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An overview of the Ornamental Aquatics sector in Sri Lanka

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ABBREVIATIONS AND ACRONYMS

AgEnt	-	Agro-Enterprises Development Project.
CITES	-	Convention on International Trade in Endangered Species.
DOA	-	Dead on arrival. A common term for fishes and invertebrates which are found dead upon unpacking a shipment.
EIA	-	Environmental Impact Assessment. An internal USAID evaluation of the possible environmental consequences of a project component.
FAD	-	Fish Attracting Device.
FOB	-	Freight On Board. In the context of this report the term refers to the fact that quoted prices for Sri Lankan aquatic do not include freight costs from Colombo.
IUCN	-	International Union for the Conservation of Nature.
SCUBA	-	Self Contained Underwater Breathing Apparatus.
USAID	-	United States Agency for International Development.

GLOSSARY

Brackish	-	A term referring to the mixture of fresh and saltwater which often occurs in lagoons and estuaries. A number of plant and animal species prefer or even require this type of water.
Cut Flowers	-	Used in this report to refer to a small number of marine fish species which will not survive for more than a few months in captivity, generally due to starvation. Like cut flowers, they are beautiful for a short time, but will not last.
Diurnal	-	A biological term referring to primary activity for a species as occurring during the day, versus nocturnal or being active at night.
Endemic	-	A biological term referring to animal or plant species which occur only in a precise geographic area. Fishes which naturally occur only in Sri Lanka are said to be endemic to Sri Lanka.
F1 Generation	-	The biological term used in this report to refer to the first offspring produced by a pair of captive fishes.
Landed Price	-	Foreign buyers of Sri Lanka's ornamental fishes must add air cargo freight costs to the price they pay for the fish. Landed cost equals the FOB price plus the air cargo cost.
Neo-tropics	-	The tropical portions of the New World; Central and South America and the Caribbean islands.
Ornamental	-	A catch-all term referring to ornamental aquatics; fishes, invertebrates, and aquatic plants.
Skin Diving	-	Diving without the use of SCUBA; also referred to as snorkeling.
Tank	-	1. A constructed container designed to hold living aquatic animals or plants, usually made of glass or concrete and glass in Sri Lanka. 2. An artificial water storage lake in Sri Lanka, many of which are very large and ancient.
Trans-Shipping	-	The practice of importing ornamental aquatics from one country and then re-exporting them to another point for sale.

Executive Summary

Ornamental fish exports from Sri Lanka have a long history, beginning in the 1930's with the export of freshwater tropical fishes to Europe by ocean liner.

One of the most important findings of this consultancy is that while the export of ornamental fishes from Sri Lanka can be easily divided into several categories, it is the combination of a core group of species which prompt foreign buyers to import fishes and other forms of aquatic life on a regular basis. While this core group of species has traditionally been wild-caught marine species, Sri Lanka's growing success in culturing freshwater species has helped to shift this emphasis as Sri Lanka develops its overall species portfolio. There is, however, still much room for enhancement to this cultured species portfolio, including the exciting possibility of commercial culture of marine fishes.

Related to this and equally as crucial to the export market are Sri Lanka's hand-caught, drug-free marine fishes. It is well known that Indonesia, for example, has many of the same species as does Sri Lanka. Furthermore, their landed prices are usually lower than Sri Lanka's. The concern is that an estimated 70-80% of Indonesia's ornamental marine fish exports are collected with drugs, primarily sodium cyanide. Foreign buyers are willing to put up with the long ride from Sri Lanka, high freight rates, and the often poor packing procedures, because Sri Lankan fishes will live where Indonesian fishes have a poor short and long term prospect.

If drugs ever enter into widespread use in Sri Lanka as a method of collecting ornamental marine fish, then Sri Lanka may quite likely lose virtually its' entire market. This point cannot be over-emphasized and must be taken into account when transhipping of ex-country marine species is undertaken.

To ensure that Sri Lanka will both maintain and increase its market share, it must improve the overall quality of its ornamental aquatics at all levels. Key areas requiring improvement are water quality, handling, nutrition, and packing and shipping methods.

Another crucial factor relating to the successful development of this sector in Sri Lanka is the unique combination of a small country and a growing world market for ornamental aquatics. This fusion has eliminated much of the greed which frequently becomes associated with the development of renewable natural resources. The world market has been interested enough in the Sri Lankan ornamental aquatics product to allow all Sri Lankan players a niche in the market.

The potential assistance for this sector through the USAID AgEnt project comes at a propitious time. Market demand is growing and at the same time the world is trying to become "greener". Many members of this sector are aware of these factors, but have little idea how they are related or what benefits or consequences they many have for Sri Lanka. It is the contention of this consultant that positive environmental steps by the sector in Sri Lanka can, if correctly taken, lead to enhanced market acceptance and even increased demand for the Sri Lankan product. This in turn will ultimately lead to higher values for ornamental species originating in Sri Lanka. Rational environmental steps in Sri Lanka can actually pay off for those who initiate them. Assistance to this sector can help secure this

imperative.

Direct assistance to this sector, will in almost every case currently under consideration, lead to enhanced sustainable employment within the individual client business. A conservative guess of the number of persons employed in this sector is about 5000.

Ornamental Aquatics Sector Strengths

- Ideal climatic and water resources for ornamental fish culture
- Recognized international reputation for disease and drug-free fishes
- A number of skilled fish breeders
- Unique species portfolio compared to neighboring countries
- Indirect government support for sector
- Low cost labor and a good work ethic
- Abundant and suitable land for fish farm sites
- Suitable access to international air cargo
- Quality of Sri Lankan product has been slowly improving while that of neighboring countries has been declining
- Most fish breeders freely give help and advice to one another
- The most successful breeders are already aware that continuing improvement of their product is a key to success

Ornamental Aquatics Sector Weaknesses

- Little final consumer awareness of the Sri Lankan product
- Small cultured fish species portfolio
- Little access to proper equipment and supplies, i.e. anti-predator netting, medications, etc
- Little understanding of water quality maintenance or monitoring
- Poor handling and shipping techniques
- Poor understanding and access to fish nutrition improvements
- Poor understanding of disease organisms and causative factors
- Poor followup communication with international buyers
- Restrictive cut-off times for air cargo export shipments

Ornamental Aquatics Sector Opportunities

- Pioneer culture of marine fishes where manpower costs are low and fish breeders have the basic skill
- Enhance species portfolio of ornamental fish farmers
- Most threatened or vulnerable ornamental fish species in Sri Lanka can be cultured. This can become a powerful marketing tool
- Sustainable technology can greatly enhance production and quality
- International buyers are becoming increasingly aware of environmental issues
- Final consumers in the West will demand Sri Lankan fishes if they are aware of positive environmental steps taken in Sri Lanka.
- Consistent quality will place exporting countries in a position where they are the last to be cut from an international buyer's list rather than one of the first
- Grow-out of ex-country species can be a valuable strategy for ornamental fish farmers
- Polyculture in fish farm grow-out ponds can more effectively utilize available pond space

Ornamental Aquatics Sector Threats

- Over-exploitation of the natural populations of commercial species
- Total export dependency upon airfreight which is related to the tourist market and therefore to the political climate in Sri Lanka
- Introduction of chemicals as a collection method for marine fish
- Disease problems if fish farms over-expand
- Restrictive import barriers from importing countries
- Competition from neighboring countries who have strong government support to this sector
- Industry inattention to a quality product
- in-fighting and price cutting among domestioc producers and importers

1.0 INTRODUCTION

The keeping of fishes and other forms of aquatic life for ornamental purposes has been practiced by humans for millennia. The maturing of this pursuit into a popular and nearly world-wide hobby has closely mirrored the modern expansion of both technology and leisure time. Although statistics vary from country to country, fishkeeping in the USA has in recent times ranked second only to photography, as a recreational pastime.

The growing popularity of this hobby has been fueled by colorful and exotic fish species which primarily occur in the tropical portions of the planet. Sri Lanka was a pioneer in the export of exotic fish species, as early as the 1930's by ocean steamer to Europe. The rapid growth of the industry and hobby did not really begin until the advent of low-cost commercial air transport following the second World War.

Sri Lanka played a major role in the collection and export of commercial species in the 1950's and 1960's, but due to a variety of factors both internal and external including foreign competition and a lack of domestic technology, it lost its preeminent role as other South East Asian countries developed their expertise and markets.

Initially, virtually all ornamental fish species were collected from wild populations, however, as the hobby expanded many of these fishes were discovered to be easily and profitably reproduced in captive situations. Often each successive generation proved more adaptable to aquarium life, and easier to breed as well. Today approximately two thirds of all freshwater ornamental fishes are captive bred, primarily in commercial fish farms in South East Asia and Florida. Less than 2% of the imports of ornamental aquatics into the US originated in Sri Lanka during 1992.

During the last quarter century and particularly during the last ten years, technology has developed to enable the keeping of tropical marine fishes with relative ease. This has fueled a renaissance in fishkeeping in general as these often gaudily beautiful tropical marine fishes and invertebrates have made their way into living rooms around the world.

At a basic level, much of the attraction of fishkeeping is related to the exotic persona of the species themselves. This has continued to fuel both market demand and value for exotic and unusual species from around the world. It is in this area that Sri Lanka has an exceptional position. Sri Lanka, located in the center of the vast Indo-Pacific faunal region, has a unique portfolio of both freshwater and marine species.

Sri Lanka has both the necessary climatic and water resources required to develop successful production of many species of freshwater ornamental fishes and plants. Most tropical fishes require temperatures in the 68 to 90F range and pH levels near neutral. Labor costs and availability also strongly support this potential. These existing parameters also lend themselves to further developing of culture of more difficult to breed freshwater fish species and pioneering work in the culture of marine species thus lessening and eventually eliminating pressure on wild populations.

1.1 CONSULTANCY FRAMEWORK AND CONSTRAINTS

Sri Lanka's ornamental fish sector encompasses much of the diversity that exists in the current worldwide supply for aquarium inhabitants. This diversity can be conveniently divided into the following components for the purposes of this report:

- captive production and export of freshwater fishes
- wild collection and export of freshwater fishes
- wild collection and export of marine fishes and invertebrates
- aquatic plant collection, culture, and export

The information gathering objective of this consultancy was to directly observe and question as many of the breeders and exporters in the above four component areas as possible. As such, all members of the Sri Lankan Live Fish Exporters Association were contacted and offered the services of the consultant within the context of information gathering visits. Prior to the consultant's arrival approximately one half of the members had responded positively and another quarter of the members were to respond during the time the consultant was in country. In keeping with the cost-sharing goals of the AgEnt Project, each sector client was asked to contribute a nominal amount towards the consultancy costs, and all did so without hesitation.

This consultancy recognizes that members of the sector who responded and were subsequently visited, potentially represent a biased sampling of the sector in Sri Lanka. This potential bias is perhaps a positive one in that sector members who are the most innovative and entrepreneurial are the first to recognize the potential benefits of such a consultancy and associated development assistance.

The ornamental fish sector in Sri Lanka is small enough that the majority of the players are aware of, often on both a business and personal level, the other members of the sector. If this assumption is correct, the consultant feels confident that the information presented in this report is a true reflection of the entire ornamental fish sector in Sri Lanka. Each client visited was able to articulate their thoughts and concerns not only about their own operation but also the strengths and weaknesses of others in the sector. The consultancy found no significant indication of rogue exporters or breeders. Most had a genuine understanding of the basic issues and a realization that the only true success that can be achieved in this sector requires a long-term view of the resources involved.

Sri Lanka's exporters are aware that in many cases they have had to work for their market share. This willingness to understand and change can be seen as the first step towards the development of a successful private sector enterprise.

2.0 CAPTIVE PRODUCTION OF ORNAMENTAL FRESHWATER FISHES

2.1 History and Background

Although foodfish aquaculture first began in Sri Lanka in the early 1950's with the introduction of the tilapia species *Oreochromis mossambicus* (Subasinghe and Siriwardena, 1990), commercial production of ornamental species did not appear on a large scale until the 1980's.

The development of this sector component appears to have been both pragmatic and pro-active. Pragmatic, in attempting to copy the success of neighboring countries such as Singapore, and pro-active in trying to fulfill the needs of foreign buyers who wanted freshwater species to complement shipments of Sri Lanka's rapidly developing ornamental marine fish and invertebrate exports.

