BOBP/REP/88

A Review of the Status and Trends of Exported Ornamental Fish Resources and Their Habitats in Sri Lanka

A REVIEW OF THE STATUS AND TRENDS OF EXPORTED ORNAMENTAL FISH RESOURCES AND THEIR HABITATS IN SRI LANKA

S. U. K. Ekaratne
Department of Zoology
University of Colombo
Colombo
Sri Lanka.

BAY OF BENGAL PROGRAMME
Chennai, India
December 2000

Edited and published by Y.S. YADAVA for the Bay of Bengal Programme, 91 St. Mary's Road, Abhiramapuram. Chennai 600 018. India.
Tel: 91 -44-4936294; 91-44-4936188; Fax: 91-44-4936102; E-mail: bobpysy@md2.vsnl.net.in
Website : hhttp://www.fao.org/waicent/faoinfo/fishery/bobp/website/homepage.htm

PREFACE

This document discusses the history and the current status of marine and freshwater ornamental fish species in Sri Lanka, which are exported to some 25 countries in response to demand. It contains lists of marine and freshwater species, including endangered species, and information on their population, biology, ecology and distribution. It briefly discusses the impact of the export effort on resources, and the status of information relevant for resource and habitat management.

This document, and the activities undertaken between 1994 and 1999 in Sri Lanka to support conservation and management of ornamental fish species in the island, were supported by the Bay of Bengal Programme (BOBP) as part of its management-oriented Third Phase.

The BOBP is a multi-agency regional fisheries programme that covers seven countries around the Bay of Bengal – Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka, Thailand. The Programme plays a catalytic and consultative role in developing coastal fisheries management in the Bay of Bengal, thereby helping improve the conditions of small-scale fisherfolk in the member-countries.

The BOBP is sponsored by the Governments of Denmark and Japan. The executing agency is the FAO (Food and Agriculture Organization of the United Nations).

FOREWORD

The capture, breeding and export of ornamental fish is an important industry in Sri Lanka. It generates jobs, incomes and foreign exchange. But it also triggers concern. The collection of ornamental fish for export could have a detrimental impact on the rich but fragile ecosystems of the island, such as coral reefs, that teem with marine life.

During its management-oriented Third Phase (1994-1999), the BOBP was requested by the Government of Sri Lanka to help facilitate improved management of the ornamental fish sector.

Working with the Ministry of Fisheries and Aquatic Resources, the BOBP sought to promote consultation and negotiation among various stakeholders in ornamental fisheries. These included as many as 15 Ministries, various exporting firms, their suppliers, and the ornamental fish divers who collect and sell ornamental fish.) To aid the consultation process, two parallel streams of activities were organised. One aimed at strengthening knowledge about the ornamental fishery and about trends concerning resources and habitats, thereby giving stakeholders the best available scientific information. Another stream aimed at awareness-building on the needs, benefits and methods of management.

This report perhaps aids both streams by strengthening knowledge as well as awareness. The report has made an excellent review of the status and trends in the export trade of ornamental fish species. Key areas have been identified and prioritised for sustainable resource/habitat management. We hope the report is found useful as a source of information and reference by everyone concerned with ornamental fisheries, including planners, decision-makers, scientists and those engaged in the export trade in ornamental fish species.

Perhaps the most fruitful outcome of BOBP's work on ornamental fisheries in Sri Lanka is that many stakeholders are giving up past suspicions and antagonisms to discuss co-operation in strengthening the industry and its potential for enriching the country's economy.

We hope that this report will have the same effect, and lead to ideas and insights on conservation and management of Sri Lanka's ornamental fish industry.

Y.S. Yadava

6.12.2000

Interim IGO Coordinator

CONTENTS

<<

TABLES

(For easy reference, tables are numbered in relation to the section in which they first appear)

<<

FIGURES

(For easy reference, figures are numbered in relation to the Section in which they first appear)

Abbrevations Commonly Used in the Report

BOBP	Bay of Bengal Programme
CEA	Central Environmental Authority
CCD	Coast Conservation Department
FAO	Food and Agriculture Organization of the United Nations
MoF	Ministry of Fisheries and Aquatic Resources Development
NARA	National Aquatic Resources Research & Development Agency

ACKNOWLEDGEMENTS

It is a pleasure to place on record my thanks to the many persons who made this review possible. Mr Rathin Roy of BOBP-FAO ranks foremost in the list. It was Rathin who first suggested that a report such as this would be useful. Thanks to him also for plugging at me to make this review acceptable and useful. My appreciation goes also to Dr Kee Chai Chong and Dr. Y. S. Yadava, Coordinators of the BOBP.

In Sri Lanka, I thank Mr H V C Fernando of the Ministry of Fisheries, not only for the work related to this report, but also for his dedicated commitment. With his keen interest to further Sri Lankan fisheries, I have found it a pleasure and a privilege to work with him.

I thank my patient assistants for helping me to finalise this report. To the various persons in the trade, whose knowledge and time were readily given to me, often confidentially, I owe a debt of gratitude. Many persons outside the trade, including a few students, have shared with me much time and aquatic-related knowledge over the years. Although they are too numerous to mention and I remain grateful to them, a few helpful friends such as the indefatigable Rohan Pethiyagoda, Vibu Perera, Samantha Goonesekera, Malik Fernando and Rex de Silva will not easily fade from memory. I sincerely thank colleagues and others who sent me supportive comments after the presentation of the draft of this report.

