hestinga, G., Perron, F. and Orak, O. 1984. Mass culture of giant clams (Family Tridachnidae) in Palau. *Aquaculture*, **39**: 197-215.

Larkin, S. and Degner, R. 2001. The US wholesale market for marine ornamentals. *Aquarium Sciences and Conservation*, **3**: 13-24.

Murty, V.S. 2002. Marine Ornamental Fishes of Lakshadweep. CMFRI, *Spl. Pub.*, **72**: 134.

Ogawa, T. and Brown, C. 2001. Ornamental fish aquaculture and collection in Hawaii. *Aquarium Sciences and Conservation*, **3**: 151-169.

Oliver, K. 2003. World trade in ornamental species. In: Marine Ornamental Species: Collection, Culture and Conservation (eds. J. Cato, C. Brown), pp. 49-63.

Wood, E. 1985. Exploitation of coral reef fishes for the aquarium trade. Marine Conservation Society, Ross-on-Wye, UK, p. 121.

Wood, E. 2001. Collection of coral reef fish for aquaria: Global trade, conservation issues and management strategies. Marine Conservation Society, UK, p. 80.