Subasinghe and Siriwardena (1990), report 200 agrofarmers engaged in the production of ornamental freshwater fishes in Sri Lanka. This figure appears to be about twice the actual amount at the time of this study, although it is possible that the figure of 200 refers only to individuals and not operations themselves. If this is the case, then there are probably 500 or more individuals either directly or indirectly involved in such activities at the present time. The size of individual operations varies considerably from back-yard production to more than a dozen hectares of ponds for the largest operators.

Although disease problems will be discussed later, an important factor influencing the development of this sector component is related to the incidence of fish disease. During the mid-1980's the primary producer of ornamental freshwater fishes in the region, Singapore, experienced major disease problems with some of its most desirable export species. These problems led to market concern with Singapore fishes which allowed other producers such as Sri Lanka to effectively enter previously closed markets. Some of these same disease problems were to be detected in Sri Lanka as well, but not in the magnitude experienced in Singapore. Singapore has since recovered, but in the process Sri Lanka's market share has continued to expand. Markets lost are difficult to regain, particularly when dealing with a live commodity where reputation is crucial.

And finally, although many of the principles and procedures are virtually identical, there appears to be something of a divorce between ornamental and foodfish aquaculture in Sri Lanka. Separate markets and the ease with which small-scale ornamental production can be begun, undoubtedly influence the situation. Cultural considerations also apply which relate to the fact that ornamental fishes are not destined to be killed for consumption purposes.

2.2 Cultured Species Portfolio

The species of freshwater fishes currently under commercial production in Sri Lanka is reasonably small, probably less than 50 species, although in some cases numerous commercial color and/or fin varieties exist for an individual species. The majority of these species fall into the "bread and butter" category, or fishes which form the core of the

freshwater tropical aquarium hobby. These fish species are listed in table 1.0.

Culture species selection by individual breeders seems to be determined by a variety of factors including; market demand, exporter request, availability of brood stock, ease of culture, and compatibility with water conditions. Predator concerns at productions sites also play a major role, and this will be discussed below in a separate section.

The most successful breeders are those who continually attempt to improve their species portfolio with new species or varieties, although in most cases the addition of a new culture species is accomplished by the phasing out of another. Breeders seem to have only a very general grasp of the international market, and the majority of breeders have never seen the final selling points for the fishes they produce.

2.3.1 Existing Production Procedures Overview

Although there is tremendous variation in this sector component, related to both species portfolio as well as individual expertise and understanding, most breeders use similar types of facilities and procedures. Two or three types of tanks or areas are used for production. Breeding pairs or groups of fishes are generally placed into glass, glass and concrete, or all concrete tanks for conditioning and subsequent spawning. Conditioning is usually accomplished by generous feedings with high protein foods tailored to the dietary needs and preferences of the target species.

Once spawning has taken place, the parents are generally removed (as many species are actively cannibalistic), although for some species sufficient aquatic plant cover is added to protect the eggs or young. Eggs generally hatch within a week or less, depending upon species and water temperature. Feeding is begun shortly after hatching and young fishes are transferred to concrete tanks for initial grow-out. Once the young fish have reached a predetermined size, generally 0.5-3.5 cm, they are often transferred to mud ponds for final grow-out to harvest size. The size at grow-out depends upon the species in question, availability of grow-out pond space, and predator concerns based upon size. The time period for this final stage depends upon feeding regimes, temperature, and species involved but can be as short as five to six weeks.

Mud pond grow-out is generally considered to be a semi-intensive form of aquaculture in that the natural foods which develop in a mud pond are supplemented with additions of prepared foods. At harvest time, the pond is typically drained and fishes are either seined or netted out depending upon pond size and design. The pond is usually sterilized with lime, prior to refilling and restocking with another group of fishes. Mud ponds are also fertilized with some type of animal dung prior to each new stocking to start a natural algal bloom. The algal bloom fuels the food chain for naturally occurring microscopic organisms upon which the young fishes feed.

Although all fish breeders visited culture a number of different species in total, most appear to practice monoculture in individual ponds. A few breeders have experimented with simultaneous grow-out of different species or polyculture, however, maximum benefit from this practice would probably not be realized with the current species portfolio in Sri Lanka. Breeders who do direct export have the greatest number of species in production in order

to satisfy foreign buyers, while smaller breeders who sell to exporters may only have a few species or varieties in production.

2.3.2 Production Seasonality

A number of factors affect production seasonality in Sri Lanka. Temperature during the hottest months can cause problems in heavily loaded tanks or ponds as the ability of water to hold oxygen dramatically decreases as temperatures rise.

Heavy rains during seasonal monsoons may occasionally cause localized flooding in some production settings. This may lead to direct loss of cultured species, adulteration of desired color strains, or mixing of inappropriate sizes of different species leading to predation.

Foreign demand also decreases during the months of June, July, and August when annual vacations occur in many western countries.

2.4 Water Quality Awareness

While many ornamental fish species can tolerate a wide range of water conditions, there is generally a discreet range which provide for optimum health and growth of cultured species. In general, larval and juvenile fishes are much less tolerant of extremes in water conditions than are adults or sub-adults.

With the exception of the largest breeders visited during the course of this study, the only water quality parameter measured on anything approaching a routine basis was pH, a measure of hydrogen ions which determine the acidity or alkalinity of the water. In some cases, the only rationale for even these measurements was to determine if newly constructed concrete tanks were still leaching carbonates into the water during the process of curing.

Even the basic and easily measured parameter of temperature was sometimes neglected. While granted, this is difficult to modify in an outdoor pond setting, periodic measurements would help fish breeders to perhaps correlate regular production problems with the stress of overly high or low temperatures.

None of the fish breeders visited during this consultancy had a good, or in most cases even rudimentary, understanding of the nitrogen cycle as it relates to water chemistry in an ornamental fish production setting. A basic understanding of water chemistry in this context is crucial because of the often strong correlation between poor water quality and disease problems.

2.5 Disease Detection and Treatment

The potential for rapid spread of both bacterial and parasitic ornamental fish diseases in a production setting is often great. As mentioned above, there is often a strong correlation between poor water quality and disease problems.

Again, with the exception of the largest facility, the only diagnostic tools available for most fish breeders in Sri Lanka is the naked eye. Consequently, much disease treatment which

does occur is based on a "shot-gun" approach which may not even target the specific disease organism at all.

A very limited selection of drugs and chemicals for the treatment of fish diseases is currently available in Sri Lanka. In many cases the breeders buy yearly supplies in Singapore due to both price and availability there. In some cases, more effective drugs and chemicals, both in cost and efficacy are available in other countries. Training in fish disease diagnosis and treatment will be mentioned in the recommendation section.

2.6 Foods and Feeding

Another crucial area in the development of a quality export product is nutrition. This an area where the sector will benefit greatly with improved feeds for various size fishes. Optimum nutrition produces the fastest growth rates and the best coloration, however, the lack of an adequate supply or variety of both prepared and live foods must be addressed for this sector to reach full potential.

Virtually all breeders use the newly hatched brine shrimp, *Artemia* species, to feed juvenile fishes. The encysted eggs are available in canned form and hatch in 48 hours for immediate feeding to juvenile fishes. All breeders visited import their eggs from Singapore, although virtually everyone used a popular American brand which gives satisfactory hatch rates in Sri Lanka. A new product developed for Penneid shrimp culture is a fatty acid booster for enrichment of live foods such as brine shrimp, *Artemia* species. The enrichment dramatically improves the nutrition of the brine shrimp when used as a food for juvenile fishes. This will be further discussed in the recommendations section below.

Other live foods used include tubifex worms, adult brine shrimp, rotifers, copepods, and *Paramecium*. All have their pros and cons and each breeder has developed certain preferences, however, most breeders, and exporters as well, were unanimous in voicing the need for quality direct culture live foods.

Prepared foods are also used by all breeders in one form or another. Some breeders use the locally produced Prima fish food exclusively, other make their own special recipe, and still others use only fresh foods such as prawn or fish to feed their fishes. The description of most of the "special recipes" seemed of dubious nutritive value, and it is obvious that the fishes cultured at these sites must supplement their diets with natural foods available in grow-out ponds.

There does not appear to be any use in Sri Lanka of color enhancing compounds in prepared foods, although other competing countries sometimes rely heavily upon these chemicals to produce brilliantly colored fishes. Sri Lankan breeders seem to be proud of their ability to produce colorful fishes without color enhancers, although some prepared foods, most notably dried shrimp, have natural color enhancers.

2.7 Marketing of Cultured Freshwater Fishes

Marketing of domestically cultured fishes seems to be a function of size of the breeder and proximity to Colombo. Larger producers or those located close to Colombo are able to have their buyers come to them to pick up fishes ready for sale and subsequent export or domestic sale. Smaller producers and those located far away from Colombo are forced to deliver their product to Colombo buyers.

The larger breeders, of which there are five or six, are becoming increasingly interested in direct export, although this seems to be a function of their expansion and not a cut off of supply to their regular local export buyers. Most mentioned that they have more demand than they can fill and are sometimes pressured by local exporters to sell fishes not yet ready for sale so the exporters can fill orders. Clearly, this is counter productive to developing a good market perception. Foreign buyers seem to be increasingly aware of developing Sri Lankan quality and demand is increasing.

Export prices are always quoted in US$ FOB. Domestic prices to local exporters are usually in Rupees per pair. Prices seem to have been fairly stable within the context of individual buyers, but may vary from buyer to buyer depending upon established relationships and regular quantity orders. Set discounts for orders above a certain dollar amount are common.

A notable exception to the price stability for the Sri Lankan export market has developed from the market strategy of a new large breeder/exporter. This strategy has been to access new foreign buyers by undercutting existing export prices by as much as 50%. In some cases, fishes were purchased from one breeder for one price and exported to a foreign buyer for half that amount. The losses are justified as necessary to gain market share and are only feasible for the short run. It is hoped that this practice will soon end as it can generate ill will from exporters who sell at a fair market price.

Few exporters appear to do any advertising other than at trade fairs. The larger exporters generally visit their foreign buyers every year or two, seeking out new buyers at the same time. Most mentioned their reluctance to target new business in the same cities or areas where they have existing relationships.

Exporters who have recently begun direct exports report the most difficulties in the sector with air cargo problems. The irregularity combined with their recent use of air cargo have sometimes caused problems. Only rarely, however, do booked shipments appear to get bumped from outgoing flights.

2.8 Human Resources

This sector component is fairly labor intensive like many other types of agro-enterprises. Even the smallest breeders had several employees involved in feeding, maintenance, breeding, and related activities. The large fish farms generally have book keeping and secretarial staff, in addition to breeders, assistant breeders, and maintenance men. Guards were also common at the largest facilities. One fish farm even had three full time men who were in charge of chasing predatory birds away.

One of the most innovative management techniques observed in this sector component was a profit-sharing program for grow-out production targets. Management, in this case the owner of the fish farm, set harvest targets for each grow-out pond. The profits from sold fishes which exceeded those goals were shared directly with employees. Production targets appeared realistic and profit sharing was a regular occurrence.

2.9 Recommendations

The cultured freshwater ornamental fish industry in Sri Lanka is still in its infancy and will benefit greatly from access to better technologies and market information. The following recommendations are not listed in any type of priority. While some may apply to every fish breeder in Sri Lanka, others are more relevant for only a select few. This consultancy has tried to find a balance in recommendations between the latest technology and that which can be perpetuated under existing conditions in Sri Lanka. All support recommendations are assumed to be on a cost sharing basis.

2.9.1 Predator Control

Natural predators are in constant competition with Sri Lanka's ornamental fish breeders. Protected grow-out ponds can achieve harvest rates of better than 90% of stocked quantities. Unchecked, predators can bring harvest rates as low as 20%. The primary problems are birds, and frogs and toads. In both cases, the most effective way to deal with the problem is to install barriers. Other predators reported by various fish farmers ranged from river otters, water snakes and monitors, to crocodiles and even fishing cats! Most of this latter group however are only occasional problems.

The AgEnt Project should support clients in the identification, procurement, and purchase of ultra-violet stabilized bird mesh netting. This is widely used in the USA and is environmentally benign.