I owe a lasting debt of gratitude to my country for fostering in me a love and dedication for the rich natural resources that we possess, for it is indeed unparalleled and it behoves on Us the obligation to hold it in trust for the benefit and enjoyment of our future generations.

SUMMARY

The ornamental fish trade in Sri Lanka has come a long way over the last 75 years of its existence to develop into a valuable foreign exchange earner for Sri Lanka. Ornamental fish are exported to over 25 countries, mostly "developed". These include USA, Japan, United Kingdom, Holland, Germany, Singapore and Hong Kong. The consignments that reach Singapore, Hong Kong and Holland are mostly re-exported to other "western" countries. Exports have shown an increasing trend over the last two to three years, particularly since prices have become more competitive. Over 25 major exporters are now involved in the trade.

The base material for this trade is the rich tropical biological diversity that Sri Lanka enjoys, which seems to be imperilled by aquarium-trade related activities and other ill-planned short-term developmental activities. The trade now seems receptive to evolving strategies for the sustainable management of the aquarium fishery.

The freshwater aquarium trade obtains specimens for export both from wild-caught and captive-bred/hatchery-reared stocks, whereas the marine trade relies solely on the natural or wild habitat to procure specimens for export, collections being done by persons employed specifically for this purpose. Collection, especially in the marine waters, involves some degree of habitat destruction and stress to the collected organism. It is therefore necessary to develop and popularise eco-friendly collecting methods. Other mortality and stress-inducing practices occur during the holding phase (until collection by the exporter) and the transport phase. Methods for mortality reduction have to be developed/popularised. Hatchery breeding that has been developed by exporters for some species of freshwater fish (such as *Puntius nigrofasciatus* and *Puntius titteya)* seems the ideal answer to the ecosystem disruptions that trade practices cause, since natural mortality as well as habitat destruction are thereby avoided.

In the freshwater ecosystems, we have some 80 species of indigenous fish of which 27 are endemic, meaning that they are found nowhere else on our planet. 59 species of these freshwater fish are presently recorded as being collected from wild populations and exported in the aquarium trade; 53 of them being regularly exported. From among the 27 endemic freshwater fish species, up to 20 species are presently being used regularly in the aquarium export trade. Among the most sought after species for exports are the endemic *Rasbora vaterifloris*, *Puntius nigrofasciatus* and *Pun tius titteya* with *Puntius cumingii* and *Belontia signata* being among the other popularly exported endemics. *Monodactylus argenteus* is the single most heavily fished non-endemic species

Recent trends in the marine trade have witnessed its expansion for exports to include more species (139 species in 1985 to over 200 species at present) and to export increased numbers of fish (from about 200,000 individuals in 1985 to almost 1,000,000 individuals at present). There is also an increasing trend to import fish from other countries for value-added transhipment.

In both the marine and freshwater exports, supply from the wild seems to be coming down. This trend is sending collectors to areas which were not previously used for collections (in the case of freshwater habitats) or to deeper and further offshore areas using SCUBA gear (in the marine habitat). Although no studies have been completed "to prove that there is a reduction in gene pools, colour varieties, etc." (NARA, 1998), collections appear to have impacted on gene pools and population characteristics of available stocks, since available sizes have changed and the desirable attractive colour varieties of freshwater species are no longer readily available. NARA (1998), however, is of the view that changes in the quality of food available for these species should not be discounted as a reason for these changes in the colours in fish. There are signs that over-collection of some species as well as over-collection of some sizes of certain species have already occurred, even though corroborating scientific studies have not been conducted.

The effects of selective over-collection are exacerbated by the habitat degradation that is taking place independently of aquarium-trade activities, but which would inevitably affect the sustainability of the aquarium industry.

<<

Habitat destruction as well as habitat change are taking place in both freshwater and marine habitats. Clearing of shade along wet zone streams affects many endemic species, since many endemics are shade-loving species that live in shallow streams. Increased siltation, sediment load, pollution and reduction in water quantity are also disturbing trends. Another alarming trend bringing about change in our freshwaters, and which would affect the future of the aquarium trade, relates to the increase of many imported exotic and invasive aquatic species (including snails such as the Golden Apple snail, *Pomacea sp.,* and piscivorous fish, such as the Clown Knife fish, *Notopterous chitala)* in our freshwaters (Bambaradeniya et al, 1988) in our freshwaters. Such freshwater fish introductions would effectively reduce the carrying capacity of Sri Lanka's fresh waters to her indigenous fish species and may well lead to their being competitively eliminated, impacting gravely on our biological diversity and seriously narrowing the biological options that remain open for future development and expansion of our export aquarium industry.

The marine habitat is also seriously impacted by increased sediment load, pollution and habitat destruction. The unprecedented coral bleaching that has been recently experienced would bring about changes in the reef and coastal ecosystems, the destabilising nature of which we are as yet unable to predict.

Some of the freshwater endemic species require urgent measures for their protection and sustainable management. This is because their collection imposes further stresses, often severe, on their already strained populations. The stress-inducing factors include their small population, heavy collection pressure, the intense targeted collection of attractively-coloured individuals or specific size groups, (Gundekera, 1995, 1998), and population declines (due to unknown factors including environmental degradation). The species meriting such concern are *Rasbora vaterifloris, Puntius nigrofasciatus, Puntius titteya, Puntius cumingii, Puntius bimaculatus, Daniopathirana, Aplocheilus werneri, Sicyopus jonklaasi* and *Belontia signata.* Among marine species, extreme care should be exercised in exploiting species that are present in low numbers (such as clown fish) and species that form key linkages (such as cleaner fish) or perform key ecological functions (such as territorial damsels, algal feeding/coral cropping parrot fish and zooplanktivores).