The AgEnt Project might also support clients in the construction of "frog walls" to deny access by frogs to ponds. Optimum height depends upon frog species, and it appears that at least three species are problems in Sri Lanka.

2.9.2 Enhancement of Species Portfolio

One of the determinations attempted during this consultancy was to ascertain what species could be added to the existing production portfolios of Sri Lankan breeders. Individual water chemistry, successes and failures with current species, world market demand, and general expertise and aptitude of breeders were all taken into consideration. Existing wildlife laws allow for the importation of "tropical aquarium fish species" and in fact most species currently under culture in Sri Lanka are endemic to the neo-tropics.

The AgEnt Project should support clients in the selection and procurement of high quality broodstock of existing and new species for potential culture. Predicate support with agreement to share F1 generations with other Sri Lankan breeders under advisement of project.

The AgEnt Project might also support procurement of a limited number of hitherto unknown fish species within the aquarium market, thus strengthening Sri Lanka's consumer perception of innovation.

2.9.3 Trial Cage Production of Ornamental Fishes

While cage production of food fish is well known and commonly practiced, its use is limited in ornamental fish production due to the often small size of cultured species conflicting with optimum mesh sizes in cage culture. Cage culture of ornamentals has shown some limited utility in Singapore and because the costs for small scale trials would be low, it is worth investigating in Sri Lanka. This is particularly true because of the traditional tank resource in Sri Lanka which has already shown its utility for food fish production.

The AgEnt Project should select and support two breeders for trialling with ornamental fish cage culture. Preferably one in a traditional tank setting and a second in a riverine setting.

2.9.4 Nutritive Enrichment of Existing Live Foods

Recent technology has produced a micro-encapsulated fatty-acid booster which greatly enhances the nutritive value of live foods fed to juvenile fishes. This has great potential for improving general quality and growth rates of cultured species in Sri Lanka.

The AgEnt Project should support clients in procurement and purchase of micro-encapsulated fatty acid nutritive booster. Predicate support with agreement for initial use to be done with a control to confirm its efficacy in Sri Lanka.

2.9.5 Disease Treatment Training Seminar

The science of detection and treatment of ornamental fish diseases has greatly advanced in the last ten years. Ongoing training seminars are recommended to teach and then reinforce new skills over the course of the project. The National Aquatic Resources Agency has already expressed interest in being the venue for such an exercise.

The AgEnt Project should identify and support an ornamental fish disease specialist who would be willing to commit to a number of short training courses specifically designed for fish breeders.

2.9.6 Investigation and Procurement of Additional Live Foods

As mentioned above, sector members were virtually unanimous in their request for help in finding new and better types of live food for culture in Sri Lanka. A variety of food and culture systems are needed in order to serve the different size requirements of growing fishes.

The AgEnt Project should support investigation of live food options used in other countries for ornamental fish culture. These should be evaluated and the best option procured. These options should be introduced with training seminars detailing culture and optimum use.

2.9.7 Trial Use of Grow-out Polyculture

The efficacy of polyculture, or simultaneous grow-out of compatible species has been demonstrated for select species combinations. This procedure makes maximum use of pond resources. The AgEnt Project should select several clients for support in polyculture trials in pond grow-out phase. This would involve work with clients to develop species groups compatible with existing conditions, and the of purchase new brood stock of selected species as necessary.

2.9.8 Handling/Shipping Training Seminar

Regardless of whether or not an individual breeder is involved in direct export, the product must still be moved a number of times within his own facility and then to the buyer, either local or foreign. Better handling and shipping procedures are mandatory if Sri Lanka is to secure a firm position in the world market. Better handling at each step of production will lead to a better overall product.

The AgEnt Project should support a training seminar introducing optimum handling and shipping techniques.

2.9.9 Development of High Quality Domestic Prepared Fish Foods

The local feed mill, Prima Foods, has already produced a single type of prepared fish food for the domestic aquaculture market. If the sizes and nutritional value of this food could be expanded, then Sri Lanka could perhaps produce a better quality and more standard ornamental fish product. If labor costs and component ingredients are available, it might be possible to develop an export product for the foreign consumer market.

The AgEnt Project should secure samples of prepared fish foods used in other countries and work with local food mill to produce a better product in a wider variety of sizes.

The AgEnt Project might also support investigation and development of high quality fish food designed for domestic and foreign consumer use.

2.9.10 International Exposure for Sri Lanka's Fish Varieties

A number of international exhibitions are staged on a regular basis where new species, color, or fin varieties of fishes are introduced to world markets. Although the number is small, the consultant has observed a few species which could generate interest in the Sri Lankan product at such a venue.

The AgEnt Project should identify international exhibitions most relevant to the Sri Lankan ornamental fish market and support a select number of breeders who have developed unique varieties or succeeded in production of Sri Lanka's endemic fishes.

2.9.11 Trial Grow-out of High Value Imported Species

A relatively recent development in the culture of ornamental fish species is the importation and subsequent grow-out of juveniles of high value freshwater species for eventual re-export. This practice is becoming increasingly common in Florida where higher labor costs are balanced with lower freight rates for imports of juvenile fishes and eventual domestic re-shipment. In Sri Lanka the opposite situation is present; low labor costs but higher air freight costs for eventual re-export. However, the consultant believes that Sri Lanka may be able to both add to their species portfolio and still make a profit by importing seasonally low-cost juveniles of value fishes from other South East Asian countries. Existing wildlife laws allow for such imports.

The AgEnt Project should support a limited number of trials of grow-out species. This would entail purchase during the optimum season for minimum price and development of cost details.

2.9.12 Development of Sri Lankan Cultured Ornamental Fish "Brand"

Sri Lanka currently has little or no consumer market perception. Foreign buyers at the retail level are not generally aware where the fishes that they purchase come from. The development of a Sri Lankan "brand" would serve to unify the export product and if successful could help to ensure that Sri Lanka maintains a healthy market share during depressed market conditions in importing countries.

The AgEnt Project should support the development of a coordinated marketing plan and associated promotional materials for Sri Lanka's ornamental fish export market in cooperation with the Live Fish Exporters Association and Fish Breeders Associations.

3.0 Collection and Export of Freshwater Fishes

3.1 History and Background

The first exports of ornamental fishes from Sri Lanka in the 1930's were almost certainly freshwater fishes, and these were without a doubt collected from wild populations. Export of wild caught freshwater fishes remains a small but important part of the overall ornamental fish sector.

Pethiyagoda (1991) records in his book, Freshwater Fishes of Sri Lanka, 111 species of "freshwater" fishes from Sri Lanka. Included in that number are 21 exotic species which have been introduced either by intention or accident during the last century. The word freshwater is in quotes above because a number of species recorded from freshwater habitats in Sri Lanka are primarily marine species which occasionally find their way into pure freshwater habitats. Many of these species are most commonly collected from the numerous brackish water lagoons which surround Sri Lanka's coastline.

The freshwater fish fauna of Sri Lanka has close affinities with that of India, although Sri Lanka does have a number of endemic fish species. Only a small percentage of the total number of freshwater fish species are regularly collected for domestic and export markets. These fishes are primarily the small and colorful species. Incidental catches of non-ornamental species are generally released although this practice is not always followed, Pethiyadoda (1991).

Collection of freshwater fishes for the ornamental fish market is somewhat unique in Sri Lanka in that the majority of fishes are collected by local collectors in the vicinity of their own village Pethiyagoda (pers. comm.). This is a very important factor in the maintenance of this resource because the individual collector has a much higher stake in his product and the collection habitat. The collector develops a sense of ownership which is the key to maintenance of the resource.

Pethiyagoda (1991) states that because the collection of ornamental fishes focuses only on adult specimens of colorful species, it is self limiting. If a particular species of fish become rare, then it also becomes uneconomical to collect. Collection pressure on that population ends and the populations are given the opportunity to recover. The seasonal monsoons are also a factor in limiting over-exploitation of this resource in that collection is difficult when rivers are muddy and swollen (Pethiyagoda, 1991). Many freshwater fish species also time their reproductive cycles to correspond with these conditions (Breeder and Rosen, 1966). Thus collection pressure is generally lowest during critical reproductive periods.

The IUCN (Anon. 1988) lists three species of Sri Lankan fishes as endangered: *Labeo fisheri, Lepidocephalichthys jonklaasi, and Puntius srilankensis*. None of these are exploited as ornamental aquarium fishes. A further six species are listed as vulnerable: *Malpulutta kretseri, Puntius titteya, Puntius cumingii, Puntius nigrofasciatus, Puntius pleurotaenia*, and *Rasbora vaterifloris* however, recent surveys by Pethiyagoda find the abundance of these species as being common in their restricted natural habitats. Pethiyagoda does, however, note eight species as being endangered although none of these are exported as ornamentals. Their endangered status appears to be primarily due to introduction of food and game fish

exotics, or habitat degradation and destruction. He states "our surveys during the past five years have indicated that the wild populations of fishes exploited by the aquarium fish export industry have not suffered significant decline as a result of the fishery" (Pethyiagoda, 1993).

Current Sri Lankan wildlife laws prohibit the export of the five species: *Belontia signata, Rasbora vaterifloris, Puntius titteya, P. cumingii*, and *P. nigrofasciatus*. There is apparently little or no official enforcement of this. An amendment to existing wildlife laws which would add to this prohibited list, but allow for export permits for some of these species, is being studied. There is some doubt, however, whether it will become law. Pethiyagoda (pers. comm.) states that local fish collectors and exporters have been very cooperative in responding to requests to limit or eliminate collection of species which may not respond well to regular collection pressure. Clearly, self-policing measures of this type are the most effective.

It must be stated here that the crucial factor in the maintenance of Sri Lanka's freshwater fish fauna is the conservation of habitats, not just individual species.

3.2 Wild Caught Freshwater Fish Species Portfolio

Table 2.0 lists all Sri Lankan fish species mentioned by Pethiyagoda (1991) as being of interest to the ornamental fish trade. This list contains 58 species. Of this number three are the result of accidental or directed introductions of exotic species which have thrived to the degree that they are now commercially collected for the domestic and export market. Also included in the total number of 58 species are 5-10 species which are generally marketed as brackish water fishes. Informal market research in the USA conducted by the consultant shows that brackish water species are a driving force behind regular orders from many American buyers.

Many of the 58 species listed in table 2.0 are only seldom collected for export purposes. This is due to many factors including size, coloration, seasonal availability, and most importantly market value. A core of only about 10 species appear to dominate the wild caught export market, and these are exported in large quantities. These are noted with an export rating of 5 on in table 2.0.

3.3 Existing Collection Procedure Overview

As mentioned above, most collections of freshwater fishes are conducted by Sri Lankan collectors working in the vicinity of their own villages. Methods employed are generally small mesh seines or occasionally hand or dip nets. Once collected, fishes are sorted according to species and then transported to an exporter's holding facilities in or near Colombo.

One somewhat unique method of collection for the commercially popular brackish water fishes is the brush pile fishery. Collectors place piles of branches and other brush in a lagoon area. These brush piles are essentially artificial reefs or FADs and are left alone for up to four weeks. Collectors then wade into the shallow waters and surround the brush pile with a seine to collect the fishes which have taken up refuge there. This technique is

apparently very effective and also environmentally friendly.

Exporters prefer to hold fish for as short a time period as possible and often request only certain species be collected to fill specific export orders. Most exporters, however, appear to have a "left over" tank somewhere on their premises for fishes which are not sold with a specific order. Larger exporters, particularly those who have regular weekly shipments to the same buyer, do maintain stocks of key species.

Procedures vary from exporter to exporter for acclimation and quarantine of newly collected fishes. Most exporters are aware of any problem fishes and will often use medications on a prophylactic basis with these species. Fishes must be fasted for a minimum of three days prior to export in order to avoid water quality problems and subsequent mortalities in route, however, it is clear that this does not always happen.

As mentioned above, fishes are generally fasted for several days prior to export, however, it appears that some exporters may use this requirement as a license to avoid feeding regularly or even at all. Healthy adult fishes can easily go a week or more without food, however, longer periods of enforced fast can seriously compromise their health and vigor leading to increased mortalities during export transit.

3.4 Water Quality Awareness

Freshwater fishes as a rule, are more tolerant of changing water conditions than are marine species, due to the often dynamic nature of their natural environment. Long and short term holding facilities vary tremendously from exporter to exporter. In some cases, only aeration and occasional water changes are provided for freshwater species, although most exporters employ some type of basic filter system for their freshwater holding systems. Only one exporter visited had a central filter system for freshwater species.

Each exporter who was visited during this consultancy was asked what water quality parameters were measured and how often. They were then asked to produce their test equipment so that the consultant could view it. In many cases the equipment could not be located, was out of test reagents, or in some cases was brand new and had never been used. Clearly, water quality testing is not a priority, or often even a regular practice. Visual and olfactory inspections of water quality are much more common. While these types of inspections are mandatory, they cannot detect water quality problems which can occur even in crystal clear water.

The most common water quality parameter which was measured with any frequency was again pH (see section 2.4 above). Few exporters had any understanding of how biological filtration works to improve water quality.

3.5 Handling/Packing and Shipping

Larger exporters have the ability to pick up wild caught freshwater fishes from at or near the collection site, while smaller operators rely on the collector to bring the fishes to their facility. The latter case often requires a long bus ride for both the collector and fishes, which may compromise the health of the latter. A few DOA's are not uncommon in these

situations.

Upon arrival at the exporters facility, newly collected fishes are generally counted into plastic containers prior to a short acclimation period which allows adjustment to the individual water conditions. Collectors are usually paid for the fishes at this point.

Newly arrived fishes may be placed alone or added to existing stocks, depending upon size, condition, and species. Few exporters seem to have any type of quarantine facility. Less than half had their individual holding tanks numbered to facilitate record keeping of arrival dates for different groups and species. Most exporters said that their workers were aware of these factors, but it is clear that it would be very easy to lose track of just how long a particular group of fishes had been in holding.

Feeding of wild caught ornamental seemed to be somewhat routine, with prepared foods being supplemented with newly hatched brine shrimp, Artemia species.

All exporters had separate holding tanks for packing water which was often continuously filtered and aerated. Some exporters routinely used low levels of antibiotics in the packing water to curb bacterial growth during shipment.

Most freshwater fishes are packed in groups. This is in contrast to marine fish which are nearly always packed singly. Fishes are netted out of holding tanks by a limited number of staff who routinely perform this task. They are taken to the packing area generally in the water from the tank they were netted from. At the packing table they are placed into new packing water and then into clear plastic polyethylene bags. The bags have a minimum of water which is generally based upon the length of the shipment, and the density and species involved. The bags are then flattened to eliminate atmospheric air and then filled with pure oxygen and sealed with rubber bands. Most exporters use double bags or triple bags depending upon species. Spiny fishes or those which are capable of biting through a bag have newspaper placed between the inner and second bag.

One exporter uses pneumatic bagging machines for packing. The initial cost of such a machine is difficult to justify in light of Sri Lanka's abundant and low cost labor force, however, the particular exporter in question viewed it not in terms of cost effectiveness, but in terms of the foreign buyer's perception of professionalism. The failure rate of rubber bands versus pneumatically installed metal clips is probably about equal. The consultant feels that this is one piece of technology which is not justified at the present time in Sri Lanka.

Another question which was posed to all exporters was standard packing time. Although this will vary depending upon export species and the exporters facility, it can also be seen as a general indicator of care exercised during packing procedures. Responses to this question are listed in figure 1.0.

Once boxes are packed, they are generally taken directly to the airport unsealed. Local security requirements mandate this and they are sealed at the airport after security checks. Air cargo space is always pre-booked, and the largest exporters have standing orders for cargo space for some flights.

3.6 Marketing of Wild Caught Freshwater Fishes

It is clear that the export of wild-caught freshwater fishes in Sri Lanka is only a supplement to either cultured species and/or marine species. See section 2.7 above.

3.7 Human Resources

Human resources in this sector are difficult to judge. No one ventured a guess as to the number of freshwater fish collectors who are involved in this activity. And again, most collectors are locally based and thus operate only seasonally. Several of the largest exporters are said to have their own freshwater fish collectors who work with village based collectors, but this was not observed. Based upon the size of this sector component compared to the wild collection of marine species, there may be as many as 500-1000 seasonal part-time freshwater fish collectors, and probably less than 100 full-time freshwater collectors associated mainly with large exporters.

Most exporters have a division of labor between marine and freshwater species for their employees. Employees dedicated to freshwater species care for both wild caught and cultured species in an individual exporters facility.

3.8 Recommendations

As above, these sector component recommendations are not listed in any particular order. Likewise, some recommendations will be of benefit to the entire sector, while others may be more applicable to individual clients.

3.8.1 Identify Species Which are Candidates for Captive Culture

Many of the 58 species in table 2.0 are potential candidates for culture in existing ornamental fish culture facilities in Sri Lanka. Some of the species which form the core group of popular wild-caught export species are included in this group.

The AgEnt Project should obtain all relevant published information pertaining to the reproduction of species listed in table 2.0. This should be supplemented by a survey of all ornamental fish breeders in country to determine experience and success in the culture of species listed in table 2.0. This information obtained should then be used to rank species which show the potential for economic viability to culture and export. The AgEnt Project should support breeders in trials with these species.

3.8.2 Support Captive Culture and Development of Desirable Color Varieties

A number of the species listed in table 3.1 are known to occur in Sri Lanka in a variety of color forms or varieties. Some of these varieties have much greater market value than others. A second group of species have relatives which have been selectively bred for commercially successful color varieties in other countries.

The AgEnt Project should support interested client fish breeders in the commercial production of known color varieties of existing wild caught species.

The AgEnt Project should support interested client fish breeders in the selective breeding of promising wild-caught species to develop new commercially viable color strains.

3.8.3 Support Trial work with Hormone Induced Reproduction of Key Species

It is clear that there are a number of key species which have never been successfully cultured in captivity, however, other ornamental fish producing countries in South East Asia have begun to have success with the artificial spawning of difficult fishes using hormone inducement. The consultant found no indication that this is being practiced in Sri Lanka, however, it is a logical next step in the development of this sector component.

The AgEnt Project should support interested client fish breeders in the trial use of hormone inducement for spawning key species which are currently being collected wild, either in Sri Lanka or in other parts of Asia.

3.8.4. Support Commercial Production of Threatened Species

As mentioned above, the IUCN has designated several Sri Lankan export species as potentially threatened. Although Pethiyagoda (1991) found little evidence to justify these listings, Sri Lanka can take the first positive steps by culturing these species for export. If successful, this can also become a powerful marketing tool as well.

The AgEnt Project should support select client breeders in the commercial reproduction of the IUCN threatened species.

3.8.5. Disease Detection and Treatment Training Seminar

See section 2.9.5 above for details.

3.8.6. Develop Standardized Packing Procedures for Exporters

Because Sri Lanka is such a long ride from many of its major markets, it must strive to improve and standardize its packing and shipping procedures.

The AgEnt Project should work with foreign buyers at the periphery of Sri Lanka's export market to determine specific areas where Sri Lanka can improve its packing procedures. This information can be used in future seminars and training.

3.8.7 Enhance Filtration Systems for Freshwater Species

Water quality is crucial to the long and short term health of ornamental fish species. Virtually every exporter visited was struggling with this concern. Enhanced filtration systems will improve water quality, decrease stress and subsequent mortality, decrease pressure on wild populations and improve overall quality and market acceptance of Sri Lanka's export product.

The AgEnt Project should support clients with small and large scale improvements to their freshwater holding systems.

3.8.8 Enhance Aeration Systems for Freshwater Species

While aeration is sometimes used to drive filtration systems, it is primarily used to increase the dissolved oxygen in levels in holding tanks allowing optimum stocking densities. Aeration systems also serve as insurance during filter system failures. New technology in the form of regenerative air blowers are energy efficient sources of air for fish holding systems.

The AgEnt Project should support clients in the installation of energy efficient aeration systems using regenerative air blowers.

4.0 Collection and Export of Marine Fishes and Invertebrates

4.1 History and Background

Export of live ornamental marine fishes and invertebrates appears to have begun on a small scale in Sri Lanka in the 1950's. One of the early pioneers in this field was the late Rodney Jonklass, and it is clear in discussions with various exporters that he was a driving force in this entire sector until his death in the late 1980's.

Exports of marine fishes and invertebrates from Sri Lanka have expanded (and contracted) along with commercial air cargo space and routes. Sri Lanka currently exports to virtually all of Europe, the Middle East, Australia, the USA, Japan, as well as other South East Asian countries.

While the keeping of a tropical marine aquarium has in the recent past been something of a challenge, recent advances in filtration and other areas have made it more within the reach of the average aquarium keeper and marine aquarium keeping has grown tremendously during the last decade. Demand for quality exotic fishes has grown along with this and Sri Lanka is now well established as at least a minor exporter to many of the countries listed above.

The key strength of the Sri Lankan marine fish export market is the methods used by Sri Lankan collectors to capture their fishes. The main source for ornamental marine fishes worldwide is the Philippine Islands, however, the unfortunate and unscrupulous practice of using chemicals to collect Philippine fishes is wide spread. Most US importers estimate that more than 90% of the fishes exported from the Philippines are collected with sodium cyanide. This drug kills many fishes immediately as well as damaging the reef. A large percentage which do survive initial collection are doomed and end up dying during the next four to six weeks.

Because this situation has grown worse and has spread to Indonesia as well, many importers are looking for other sources to supply quality marine fishes. Sri Lanka enjoys the worldwide reputation, at least among foreign importers, of having only drug-free, net caught fishes. Foreign buyers are willing to put up with high air cargo rates, long shipping times, and often poor quality packing in order to obtain net caught marine fishes.

A second important factor in the development of Sri Lanka's ornamental fish export market is the species portfolio itself. Sri Lanka's location in the center of the vast Indo-Pacific faunal region makes it a treasure house of fish and invertebrate diversity. This is particularly true for the US market which pays premium prices for Indian Ocean fishes and invertebrates. Thus the combination of Sri Lanka's drug free, net caught fishes and the uniqueness of many of the abundant Indian Ocean species are the keys to Sri Lanka's ornamental marine fish export market.

Beginning in 1980, Sri Lankan exporters began to import fishes from the Maldive Islands for re-export to their foreign customers. This link was apparently designed to add additional species to Sri Lanka's export portfolio as well as to supplement quantities of certain species during seasonal monsoon periods which make collections difficult in certain areas around

Sri Lanka. Domestic unrest also apparently made collections in some parts of Sri Lanka difficult as well.

There are no data detailing the current population health or size of the various species of ornamental marines commonly collected for export from Sri Lankan waters. Seasonal monsoons preclude collections in most areas for at least half of a given year, but it is unknown if these periods are sufficient to maintain populations. Furthermore, it is unclear how much of the juvenile fauna which dominates collections comes to Sri Lanka via larval drift from nearby areas in the Indian Ocean such as the Maldive or Andaman Islands. Current exports appear to be the same species which have been exported for the past twenty or more years. Many species are reported to be more common one year than another, but this is probably more a function of larval recruitment than overcollection, nevertheless, it is clear that estimates of population health and sizes are needed to evaluate assistance to this sector component.

4.2 Wild Caught Marine Fish and Invertebrate Export Species Portfolio

It is difficult at best to put an accurate count on the number of fishes and invertebrates which are regularly or occasionally exported from Sri Lanka. As mentioned above, this list is supplemented with fishes which originate in the Maldives as well as occasional shipments from the southern Red Sea. Table 3.0 is a composite of the main fish species exported from Sri Lanka on a regular basis and is based upon both exporter sales lists and direct observations during client visits. Probably somewhere in the order of 200 species occur on price lists, although many of these are collected only seasonally or rarely.

This 200 species represents about 150 species of fish out of perhaps 600-800 in the waters surrounding Sri Lanka and 50 species of invertebrates out of easily over 1000 species in the same area.

Although nearly 200 species may appear on price lists, it is clear from client visits that a core group of species account for perhaps two thirds of every shipment. Once again, it must be stated that individual exporters may have cultivated particular niche markets, and different importing countries often have differing tastes in fish and invertebrate species. It is clear, however, that a key group of cornerstone species are crucial to the current export market.

4.3 Existing Marine Fishes and Invertebrates Collection Procedures Overview

The information presented in this section is based upon discussions with marine fish exporters, some of whom are former collectors themselves. Although plans were made for direct observation and questioning of individual collectors, this was not possible due to circumstances beyond the control of the consultant.