Most endemic and sensitive species are restricted to very narrow specific habitats. Their survival, affected by physical over-exploitation for the aquarium trade, may be further hit by habitat alteration. No comprehensive studies have been carried out on the requirements of these endemic or sensitive exported species. In the absence of suitable impact studies, it is not possible to predict what impact habitat alteration will have on these species. Exporters target the more colourful varieties and since their ecological significance has not been studied, what long-term effect such selective exploitation will have on genetic diversity cannot yet be detailed.

Some species are more susceptible to poor handling and transport conditions. Exporters simply harvest larger numbers to offset attendant mortalities of such species. Inadequate space and water volume, poor oxygenation during export and excessive pre-export starvation and stress increase the mortality of exported numbers of some species.

Apart from legislation that can be effectively implemented, eco-physiological and population studies of a quantitative nature are urgently needed to advise on collection, maintenance and transport conditions that need to be followed by exporters to safeguard collected stocks from unnecessary mortality. Exporters are eager to learn and would be receptive to receiving appropriate, scientifically formulated, well-meaning practical advice. Studies should be targeted towards this end, since it seems unlikely that the export trade can at present be voluntarily modulated on the basis of conservation requirements. Such a strategy could only become feasible after an adequately robust ecological data base has been compiled, which would necessarily require time.

An effective management strategy needs to address not only aquarium-trade related matters, but also policy and other matters in an integrated approach if we are to be hopeful of sustaining the aquarium industry in the long-term.

<<

Indonesia	9,100,000
Philippines	8,600,000
Hong Kong	7,400,000
Colombia	3,000,000
Brazil	1,800,000
Japan	*1,750,000*
Malaysia	1,600,000
Sri Lanka	1,200,000
Others	ca 42,550,000
Total imports:	US$ 100,000,000

Table 3.3 Countries competing to export tropical fish to the EEC as indicated by import figures (freshwater & marine, 1992; Bassleer, 1994)

(in US$)

Country of Origin	*Freshwaterfish*	*Marine fish*
Singapore	35,000,000	1,800,000
Netherlands	5,800,000	1,650,000
USA	5,350,000	1,100,000
Israel	5,300,000	1,300
Japan	4,800,000	
Czechoslovakia	4,700,000	
Indonesia	1,800,000	2,100,000
Brazil	2,850,000	
Thailand	2,200,000	
Philippines	75,000	1,300,000
Germany	2,000,000	
Colombia	1,700,000	
Sri Lanka	400,000	1,200,000
Others	10,025,000	1,850,000
Total	**ca** 82,000,000	**ca 11,000,000**
Total imports	**ca US$** 93,000,000	

SECTION 1

Scope, Objectives and Methodology

The live export trade in relation to faunal aquatic resources deals with both ornamental aquatic species and food-fish species. Some of these species are cultured while others are harvested from the wild. The trade exports freshwater, brackish as well as marine species. Whereas live animal freshwater exports are made up of fin-fish species, the live marine exports consist of both fin fish and invertebrate species.

There is thus a wide range of aquatic species that provide the base for the fishery-related live export trade. From among this diversity of species that support the live aquatic export industry, this report deals with fin fish species that are caught from their natural (or "wild") freshwater and marine habitats and exported from Sri Lanka for ornamental purposes.

In relation to these aquarium wild-caught fin fish species from freshwater and marine habitats, the present report will review their status **and** trends, making use of existing literature as well as views expressed by key stakeholders and experts. These views were often expressed in confidence, for the export of live species often engenders much controversy and emotional debate (e.g., Marcelline, 1997). The report will present a reference list of the relevant literature and will also highlight Sri Lanka's ornamental fish resources and habitats that are considered as vulnerable or in danger, together with identifiable causal factors. The report will identify and priontise key areas where information is lacking for effective and sustainable resource/habitat management and suggest actions in terms of research and information collection.

This report shows that there is a severe dearth of objective scientific information in relation to Sri Lanka's aquatic ecosystems. This situation has led to various views being expressed. This report attempts to document these diverse viewpoints, some of which are not supported by detailed scientific study. Their inclusion is meant to encourage further examination and scientific study. The Report is based on a perusal of both published information and unpublished "grey" literature, which however proved to be insufficient and inadequate, especially with reference to population and ecological studies of our aquatic organisms. Therefore, interviews and discussions with exporters, divers and collectors were used to augment the limited information contained as published or grey information, which was supplied in good faith but lacked substantiation with orthodox scientific tests. Apart from individual discussions, questionnaires were also used. Inputs were used from workshops that had been held with personnel associated with the aquarium fish industry. These workshops included a 2-day workshop held at the Lighthouse Hotel, Galle on the 5th and 6th of September 1997 for members of the Association of Live Tropical Fish Exporters of Sri Lanka and the Association of Specialised Aquarium Fish Breeders of Sri Lanka.

The wide interest in the export aquarium trade was borne out by a presentation of a draft version of this report to an interested audience. It generated considerable interest and discussion, including criticism that some of the infonnation presented lacked scientific testing/corroboration (e.g. NARA, 1998). This is acknowledged. Such lively criticism portends well for scientific debate on the subject. It is hoped that the information presented in this report, particularly information requiring scientific validation, is subjected to in-depth scientific study, and that responsible researchers embark on well-organised programmes to fill the vast gaps that presently exist in our knowledge base on aquatic ecosystems. We will then be better equipped to deal with the diversity of issues that must be addressed so that we manage our aquatic resources in a sustainable and effective manner.