As mentioned above, marine fishes and invertebrates are collected with hand and hand nets by both SCUBA and skin divers. The latter are most often part-time collectors who may work only in the vicinity of their own village, and the former are generally full-time collectors who move around the island depending upon weather conditions.

Estimates for the total number of marine fish and invertebrate collectors in Sri Lanka varied widely, even among those who should have a good idea, including other collectors and major exporters. It appears that there are somewhere between 500 and 1000 full time SCUBA diving collectors and perhaps as many seasonal part-time opportunistic collectors.

Although several of the largest exporters have their own teams of divers, most exporters spoken with during the consultancy have found that divers generally took better care of the diving equipment if the divers owned it. Most exporters who used this system had loaned the collectors money to purchase equipment and then allowed them to pay it off slowly during the course of selling their catch back to the exporter. Another problem which led to this development was that collectors who were formerly supplied with equipment by individual exporters would often sell their catch to the highest bidder on the beach and not necessarily the one who supplied their equipment.

Full-time collectors who utilize SCUBA generally collect in the 10-40 meter depth range using 3-4 cylinders of compressed air per day. The deepest dives are generally the first of the day in accordance with safe diving practices. Certain species may require dives to depths of 50 or more meters, but this appears limited.

Collection of marine fishes and invertebrates is highly seasonal in Sri Lanka and directly related to the annual monsoon cycles. The West and South Coasts are collected during the period from about November through April and the East Coast is collected from May through November. There is apparently some overlap depending upon the onset of the monsoon.

Collectors on SCUBA utilize a variety of hand nets depending upon the species that they are seeking. Once an individual fish or invertebrate is captured, it is placed in a plastic bag which is secured in the diver's weight-belt. Often a diver will work with a "tickler" and a net for most effective capture. The tickler is generally a short length of stainless steel wire which is blunted on the end and can be used to coax a fish out of a crack or crevice and into a waiting net.

Skin diving collectors are said to most often use what is locally called a "moxy net". The moxy net is usually about a meter square and has weighted edges and a float in the center. The diver swims on the surface following a target fish until it tires and hides. The net is then dropped in such a way as to entrap the entire area where the fish is believed to be hiding. The diver then swims down and attempts to drive the fish into the moxy net or sometimes a hand net. Most of the incidental damage done to reef habitats probably occurrs from skin divers using moxy nets. Their use should be discouraged or outlawed.

Another important collection method is apparently night diving. Most ornamental marine fishes in Sri Lanka are diurnal. Although many diurnal species are difficult to even locate at night, others are much easier to catch as they are found "asleep" in various locations in and around the reef. Night diving obviously requires the use of underwater lights.

Marine fish collection in the Maldives is similar except that the moxy net is not used. There appears to be an even mix of Sri Lankan and Maldivian collectors currently operating in the Maldives, with the Sri Lankans having trained the Maldivians in collection techniques.

Exporters have apparently agreed not to buy either tiny juveniles or large adults of most species and the collectors no longer target these sizes.

4.4 Holding and Transport to Colombo

At the end or each collection dive, the species collected are transferred either to the boat or beach depending upon venue. Some species such as high value and often territorial angelfish species are placed in individual plastic bags at this point. Other species of fish and invertebrates are placed together in plastic holding containers until the end of the day. The boat tender is responsible for maintaining water quality during the course of a day's collections by making regular water changes. Fishes which wait on the beach are apparently often bagged individually to await the arrival of buyers at the end of the day.

Collections which occur seasonally on the West Coast usually end up in the exporter's holding tanks within 12 to 18 hours of collection. Buyers from an individual exporter often travel to areas where collectors are working to purchase newly collected species, but many collectors will bring their collections to the exporter's facility.

East coast collections are much more complicated and a variety of systems exist. The largest exporters maintain small holding facilities in Trincomalee. Fishes are brought there daily by both buyers and collectors and then taken by truck to Colombo every few days. Other exporters maintain fishes in plastic bags with oxygen from the time they reach the beach until the next regular truck run to Colombo. Fishes collected early on is such a cycle may sit in bags for 36-48 hours or more, often without a water change.

Most truck runs occur in open trucks, although the roof of the bed may be covered. Regardless of how they are held in the East, all fishes and invertebrates are transferred to Colombo in plastic bags filled with water and pure oxygen. These bags are packed into open wooden crates. Most transport occurs during the night or early morning hours to avoid the heat of the day. Bags which are exposed to direct sunlight are subject to the greenhouse effect.

Once reaching an exporter's facility in Colombo, the bags are unpacked and the animals generally go through some type of acclimation procedure prior to being placed into the exporters holding tanks.

4.5 Water Quality Awareness and Holding Systems

Although there are only ten to fifteen exporters of live marine fishes and invertebrates in Sri Lanka, there is a wide variety of holding and filtration systems. These range from bare glass tanks which have only aeration to fairly sophisticated central water filtration units which service hundreds of holding tanks.

The exporters with the most advanced systems are often patterned after the systems used by their foreign buyers, but in most cases the exporter really didn't know how and why his system worked, or how to get the most out of it.

Marine fishes and invertebrates have evolved in a very stable medium and most species are

not well adapted to abrupt changes in water quality parameters. It is clear that improvements made in these areas can dramatically decrease mortalities during holding and shipping and thus decrease pressure on wild populations, as well as improving the quality of the product. This factor was mentioned by most US importers of Sri Lankan marine fishes contacted by the consultant prior to arriving in Sri Lanka.

All exporters utilize natural seawater in their holding systems although the quality of such water is often compromised when collected during periods of heavy rain. Water quality testing follows the same pattern as discussed in 3.4 above.

Again, less than half of the marine fish exporters visited had their holding tanks numbered to facilitate record keeping and separation of new and old stock. A number of marine fishes were noted which had obviously been in holding for many months and were poorly fed during that time period.

4.6 Foods and Feeding

Marine fishes are generally less willing to take prepared foods than are freshwater species. In addition they have the added disadvantage of not normally feeding at the surface. Most marine fish exporters practice only minimal feeding of their animals in holding.

Newly hatched brine shrimp, *Artemia* species, are cultured and used to feed some filter-feeding invertebrates. Most exporters appear to feed marine species only haphazardly and use primarily fresh foods such as prawns or fish cut to appropriate sizes.

4.7 Disease Detection and Treatment

Marine species, with the exception of invertebrates, are often much more subject to contagious parasitic diseases then are freshwater species. Exporters who have central filtration systems generally also have in-line ultra-violet sterilization systems, however, it is clear that the germicidal bulbs used in these systems are not changed often enough for maximum efficacy.

A number of exporters also regularly or occasionally use copper sulfate as an paracide in their marine fish systems. Although this is a common practice, it is apparently accomplished in Sri Lanka without the benefit of copper test kits. This is both dangerous and remarkable since the difference between a therapeutic dose and a lethal one is only about 0.05 parts per millon.

General disease diagnosis and treatment is much the same as for freshwater species as mentioned above in section 2.5. Improvement in this area will decrease mortality, decrease pressure on wild populations, and increase both overall quality and foreign perception of quality.

4.8 Packing and Shipping Procedures

Although packing techniques vary from exporter to exporter, it is clear that improvements can be made in the entire sector. The number one complaint voiced by US importers of Sri

Lankan fishes was poor packing. And because the US is such a long ride away from Sri Lanka, there is little room for sloppiness.

All exporters had separate packing water holding facilities which were generally filtered and in some cases also had ultra-violet sterilization equipment in use as well.

Virtually all marine fishes are bagged individually in clear polyethylene bags. Double and triple bags are common with a newspaper between layers for spiny species or those which are prone to bite bags.

Some exporters use low doses of antibiotics in packing water and one exporter uses a buffer to maintain water quality during shipping. The amount of packing water is kept to an absolute minimum in order to keep freight rates down. Theoretically, this amount is varied with length of transit time to destination, but it is clear that this does not always happen. Such mistakes lead to needless DOA's or severely stressed animals at arrival. Shipping bags are emptied of atmospheric air and then refilled with pure oxygen and sealed with rubber bands.

All exporters use the same locally manufactured styrofoam box for shipping fishes. During the hottest times of the year, shipping boxes are iced down to maintain temperatures. While this is often hard to avoid, it is a tricky practice at best.

As with exports of freshwater fishes above, marine aquatics are taken to the airport unsealed for security checks and then sealed at the airport. The largest exporters have standing orders for cargo space on select flights while smaller exporters generally book from two days to one week ahead for space. Only rarely, are live fish shipments bumped from flights.

4.9 Human Resources

This sector component is still the most profitable and complicated with the greatest number of employees from collectors and boat tenders to packers and aquarists. Probably somewhere between 2000-3000 persons are employed either directly or indirectly in this sector component. It is interesting to note that several of the largest export companies were started by marine fish collectors many years ago.

4.10 Environmental Issues

The collection of marine fish and invertebrates in natural areas can be seen at a basic level as an extension of fishery practices around the world. But because the activity takes place almost entirely underwater and out of view, there is much suspicion and concern that has arisen from the development of this sector. This concern is exacerbated by collection abuses with chemicals like sodium cyanide in the Philippines and Indonesia.

There is currently only one Sri Lankan ornamental marine species group which is recognized as endangered internationally. These are the giant clams of the genus *Tridacna*. These invertebrates are widespread in the Indo-Pacific, but numbers of large individuals have dramatically declined due to fishing pressure for food use and the sea shell trade.

Giant clams are now being cultured for the ornamental aquarium trade in Palau.

Looming on the horizon is the listing of all stony reef building corals on appendix I of the CITES list. The market for a limited number of living coral species has grown almost exponentially in the last decade as the technology required to maintain them long-term in captivity has been mastered. It is clear that the CITES ban will eliminate this trade.

The biggest dilemma surrounding the collection of ornamental marine fishes and invertebrates is the lack of understanding of just what effect the selective removal of species may have on a reef community. This has not been well studied at all and most of the marine fish exporters in Sri Lanka expressed a desire to help in this kind of basic research. An environmental assessment directed at this question would be most appropriate.

The basic problem in understanding what effect selective collection may have is that natural fluctuations in species and densities are very common on coral reefs and reef areas. These effects must be factored out before the true effect of removing select ornamental species can be determined.

The major concern facing the future of coral reefs in Sri Lanka is not collection of ornamental species, but wholesale destruction of the reef by coral mining for the construction industry. Once again, it is the habitat and not the species which must be maintained. And one thousand plus divers whose future livelihood depends upon the health of this resource may represent the best policemen and management agents possible.

It is clear that collection of ornamental fishes and invertebrates is not totally environmentally benign, however, neither is artesianal or trawler fishing in Sri Lanka. The consultant strongly feels, after discussion with those involved in this sector, that the number of collectors is small enough to be able to positively influence to become the care-takers of a renewable resource. The goal is to engender a feeling of ownership of the resource which will lead to by far the most effective practice of self policing.

The exporters spoken with during this consultancy have already agreed to a tentative self-imposed voluntary ban on the export of "cut flower" marine fishes, that is, those species which will not survive in captivity due to dietary requirements. This proposal will be discussed further at the sector presentation scheduled at the end of the consultancy. The number of species involved in this voluntary ban is small (see Table 4.0), but it may ultimately lead to enhanced acceptance of the Sri Lankan export product in western markets. In this manner, the collectors and exporters may see positive environmental steps pay off in terms of enhanced prices for fishes supplied by environmental conscious collectors and exporters.

4.11 The Maldives Connection

As mentioned in the history portion of this sector component, the Maldives were first cultivated as a potential source of ornamental marine species in 1980 by late Rodney Jonklass. Figure 4.1 shows the development of this collection export product since that time. As air cargo routes from Male have opened up, the Maldives have begun to direct export ornamental marine fishes to European, Japanese, and even occasionally American

markets. The majority of fishes, however, are exported to Colombo for re-export to Sri Lanka's international buyers.

The Maldive Islands have dedicated the major portion of their economy to tourism, and have been unusually successful in this endeavor. They are recognized by many as having the best SCUBA diving on the planet. One step which the government of the Maldives took to help place themselves in this position was to ban spear-guns from the entire island chain nearly twenty years ago. Their move into the ornamental fish collection and export market has been a cautious one based on concerns of possible conflict with tourist interests.