<<

SECTION 2

Introduction

The recorded history of the ornamental fish exports from Sri Lanka can be traced to around 1920 or 1930. The trade at this time was limited to a few exporters. The vessels used for the exports were passenger and cargo steamers that called at Colombo (Jonklaas, 1985). The packing material was imported from abroad and the fish, which were predominantly freshwater species, were kept in tanks on the deck of the boat until the final destination was reached. In some cases, they were housed in specially converted cabins that served as aquarium rooms (Axelrod, 1960). The export aquarium trade expanded gradually from the 1950s as more exporters began to operate from Colombo. As air transport got more popular and less costly, live aquarium fish for export took to the skies. Initially confined to specialists meeting the needs of large aquaria, the export market expanded, with individual hobbyists enjoying the calm and tranquility of an aquarium in the comfort of one's home, joining the rank of exporters. The expansion of domestic power supply, the lowering of air transport costs in the post-war period, and the development of cost-effective aquarium accessories such as aerators and heating elements, helped the aquarium hobby boom. These developments made it easier for people in the colder temperate countries to procure and maintain the more colourful warm-water aquarium fish species that originated in tropical countries. The popularity of fish-keeping as a hobby in the developed world can best be gauged by its recognition as the second-most popular hobby in the USA (Alava and Gomes, 1989). Rarely did the hobbyist realise the complex chain of events set in motion when fish were brought from the biodiverse tropics to the home tank in cold temperate climes.

As market demand for the attractively-coloured fish grew, to brighten the interiors of wintry western temperate human abodes, the tropical habitats of the exported fish began to decline in quality. This was because the catch rates of tropical fish captured to meet the increasing demand exceeded the numbers that could be sustainably harvested. Also, catching methods became more damaging. Collectors were forced to destructively extract, from less accessible niches located further afield, declining numbers of fish. The sustainability of ecosystems got further imperilled with the mounting pollution of our aquatic systems, stemming from our misuse of natural resources and the overuse of diverse chemical agents in many land-based activities.

The disruption of ecosystem processes caused by such pollution affected many livelihoods. People were no longer able to follow practices that had until then been supported by our natural resources. The quality of life changed; fish collectors had to risk their lives by diving deeper using aqualungs, to obtain what they used to collect earlier with little risk from near-shore niches using only simple snorkeling gear. Less directly, changes to the quality of life of many more people were brought about when products that were supported by ecosystem linkages were no longer supportable because of the removal of link species or because of habitat destruction.

The expanding aquarium trade, even though not properly managed, generated much-needed foreign exchange (see next section) as well as employment benefits for a number of persons, particularly to collectors in the coastal low-income sector of the population. The right strategy would be to examine the management possibilities of this trade and to collectively adopt practices that would result in the sustainable management of the ornamental fishery.

The perception that the aquarium trade has hit ecosystems and economic life has led to diverse results. It has spurred both the exporter-collector and the conservationist to contemplate how best we can evolve mechanisms to effectively manage natural aquatic resources and to arrest further deterioration of our aquatic ecosystems. Many agree that the resource base has been impacted negatively, affecting the future of the export aquarium trade and ecosystem functions. Understandably, various stakeholders have failed to find agreement about the extent of the impact, mostly due to lack of a standardisation on field observation methodology. Even so, there is a common perception of an unfavourable impact on some species together with a positive outlook that still exists for sustainable management of the fishery. This must be utilised to evolve a management ethic among stakeholders and a consensus strategy for the sustainability of this valuable fishery.

<<

SECTION 3

Trends Common to Freshwater and Marine Resource Management

3.1 Expansion of the Export Trade

The **common trends** associated with the export aquarium trade are by now clearly discernible, with a steady expansion witnessed overtime. Such expansion, at an annual rate of about 10% over the last 5 years, served to bring in increasing amounts of foreign exchange and job opportunities. These were necessary for a growing economy and the government therefore gave this growing industry encouragement and assistance.

The largest demand (99%) for ornamental fish is from home hobbyists, and the remaining 1% is from public aquaria and research institutes. The total annual wholesale trade value of live ornamental fish supplying this market demand was estimated at US$ 900,000,000 and its retail value was US$ 3,000,000,000 (Bassleer, 1995). The largest markets are in the USA, Europe (with Germany being the leading country) and Japan (see table below). The EEC was the biggest importer (by value) of tropical fish from Sri Lanka (freshwater and marine). The USA came next, then Japan.

Of the EEC's imports from Sri Lanka, US$ 400,000 was the freshwater component, while the marine component was US$ 1,200,000 (Bassleer, 1995). Marine organisms exported were three times as valuable as freshwater fish exports.

Table 3.1 Annual trade values (in US$) of live ornamental organisms in relation to major importing countries and Sri Lankan share of market

Countrylies	*Global Import Value to respective country/ies*	*Export Value from Sri Lanka to respective country/ies*	*% Sri Lankan share of the country market*
USA	$100x10^6$	$1.2x10^6$	1.2
EEC	$93x\ 10^6$	$1.6x\ 10^6$	1.72
Japan	$65\ x\ 10^6$	$0.48\ x\ 10^6$	0.74

The monetary value of aquarium fish exports from Sri Lanka was Rs 248 million in 1994 which is a mere 0.5 to 1% slice of the global aquarium trade. The value of Sri Lankan aquarium fish exports has been increasing annually at a growth rate of 16.9%. Although prices for individual fish have fallen in absolute terms over the recent past (because of inflation), the increase in export of overall numbers has helped to generate increased income from the trade as a whole (Section 5).

The principal countries competing against Sri Lanka and vying for the lucrative aquarium products market are Singapore, Indonesia, Thailand and Philippines, as shown in the tables below;

Table 3.2 Countries competing to export tropical fish to USA as indicated by import figures (freshwater & marine) (1992; Bassleer,1994)

Country of Origin	*Value (US$)*
Singapore	12,500,000
Thailand	10,500,000

Contd

<<

Table 3.4 Countries competing to export tropical fish to Japan as indicated by import figures (freshwater & marine, 1992; Bassleer,1994)

Country of Origin	*Value (US$)*
Hong Kong	12,150,000
Singapore	10,900,000
USA	8,300,000
Thailand	5,400,000
Indonesia	4,850,000
Germany	4,750,000
Philippines	3,850,000
Brazil	3,700,000
Malaysia	2,350,000
Netherlands	2,250,000
Sri Lanka	480,000
Others	ca 6,000,000
Total imports	**ca US$** 65,000,000

Sri Lanka exports to more than 25 countries including USA, Japan, United Kingdom, Holland, Germany, Singapore, Malaysia, Bahrain, Canada, Belgium, Finland, Austria, Sweden, Finland, Portugal, Denmark, France, Italy, Spain, Israel, UAE, Maldives, India, South Africa and Argentina. The USA is our highest buying country, Hong Kong ranks next, followed by Japan. Germany is also a leading buying country. Countries such as Singapore, Hong Kong, Malaysia, Bahrain and Holland purchase our aquarium fish mostly for re-export. The exports to Europe have been increasing at an annual rate of 10% over the last five years.

The exports from Sri Lanka are undertaken by about 25 exporting companies.

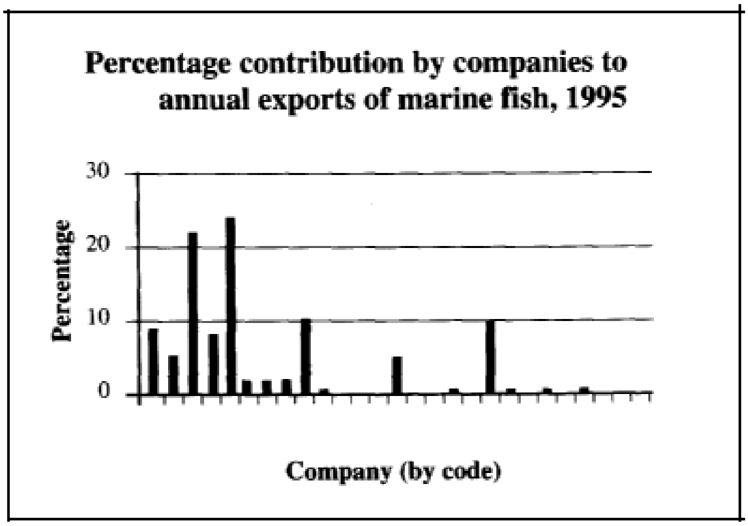


Figure 3.1 Percentage contribution by companies to annual exports of marine fish

Fifteen of these companies are registered with the Export Development Board and a single company is registered also with the Board of Investment. Among the companies engaged in the export trade, two companies command about 50% of the export volume, another 36% is shared among four other companies, while the remaining companies export very low quantities, as shown in the graph above.

Exports are carried out under the HS Code allocated for this trade practice under the number 0-300-11010 for freshwater fish exports. Exported quantities reach a peak from around September to March/May of each year, which corresponds with the colder season of the developed northern hemisphere countries. Apparently people purchase more aquarium fish over the colder, bleaker period when inclement weather confines them to their homes. Reviewing the export statistics for 1995, such an increase in exports is true for freshwater fish, but not for marine fish exports (please see graphs below), where the period June to August recorded increased exports. December to January is a brisk sale period for aquarium fish in many of the developed countries because this is the "gift season".