Wood (1985) reports that the Maldives had instituted a quota ceiling system on the collection and export of marine fishes which was designed to hold the export numbers in the 40-50,000 fish per year range until general effects could be determined. The consultant was able to travel to the Maldives as a part of this consultancy and interview both government officials and exporters.

The results of these discussions were both surprising and encouraging for the Sri Lankan import/re-export market. Results of studies based on coral mining activities and their effects on coral reef communities were extrapolated for the collection of ornamental fishes. The Ministries of Fisheries and Trade and Industry are now convinced that ornamental fish are a renewable resource which can be safely collected in the island chain, without detriment to the tourist industry or the resource itself. They have chosen, however, to focus only on fish species and very few invertebrates are collected for export.

Up to this point, all of the collection of ornamental species in the Maldives has been carried out in the vicinity of the Male atoll which comprises only a very small part of the nearly 1200 islands in the group. The government feels that the potential for ornamental export is thus tremendous and are pleased with the initial foreign exchange earnings.

There are currently five collector/exporter stations operating in the Maldives. Some of these are jointly owned by Sri Lankans and export exclusively to Colombo for re-export, while Maldivian owned concerns do both direct export and to Colombo. As mentioned above, the collectors themselves are a mix of Sri Lankan and Maldivian. All appear to practice ethical collection techniques learned from Sri Lankan collectors.

The Ministry of Fisheries in cooperation with the Ministry of Trade and Industry have essentially eliminated the quota system for most species. Everyone spoken with mentioned the existence of some species which were either banned or still under a quota, but no one including government officials could tell what species were involved, with a single exception. Apparently, some species endemic to the Maldives are potential concerns, as well as the exception, the Cleaner Wrasse, *Labroides dimidiatus*. The latter is wide-spread and abundant in the Indo-Pacific and not a highly targeted ornamental species, however, it is officially banned from export. The reason for the export ban on this species is related to its' known behavior of removing parasites from larger reef fishes. A ban on this species is perhaps over-cautious but has little effect on the total market.

Wood (1985) also mentions a ban on collections of ornamental within 3000 feet of any tourist island, however, none of the government officials or exporters spoken with were

aware of any such ruling. However, the collection areas, even in the vicinity of Male atoll are large and collectors are unlikely to ever collect near tourist islands.

The major exporter on Male visited by the consultant had a more sophisticated filtration and holding system than anything seen in Colombo, which was something of a surprise. This system was completed just as the quota system went into effect with near disastrous cash flow results, however, the exporter has recovered in recent years. Other exporters in the Maldives apparently have much more primitive systems, more so than even the most primitive in Colombo.

There are two basic camps concerning the import of ornamental fishes from the Maldives into Sri Lanka. Many Colombo exporters are reluctant to buy fishes from the Maldives due to the history of poor handling and subsequent DOA problems with the short ride from Male to Colombo. Some exporters had stopped buying Maldivian fishes because of DOA's which reached 30 or 40%. Other exporters, especially the larger ones who either have their own collectors in the Maldives or the clout of large orders have increased their purchases of Maldivian fishes as world demand has increased. Because export figures of ornamental fishes are not broken down by country, it is difficult to determine just how big a role they play in Sri Lanka's export market. It is clear, however, that the positive stance that the Maldives government has taken towards this sector will be helpful for the Sri Lankan sector. Overall, a 15-20% figure is probably accurate for the percentage of Sri Lankan marine fish exports which originate in the Maldives.

Officials at the Maldives Ministry of Fisheries were also eager to play a role in any formal or informal survey on the effects of selective collection of ornamental fishes. Such studies would be in many respects easier to control in the Maldives.

Although the Maldive Islands are subject to the same South-west monsoon influence as is Sri Lanka, collecting goes on year around, stopping only for the worst storms which make boat travel and diving difficult.

4.12 Marketing of Ornamental Marine Fishes and Invertebrates

Several of the biggest marine aquatics exporters have had some of the same buyers for decades. This sort of arrangement is the goal for most exporters; that is, to have a regular and reliable customer who buys a fairly set amount of fishes on a weekly or bi-monthly basis.

The largest exporters travel every year or two to visit their buyers and try to locate new buyers. Most mentioned that they did not look for new buyers in the same city or area where they already sell to avoid competition problems. Few exporters advertise except at regular trade fairs such as AQUARAMA in Singapore or INTERZOO in Germany.

Many marine fish exporters have been successful in developing niche markets for the species they sell. These were a closely guarded secret and will not be revealed here.

The largest exporters generally had a mixture of several large regular buyers and a number of smaller infrequent buyers. The smaller exporters often had as many as twenty five

foreign buyers, few of which ordered on a regular basis.

Ordering is nearly always conducted by fax and nearly all of the exporters had a fax machine on site. An in-stock species list is faxed out to buyers and they fax back their order with preferred arrival times and flight details. Buyers always pay for the freight costs, although some exporters will pre-pay for their best customers.

Acceptance of DOA percentages varied from a couple of percent to as high as 10% for some exporters. There is a direct correlation between this figure and general quality of the shipped species and packing and handling procedures. DOA notification varied with individual customer and was based on previous history. It is clear that some foreign buyers take advantage of this situation, and claim DOA's which are not. Some exporters deal with this problem by requiring a polaroid photo of the DOA's with the date imprinted. This is then mailed to Sri Lanka for credit on a future order. DOA's caused by air cargo errors are shared by exporter and buyer after getting as much as possible from the airline, although airlines are reluctant to compensate even when they are clearly at fault.

4.13 Recommendations

4.13.1 Begin Formal Survey on Effects of Selective Ornamental Marine Species Collection

Most exporters spoken with in both Colombo and Male were aware to some degree, of both sides of the marine fish and invertebrate collection coin. On one side is a renewable resource which provides thousands of jobs and valuable foreign exchange. On the other is a growing environmental awareness and concern about the possible detriments of this and any other type of utilization of such a resource.

Collectors and exporters have begun small steps of self policing, and as mentioned above are willing to make positive environmental steps such as a voluntary ban on the export of obligate coral feeding butterflyfishes or "cut flower" fishes. Virtually every exporter spoken with was supportive of research which would determine what some of the effects of their collection efforts are, and all realized that the results of such research would potentially modify both their species portfolio and collection venues.

The AgEnt Project should support an environmental study relating to this component sector. This would be a study of the effects of selective collection of ornamental marine fishes and invertebrates. The results of this study will clearly influence any AgEnt support of this sector component.

4.13.2 Support Ban on "Cut Flower" Fishes

As mentioned, there are a small number of fish species which are doomed to death by starvation in captivity. Exporters and collectors spoken with seem to understand both the cost and potential marketing benefits of beginning a voluntary ban on the export of these species. See related recommendation 4.13.3 below.

The AgEnt Project should support a voluntary ban on the export of such "cut flower" species.

4.13.3 Identification Card for Sri Lankan Reef Species

There are two keys to the success of positive environmental steps such as 4.9.2 above. The first is the interpretative aspect at the beginning of the export chain; the collectors. They must be able to understand what is asked of them and the value of supporting such a decision. The second key is to make the final consumer aware of the positive steps which the already drug-free Sri Lankan collectors are taking.

As an environmental initiative of the AgEnt Project, AgEnt should support the design, printing, and distribution of laminated card which would identify Sri Lanka's reef species as well as highlighting those Sri Lankan species which are voluntary banned from export. The primary use of such an identification card would undoubtedly be with the tourist market. Most tropical island tourist destinations have such identification cards.

4.13.4 Pioneer Marine Fish Breeding Facility in Sri Lanka

Virtually no marine fish species are cultured for ornamental use due to the difficulty and expense involved, however, there are a number of species which are showing promising results in small scale production in the US and the Caribbean. Sri Lanka's low-cost and abundant labor might be the balancing factor necessary to make such culture economically viable.

The AgEnt Project should aggressively support efforts of any interested clients to pursue the commercial culture of marine species in Sri Lanka. AgEnt should work with American marine fish culture facilities to develop a technology transfer package suitable for a select number of ornamental aquatics clients.

PROVISO: The following recommendations should be considered following a EIA of this sector by USAID.

4.13.5 Enhance Filtration Systems for Marine Aquatics

Even Sri Lankan exporters who had the most advanced filtration systems could benefit from improved technology and techniques. Improvement in water quality will give immediate benefits by decreasing both in-house mortalities and shipping DOA's. This translates into less pressure on wild populations and higher quality and subsequent customer satisfaction. See 3.8.8 above.

The AgEnt Project should consider support of selected clients with both large and small improvements of marine filtration systems.

4.13.6 Enhance Aeration Systems for Marine Aquatics

While most marine aquatics exporters have aeration systems of some type, they are often inadequate and utilize energy inefficient air production systems. Assistance in providing new air systems will help to increase dissolved oxygen levels in holding systems and thereby increase holding capacity and decrease stress levels in holding situations. Energy efficient American blowers will decrease running costs and allow energy saved to be used in other sectors of Sri Lanka.

The AgEnt Project should consider support of client procurement, purchase, and installation of energy efficient air systems.

4.13.7 Filtration Theory and Practice Seminar

As mentioned above, marine ornamental aquatics are much less tolerant of changes in water quality then are their freshwater counterparts. Filtration is the management tool for water quality and to be properly implemented, it must be properly understood. Each marine exporter has a minimum of two to three employees who would benefit from a seminar dealing with filtration theory and practice. These benefits for the employee will translate directly into benefits for the livestock during holding and shipping; again leading to decreased mortalities and DOA's.

The AgEnt Project should consider supporting consultant led seminar series on water filtration theory and practice for employees of exporters.

4.13.8 Marine Fish Disease Detection and Treatment Seminar

This recommendation is similar to above recommendation 2.9.5, except that it would focus on disease detection and treatment of marine fish diseases.

4.13.9 Annual Meeting for Marine Fish Collectors

Marine fish collectors in Sri Lanka are not licensed and belong to no organizations, however, they all operate on the West coast near Colombo during the winter months. If they could be brought together for annual seminar presentations on environmental issues, collection and handling techniques, etc, it could bring tremendous benefits for the environment, the divers themselves, and the sector as a whole.

The AgEnt Project should spearhead a plan to bring all marine collectors together for an annual informational training seminar in Colombo each winter.

4.13.10 Marine Aquatics Packing and Training Seminar

See section 3.8.7 above.

5.0 Collection and Culture of Ornamental Aquatic Plants

5.1 History and Background

The ornamental aquatic plant export market was originally not a focal point of this consultancy, however, during the course of client visits it is clear that this sector component is growing along with world demand. Ornamental aquatic plants have probably been exported in small numbers from Sri Lanka for many years. It is entirely likely that the first exports of freshwater fishes aboard steamships also contained aquatic plants, even if only as a floating shade cover.

For many years the strongest market for aquatic plants has been Europe, but demand has been growing in the US market as species variety and quality has increased. Sri Lanka is now firmly established as a supplier of freshwater aquatic plants in both bulb form, cuttings, and entire plants. The latter are sold both potted and bare-root.

Figures are unavailable for quantities and species involved, but several of the largest exporters have regular shipments in excess of 100,000 *Aponogeton* bulbs per month. The majority of these bulbs, and plants as well, are collected in the wild. Several exporters and breeders have recently begun propagating a variety of species for export.

It is unknown what the extent of the natural resource is, but it is clear that assistance to growers of ornamental aquatic plants can lessen the pressure on wild populations as well as giving a more standard and higher value product to the export market. One exporter of collected aquatic plants mentioned growing government concern with the quantities that are routinely exported.

5.2 Ornamental Aquatic Plant Production Procedure Overview

This section will focus on culture of aquatic plants as no observations of plant collection were made during the course of this consultancy.

Several exporters and breeders visited during the course of this consultancy are either involved in trialling and export of ornamental aquatic plants, or mentioned this area as one where their expansion plans focused.

A variety of systems were used for culture, from cuttings planted in individual plastic pots to a simple ground pond which received the nutrient rich overflow from fish grow-out ponds. All work in this sector component sector is proceeding on a very low-tech basis, although at least one exporter expressed interest in investigating the applicability of tissue-culture technology to this sector component.

5.3 Shipping and Handling of Ornamental Aquatic Plants

Ornamental aquatic plants are obviously much easier to ship than are live fishes and invertebrates. The can be packed moist or even dry, and very dense as well. All are exported by air cargo in card-board rather than styrofoam boxes.

Depending upon country of destination, exporters secure certificates stating that the shipment is free of plant diseases. The costs of such certificates is added to the order.

5.4 Recommendations

5.4.1 Support Trial Aquatic Greenhouse Production

As mentioned above, several breeders and exporters have begun to culture ornamental aquatic plants on a limited export basis. Early indications are that this will be very successful and decrease pressure on wild populations.

The AgEnt Project should support client expansion of trial culture systems for ornamental aquatic plants.

5.4.2 Support Local Production of Marketable Aquatic Plant Pot

Highest market value is given to potted aquatic plants, but Sri Lankan aquatic plant growers have been forced to adapt a locally produced plastic pot for export use. The raw materials for the correct type of pot are available as is the manufacturing capability, however, aquatic plant growers have been unable to come up with the necessary funds to pay the one-time costs of having several molds made.

The AgEnt Project should support the production of locally produced aquatic plant pots by helping to fund the costs of producing several different size plant pot molds.

5.4.3 Investigate Applicability of Tissue Culture Methods for Ornamental Aquatic Plant Propagation

Tissue culture methods have proven of great value in large scale propagation of terrestrial plants and some aquatic plants. It is unknown if this method has applicability in the Sri Lanka ornamental aquatic plant export market.

The AgEnt Project should support investigation of applicability of tissue culture technology for the ornamental aquatic plant culture market.

6.0 Sectorial Recommendations

This report has been purposely divided into the above four sector components to facilitate organization of this report as well as to recognize natural divisions which exist with the sector today. However, where as above there are some recommendations which are common to each sector component, there are others which are best presented in a sectorial context here.

6.1 Investigate Easing of Local Air Cargo Constraints

One factor which is shared by all live aquatics exporters from Sri Lanka is the airport imposed mandate which requires all export shipments to be delivered to the airport unsealed and a minimum of four hours prior to shipment. This time period is sometimes lengthened to six hours for some airlines. Internal security concerns have brought about these requirements.

A two hour lead time is normal in most international air cargo situations, and there is little doubt that the extra time period required in Sri Lanka causes a decrease in product quality. This is especially true in very long flights which push the limits of safe transport of live aquatics. Further investigation of this area may lead to mutually acceptable compromises which benefit the sector.

The AgEnt Project should initiate a proposal for the investigation of air cargo flight cut-off requirements and potential compromise modifications.

6.2 Investigate Expansion of Existing Sector Organizations into Co-ops

As mentioned above, both the live fish exporters and the fish breeders have already formed organizations. Also mentioned above is the fact that many types of sector supplies are difficult to obtain at cost effective prices in Sri Lanka. The development of a co-op organization to obtain and distribute such supplies could be a very effective improvement to the entire sector.

The AgEnt Project should support and facilitate the development of co-ops within existing sector organizations, or alternatively the development of commercial import suppliers.

6.3 Promotional Campaign for SL Fishes in Consumer Publications

Aquatic species from Sri Lanka have numerous advantages on the world market. Few consumers are aware that Sri Lanka is even a supplier of ornamental. An inexpensive media campaign to highlight some of these attributes could create interest and demand for the Sri Lankan product.

The AgEnt Project should consider supporting an ongoing promotional campaign for Sri Lankan ornamental aquatics in consumer publications in US, Europe, and Japan.

6.4 Fish Disease Diagnostic Equipment

As a follow-up to disease detection and treatment seminars detailed above, exporters and breeders will need to have access to various types of diagnostic equipment. This type of equipment is either difficult or impossible to obtain in Sri Lanka.

The AgEnt Project should support procurement and purchase of relevant disease diagnostic equipment for the sector.

6.5 Water Quality Diagnostic Equipment

As a follow-up to water quality/filtration improvements, exporters and breeders will need to obtain individual water quality test equipment and extra reagents.

The AgEnt Project should support selection, procurement, and purchase of water quality test equipment.

6.6 Critical Reference Book Procurement

The availability of reference books on sector subjects such as water quality, disease treatment, etc is almost non-existent in Sri Lanka. While AgEnt already has the beginnings of a library which will help with this problem, there are a number of reference books which should be in the hands of individual clients in the sector.

The AgEnt Project should support clients in procurement and purchase of a small number of critical reference books for their exclusive in-house use.

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TABLE 1.0

Commercially Cultured Ornamental Freshwater Fishes in Sri Lanka

Species	Common Name
Aphyocharax anisitsi	Bloodfin Tetra
Gymnocorymbus ternetzi	Black Widow Tetra
Hasemania nana	Silver Tip Tetra
Hemigrammus caudovittatus	Buenos Aires Tetra
Hyphessobrycon herbertaxelrodi	Black Neon Tetra
Hyphessobrycon pulchripinnis	Lemon Tetra
Hyphessobrycon serpae	Serpae Tetra
Megalmaphodus megaolpterus	Black Phantom Tetra
Moenkhausia oligolepis	Red Eye Tetra
Pristella riddlei	Pristella
Carassius auratus	Goldfish
Cyprinus carpio	Koi Carp
Tanichthys albonubes	White Cloud
Brachydanio albolineatus	Pearl Danio
Brachydanio frankei	Leopard Danio
Brachydanio rerio	Zebra Danio
Capeota tetrazona	Tiger Barb
Capoeta titteya	Cherry Barb
Puntius conchonius	Rosy Barb
Puntius nigrofasciatus	Black Ruby Barb
Poecilia reticulata	Guppy
Poecilia latipinna	Molly
Poecilia sphenops	Molly
Poecilia velifera	Sailfin Molly
Xiphophorus helleri	Swordtail
Xiphophorus maculatus	Platy
Astronotus ocellatus	Oscar
Cichlasoma meeki	Firemouth Cichlid
Microgeophagus ramirezi	Golden Ram
Melanochromis auratus	Auratus Cichlid
Pelvicachromis pulcher	Kribensis
Pseudotropheus lombardoi	Lombardoi Cichlid
Pseudotropheus species	Blue Malawi Cichlid
Pterophyllum scalare	Angelfish
Saratherodon mossambicus	Mossambica Mouthbrooder
Betta splendens	Fighting Fish
Colisa lalia	Dwarf Gourami
Colisa chuna	Honey Gourami
Colisa labiosa	Thicklip Gourami
Helostoma tenninck	Kissing Gourami
Macropodus opercularis	Paradise Fish
Trichogaster leeri	Pearl Gourami
Trichogaster pectoralis	Snakeskin Gourami
Trichogaster trichopteru	Three-spot Gourami
Glossolepis incisus	Red Rainbowfish
Melanotaenia nigrans	Australian Rainbowfish

TABLE 2.0

Wild Caught Freshwater Fishes Exported from Shri-Lanka
(listed in taxonomic order)

Export Rating	Scientific Name	English Name
1	*Anguilla bicolor*	Level Finned Eel
4	*Chela laubuca*	Blue Laubuca
5	*Danio malabaricus*	Giant Danio
3	*Danio pathirana*	Barred Danio
2	*Esomus thermoicos*	Flying Barb
2	*Garra ceylonensis*	Stone Sucker
3	*Puntius asoka*	Asoka Barb
3	*Puntius bimaculatus*	Redside Barb
1	*Puntius chola*	Swamp Barb
5	*Puntius cumingii*	Cuming's Barb
3	*Puntius dorsalis*	Long Snouted Barb
5	*Puntius filamentosus*	Filamented Barb
5	*Puntius nigrofasciatus*	Black Ruby Barb
4	*Puntius pleurotaenia*	Blacklined Barb
2	*Puntius sarana*	Olive Barb
2	*Puntius ticto*	Tic-tac-toe Barb
5	*Puntius titteya*	Cherry Barb
2	*Puntius vittatus*	Silver Barb
4	*Rasbora caverii*	Rasbora
4	*Rasbora daniconius*	Striped Rasbora
4	*Rasbora vaterifloris*	Golden Rasbora
4	*Lepdidocephalichthys thermalis*	Common Spiny Loach
3	*Acanthocobitis urophthalmus*	Tiger Loach
2	*Schistura notostigma*	Banded Mountain Loach
1	*Mystus gulio*	Long-whiskered Catfish
1	*Mystus keletius*	Yellow Cat Fish
3	*Mystus vittatus*	Stripped Dwarf Catfish
1	*Ompok bimaculatus*	Butter Cat Fish
1	*Clarias brachysoma*	Walking Cat Fish
1	*Heteropneustes fossilis*	Stinging Cat Fish
1	*Zenarchopterus dispar*	Halfbeak
1	*Oryzias melastigma*	Blue Eye
4	*Aplocheilus dayi*	Day's killifish
3	*Aplocheilus parvus*	Dwarf Panchax
4	*Aplocheilus werneri*	Werner's Killifish
3	*Xiphophorus helleri* **Introduced Sp.**	Green Sword Tail
2	*Microphis brachyurus*	Short Tailed Pipe Fish
5	*Monodactylus argenteus*	Mono..
4	*Toxotes chatareus*	Archorfish
5	*Scatophagus argus*	Scat
4	*Etroplus maculatus*	Orange Chromide
2	*Etroplus suratensis*	Pearl Spot
1	*Butis butis*	Upsidedown Sleeper
1	*Eleotris fusca*	Brown Gadgeon
3	*Redigobius balteatops*	Rhinohorn goby
2	*Schismatogobius deraniyagalai*	Redneck Goby
1	*Sicyopus jonklaasi*	Lipstick Goby
1	*Anabas testudineus*	Climbing Perch
4	*Belontia signata*	Combtail
2	*Malpulutta kretseri*	Ornate Paradise Fish
3	*Pseudosphromenus cupanus*	Spike tailed Paradise
2	*Trichogaster pectoralis* **Introduced Sp.**	Snakeskin Gourami
1	*Osphronemus goramy* **Introduced Sp.**	Giant Gourami
1	*Channa orientalis*	Smooth Breasted Snake Head

1	*Channa striata*	Murrel
4	*Mastacembelus armatus*	Marbeled Spiny Fish
4	*Tetraodon fluviatilus*	Common Puffer

Key to Export Rating:

1	=	Rarely exported
2	=	Occassionally exported
3	=	Exported in moderate amounts
4	=	Regularly exported
5	=	Cornerstone export species

TABLE 3.0

Wild Caught Marine Fishes Exported from Sri Lanka

Carcharhinus melanopterus	Black Tip Reef Shark
Triaenodon obesus	White Tip Reef Shark
Chiloscyllium plagiosum	Bamboo Shark
Taeniura lymna	Blue Spot Reef Ray
Echidna nebulosa	Snow Flake Moray Eel
Gymnomuraena zebra	Zebra Moray Eel
Gymnothorax favagineus	Honeycomb Moray Eel
Gymnothorax nubilis	Brown Moray Eel
Myrichthys colubrinus	Banded Snake Eel
Myrichthys maculosus	Tiger Snake Eel
Rhinomuraena quaesita	Ribbon Eel
Antennarius species	Angler Fish
Plotosus anguillaris	Coral Catfish
Histrio histrio	Sargassum Fish
Holocentrus diadema	Squirrel Fish
Holocentrus rubrum	Squirrel Fish
Corythoichthys paxtoni	Grey Pipefish
Hippocampus kuda	Seahorse
Dendrochirus bioocellatus	Butterfly Scorpionfish
Dendrochirus zebra	Lionfish
Pterois antennata	Antennae Lionfish
Pterois miles	Lionfish
Pterois mombassae	Mombassa Lionfish
Pterois radiata	Whitefin Lionfish
Scorpaena parvipinnis	Red & White Scorpionfish
Anthias squamipinnis	Lyretail Anthias
Mirolabrichthys dispar	Dispar Anthias
Mirolabrichthys evansi	Evan's Anthias
Nemanthias carberryi	Carberry's Anthias
Cephalopholis argus	Bluespot Grouper
Cephalopholis boenack	Blueline Grouper
Cephalopholis miniata	Red Grouper
Epinephelus flavocoeruleus	Blue & Yellow Grouper
Epinephelus lanceolatus	Grouper
Grammistes sexlineatus	Soapfish
Pogonoperca punctata	Bearded Soapfish
Pseudochromis dilectus	Jaffna Pseudochromis
Siphaeramia nematoptera	Cardinalfish
Echeneis naucrates	Remora
Gnathodon speciosus	Golden Trevally
Lutjanus kasmira	Blueline Snapper
Lutjanus sanguineus	Red Stripe Snapper
Lutjanus sebae	Red Emperor
Plectorhinchus albovittatus	Sweetlips
Plectorhinchus diagrammus	Yellow Gaterin
Plectorhinchus lineatus	Gaterin Sweetlips
Plectorhinchus pictus	Pictus Gaterin
Parupeneus species	Goatfish
Parupeneus cyclostomus	Yellow Goatfish
Platax orbicularis	Batfish
Platax teira	Teira Batfish
Chaetodon auriga	Auriga Butterflyfish
Chaetodon bennetti	Bennett's Butterflyfish
Chaetodon chrysurus	Pearlscale Butterflyfish
Chaetodon citrinellus	Citrine Butterflyfish
Chaetodon collare	Pakistani Butterflyfish