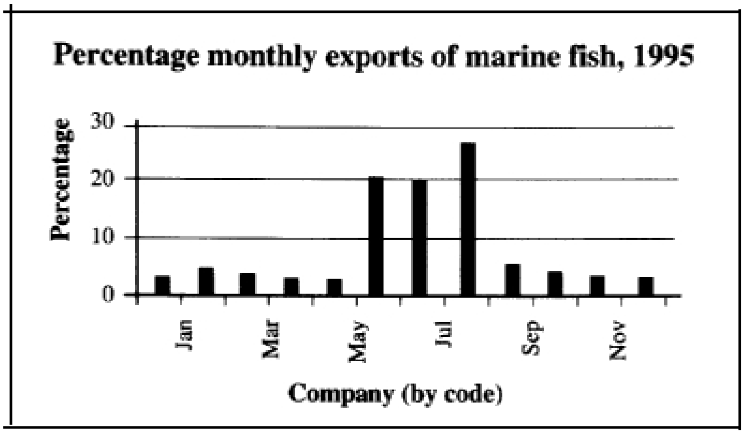


Figure 3.2 Percentage monthly export of marine fish

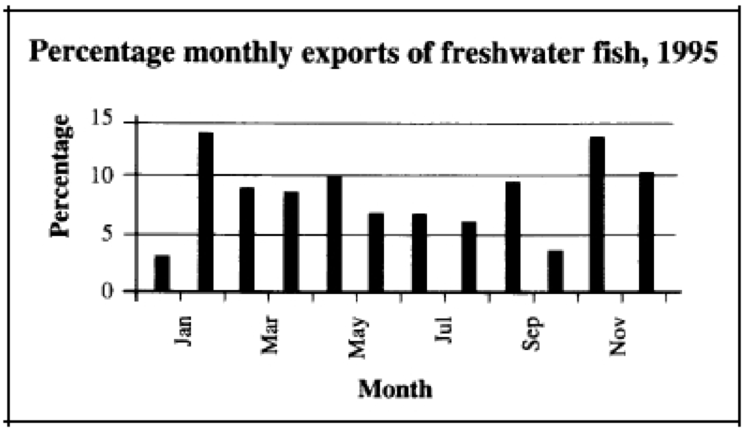


Figure 3.3 Percentage monthly exports of freshwater fish

This expansion in turn brought about the gradual over-exploitation of the more popular species of wild-caught aquarium fish. Although blame for such a trend is commonly placed solely on the aquarium trade, it is not fully justified unless it is to be accepted that individual traders harvesting a common-property natural resource generate the capacity, training and the knowhow to regulate themselves.

3.2 Advisory, research and management capacity

The only regular training given in the aquarium-related industry is at the National Aquatic Resources Research & Development Agency (NARA). Its training courses are geared to the breeder and grow-out farmer. These could eventually help develop proper breeding and holding methods for the indigenous and endemic species. NARA also provides advice and back-up on aquarium-related activities such as site selection, water quality, pond construction, identification of fish, etc.

The College of Icthyology at 37/6 Terence Avenue, Mt Lavinia, conducts 2-day, 1-month and 3-month courses. The University of Kelaniya conducts an M Sc course in Aquaculture. Other universities such as the University of Colombo and Ruhuna conduct special degree courses in Fisheries Science or/and course units in aquaculture and aquatic ecology for undergraduates/post-graduates. These courses are not dedicated to aquarium fish but would contain components related to aquarium fish keeping, breeding and ecology. Graduates with such training could undergo further training, particularly for research activities in the aquatic habitats.

The national-level research conducted at present about the problems related to the export of indigenous/endemic species is inadequate. Though export of live fish has been going on for so many decades and regulations governing export of live fish have been in existence for a long time, there has been no attempt to introduce systematic research programmes concerning the resources of ornamental-fish species and to improve their management systems (Dr K. Sivasubramaniam: in comments on Draft Report, 1998).

3.3 Resource base

The general trends concerning the resource base are common to both freshwater and marine aquarium fish resources;

Increased market demand

lower prices

⇓

⇓

Increased collection for increased exports

⇓

When collection pressure> sustainable quantities

® Pollution impacts

⇓

Decreased stock availability

⇓

- Less economical collection
- Life-supporting ecosystem disruption

⇓

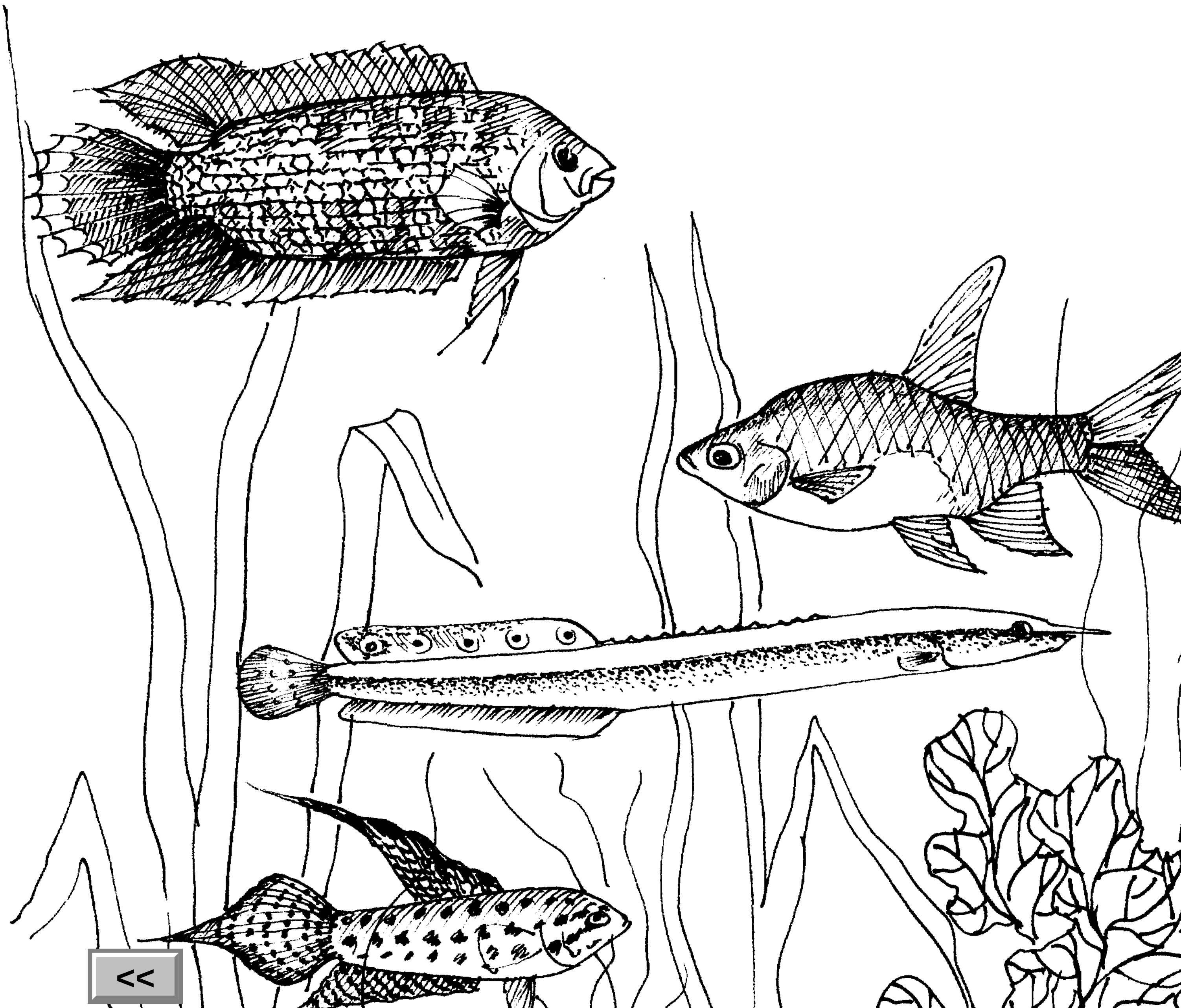
- Economic hardship
- Lifestyle changes
- Loss of trade sustainability
- Ecosystem Imbalance
- Reduced ecosystem carrying capacity