Chaetodon decussatus	Pictus Butterflyfish
Chaetodon ephippium	Saddleback Butterflyfish
Chaetodon falcula	Doublesaddle Butterfly fish
Chaetodon guttatissimus	Spotted Butterflyfish
Chaetodon kleini	Klein's Butterflyfish
Chaetodon lineolatus	Lined Butterflyfish
Chaetodon lunula	Racoon Butterflyfish
Chaetodon melanotus	Black Butterflyfish
Chaetodon meyeri	Meyer's Butterflyfish
Chaetodon octofasciatus	Blackband Butterflyfish
Chaetodon ornatissimus	Ornate Butterflyfish
Chaetodon plebius	Bluespot Butterflyfish
Chaetodon rafflesi	Lattice Butterflyfish
Chaetodon triangulum	Triangle Butterflyfish
Chaetodon trifascialis	Chevron Butterflyfish
Chaetodon trifasciatus	Melon Butterflyfish
Chaetodon unmaculatus	Teardrop Butterflyfish
Chaetodon vagabundus	Vagabond Butterflyfish
Chaetodon xanthocephalus	Gold Ring Butterflyfish
Forcipiger longirostris	Longnose Butterflyfish
Heniochus acuminatus	Bannerfish
Heniochus singularis	Bannerfish
Hemitaurichthys zoster	Pyramid Butterflyfish
Apolemichthys trimaculatus	Blue Lipstick Angelfish
Apolemichthys xanthurus	Cream Angelfish
Centropyge flavopectoralis	Yellowfin Dwarf Angelfish
Centropyge eibli	Eibli Dwarf Angelfish
Centropyge multispinnus	Bluefin Angelfish
Pomacanthus annularis	Blue Ring Angelfish
Pomacanthus imperator	Emperor Angelfish
Pomacanthus semicirculatus	Koran Angelfish
Abudefduf saxatilis	Sergeant Major Damselfish
Amphiprion clarkii	Clark's Clownfish
Amphiprion nigripes	Teak Clownfish
Amphiprion sebae	Sebae Clownfish
Dascyllus aruanus	Threestripe Damselfish
Dascyllus careus	Carneus Damselfish
Dascyllus trimaculatus	Domino Damselfish
Neopomacentrus cynanomos	Green Damselfish
Pomacentrus species	Rock Damselfish
Pomacentrus amboinensis	Jade Damselfish
Pomacentrus caeruleus	Blue Damselfish
Cirrhitichthys oxycephalus	Coral Hawkfish
Oxycirrhitus typus	Longnose Hawkfish
Anampses caeruleopunctatus	Green Wrasse
Anampses lineatus	Deepwater Wrasse
Anampses meleagrides	Spotted Wrasse
Anampses timorensis	Timor Wrasse
Bodianus diana	Diana's Hogfish
Cirrhilabrus species	Fighter Wrasse
Coris formosa	Red & White Wrasse
Coris gaimard	Clown Wrasse
Gomphosus varius	Bird Wrasse
Halichoeres hortulanus	Halichoeres Wrasse
Halichoeres scapularis	White Wrasse
Halichoeres trispilus	Yellow Wrasse
Hemmigymnus fasciatus	Half Parrot Wrasse
Labroides bicolor	Bicolor Cleaner Wrasse
Labroides dimidiatus	Cleaner Wrasse

Macrophargodon bipartitus	Male Wrasse
Macrophargodon geoffroyi	Jewel Wrasse
Macrophargodon ornatus	Matara Wrasse
Novaculichthys taeniourus	Dragon Wrasse
Paracheilinus filamentosus	Threadfin Wrasse
Thalassoma hardwickii	Striped Wrasse
Thalassoma jansenni	Black Bar Wrasse
Thalassoma lunare	Lunar Wrasse
Scarus atrilunula	Green Parrotfish
Parapercis bivittata	Blackfin Sand Perch
Ecsenius bicolor	Bicolor Blenny
Ecsenius pulcher	Blenny
Ecsenius species	Blue Blenny
Amblyeleotris diagonalis	Leopard Goby
Fusigobius species	Fusi-Goby
Gobiodon citrinus	Lemon Goby
Meiacanthus smithi	White Goby
Nemateleotris decora	Violet Goby
Nemateleotris magnifica	Fire Goby
Ptereloetris evides	Scissortail Goby
Ptereloetris heteropterus	Green Goby
Synchyropus marmoratus	Scorpion Goby
Valencienna helsdingenii	Railway Glider Goby
Valencienna longipinnis	Viva Goby
Valencienna puellaris	Diamond Goby
Valencienna strigata	Milk Goby
Acanthurus leucosternon	Powder Blue Surgeonfish
Acanthurus lineatus	Lined Surgeonfish
Acanthurus nigricauda	Black Surgeonfish
Acanthurus pyroferus	Mimic Surgeonfish
Acanthurus tennenti	Tennent's Surgeonfish
Acanthurus triostegus	Conwick Surgeonfish
Ctenochaetus strigosus	Yellow Eye Surgeonfish
Naso brevirostris	Unicorn Surgeonfish
Naso lituratus	Lipstick Surgeonfish
Naso vlamingi	Vlamingi Surgeonfish
Paracanthus hepatus	Regal Blue Tang
Zebrasoma scopas	Scopas Surgeonfish
Zebrasoma veliferum	Sailfin Tang
Zanclus canescens	Moorish Idol
Bothus mancus	Flounder
Pervagor melanocephalus	Filefish
Oxymonacanthus longirostris	Longnose Filefish
Abalistes stellatus	Black Triggerfish
Balistapus undulatus	Undulate Triggerfish
Balistoides conspicillum	Clown Triggerfish
Melichthys indicus	Blackfin Triggerfish
Odonus niger	Redtooth Triggerfish
Pseudobalistes fucus	Blue & Gold Triggerfish
Pseudobalistes viridescens	Titan Triggerfish
Rhinecanthus aculeatus	Picasso Trggerfish
Rhinecanthus rectangulus	Rectangle Triggerfish
Sufflamen chrysopterus	White Rim Triggerfish
Ostracion cubicus	Yellow Boxfish
Ostracion meleagris	Boxfish
Lactoria cornuta	Cowfish
Tetrasomus gibbosus	Thornback Trunkfish
Arothron meleagris	White Spotted Dogfish
Arothron nigropunctatus	Gray Dogfish

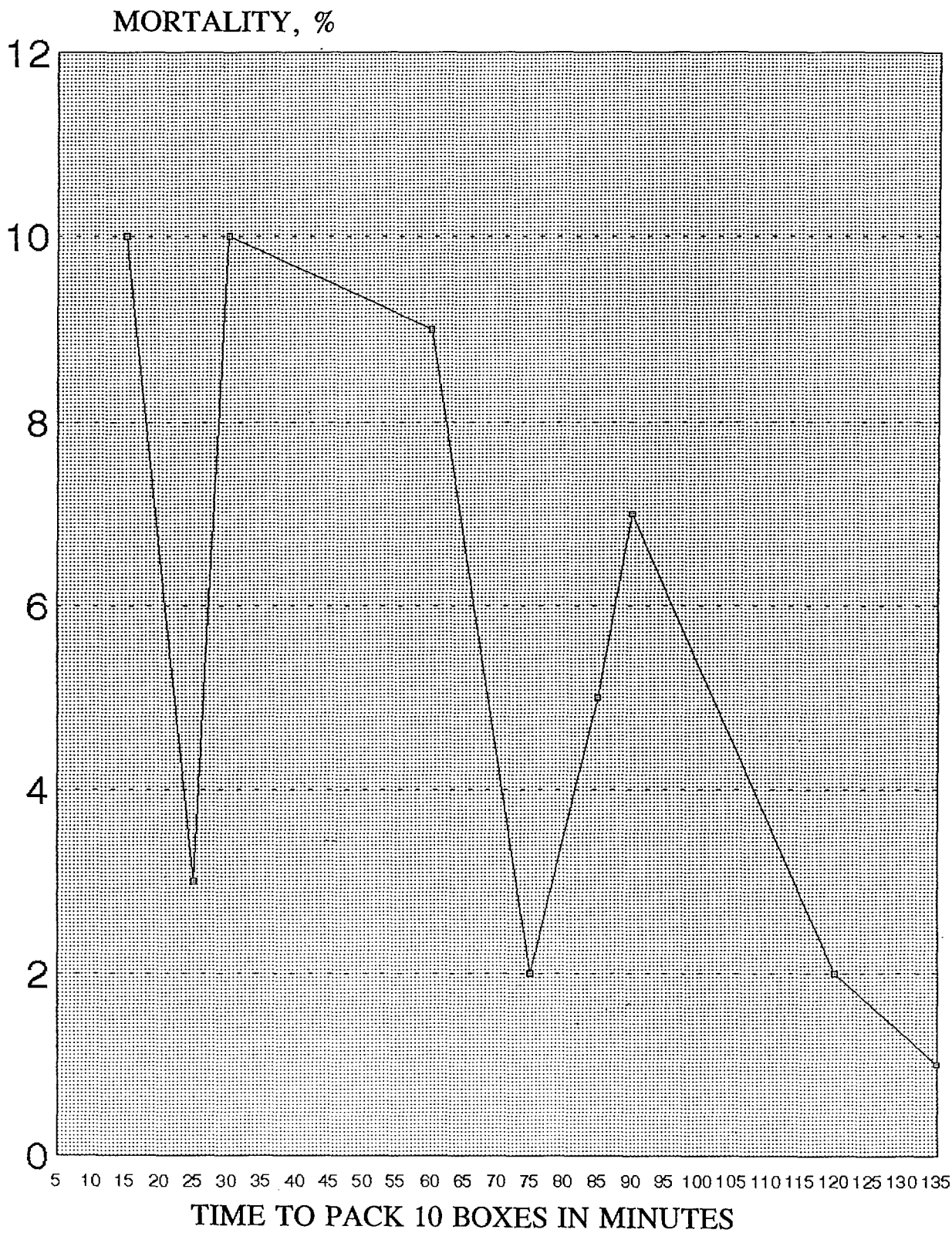
Canthigaster jactator	White Spot Toby
Canthigaster margaritata	Pearl Toby
Canthigaster valentini	Valentine's Toby
Diodon hystrix	Pufferfish

TABLE 4.0

"Cut-Flower" Marine Fishes Currently Exported From Sri Lanka

Species	Common Names
Chaetodon bennetti	Bennett's Butterflyfish
Chaetodon citrinellus	Lemon Butterflyfish Citrine Butterflyfish
Chaetodon meyeri	Meyer's Butterflyfish
Chaetodon octofasciatus	Eight-stripe Butterflyfish
Chaetodon ornatissimus	Ornate Butterflyfish
Chaetodon plebius	Blue Spot Butterflyfish Plebius Butterflyfish
Chaetodon triangulum	Triangle Butterflyfish
Chaetodon trifascialis	Chevron Butterflyfish
Chaetodon trifasciatus	Melon Butterflyfish Sunset Butterflyfish

Figure 1.0

REPORTED DOA MORTALITY VS PACKING TIME

Based on 10 boxes of live fish