From the foregoing, it becomes apparent that increased collection pressure would affect the species for which there is higher demand and that it would lead, in the first instance, to an impact on their population.

- reduction in numbers *(i.e.,* population size),
- changes in their size characteristics *(i.e.,* population structure)

The less popular species will also be affected, indirectly, when ecosystem functions change.

It must be kept in mind that the more popular species are harvestable economically because they are available in larger numbers. **When quantities decline below a threshold number, it becomes uneconomical to collect them as a target species. Because of their numerical abundance, their contribution to** ecosystem processes and functions could be significant. Their removal (in high numbers to meet the "popular" demand) could therefore have a significant effect on the ecosystem and would, in turn, affect even the less popular species in the aquatic habitat, although it may take longer for the effect to be clearly discernible.



SECTION 4

Trends in the Freshwater Aquarium Trade

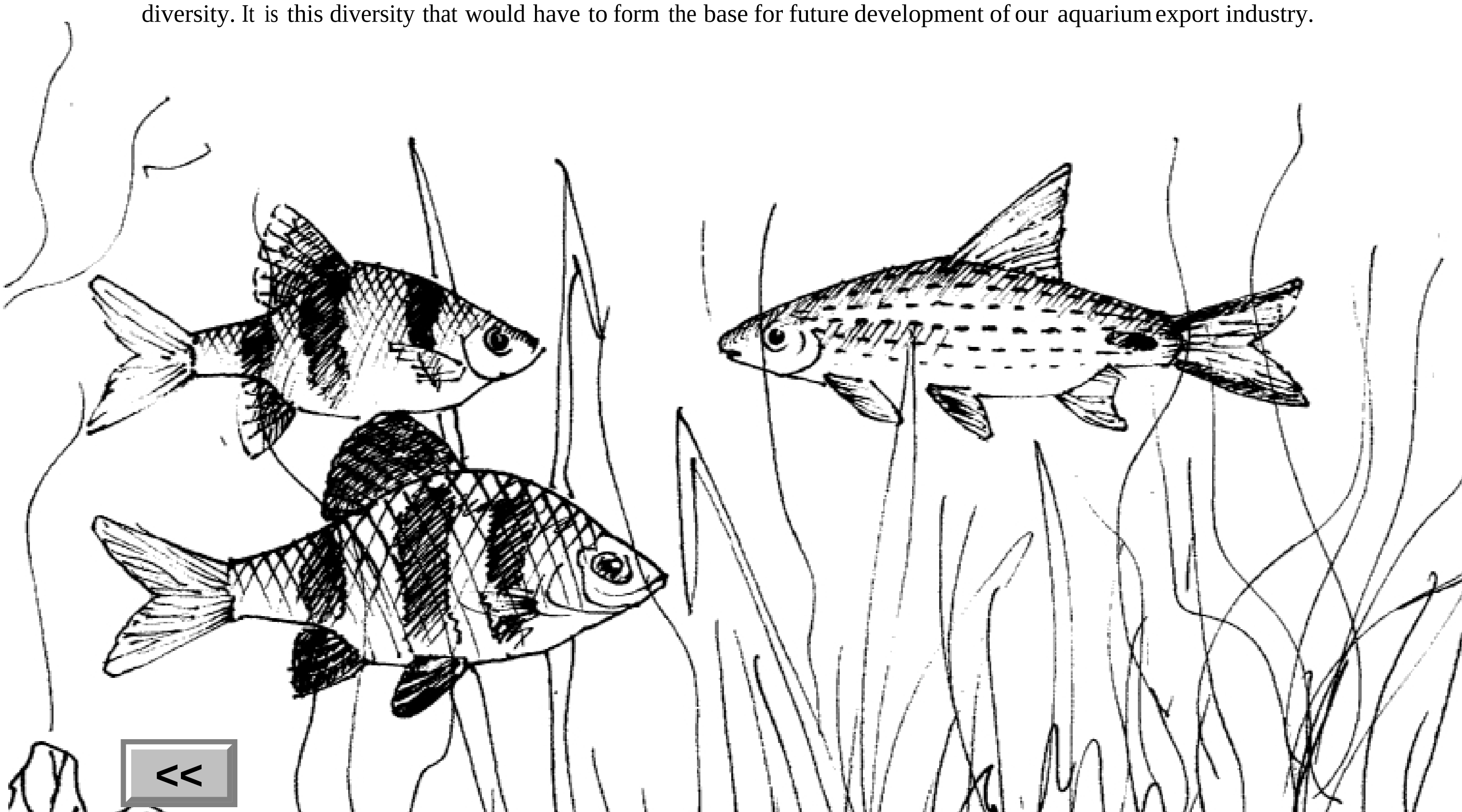
It is common practice among collectors to target the more attractive individuals, even within a species, that fetch a higher market price. Thus some of the most colourful morphs are selectively targeted for wild collection. This has led to a reduction in brightly coloured populations, such as the rust coloured and "neon" blue-finned *Belontia signala.* Other species also suffer from such selective exploitation; that can impoverish their genetic diversity.

It is noteworthy that many aquarists have embarked on programmes of captive breeding of our endemic/indigenous fish species used for the export aquarium trade (Dawes, 1998). Considerable work has also been done in this regard at the Universities of Sri Jayawardenapura and Ruhuna as well as by Mr J Chandrasoma (Chardrasoma, 1994, 1996). These trends have led to successes with several species such as *Puntius nigrofasciatus, P. titteya, P cumunigii* while initial successes and development of breeding in other species have also been reported (e.g. Chandrarathna *et al.,* 1998).

There are signs of over-collection of some species as well as over-collection of some sizes of certain species, as reported in Section 6 of this Report.

Habitat destruction as well as habitat change are taking place in relation to freshwater habitats. Clearing of shade along wet zone streams affects many endemic fishes since most are shade-loving species that live in shallow streams. Increased siltation, sediment load and pollution and reduction in water quantity are also disturbing trends that are discussed further below.

Another alarming trend bringing about change in Sri Lanka's freshwaters and which would affect the aquarium trade, relates to the increase of many exotic species in our freshwaters. Apart from the introduced tilapias having extensively colonised the island's freshwaters, more numbers of species that have been brought into the country by the aquarium retail trade (which includes destructive carnivores) are increasingly finding their way into freshwater habitats and are said to be breeding therein. The resulting predation and competition would eventually affect our freshwater biological diversity. It is this diversity that would have to form the base for future development of our aquarium export industry.



<<

SECTION 5

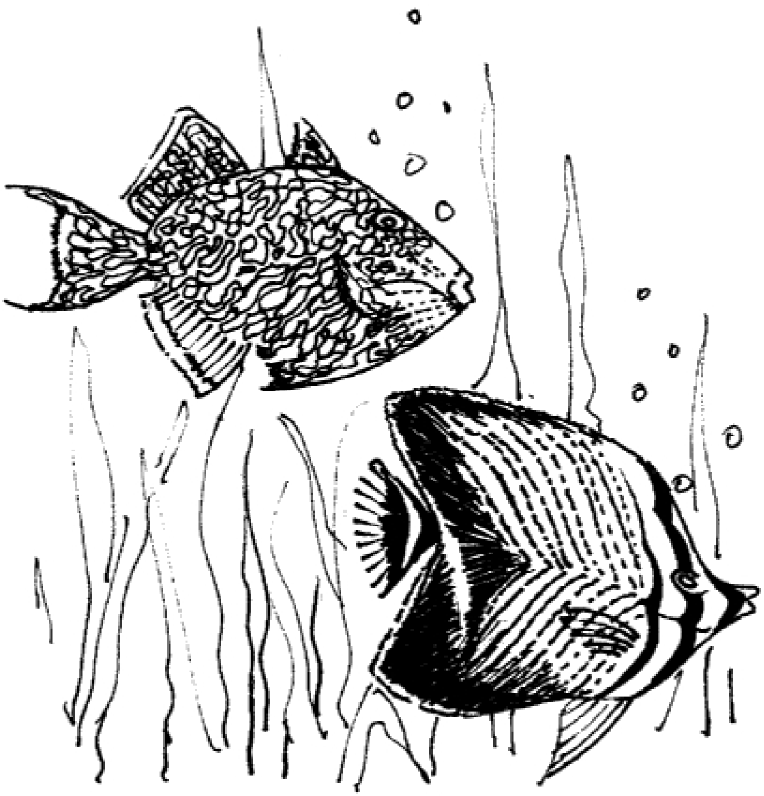
Trends in the Marine Aquarium Trade

Dwindling supplies of ornamental fish from the wild are sending collectors to areas deeper and further offshore. Thus, the use of SCUBA gear for collection is becoming commonplace though it is a dangerous trend because very few divers receive even basic training in the use of SCUBA. The unprecedented coral bleaching that has been recently experienced in Sri Lanka (Ekaratne and Jinendradasa, 1998) and much of the Indo-Pacific region would bring about changes in the reef and coastal ecosystems, the nature of which we are as yet unable to predict. Personal observations in Sri Lanka have indicated a shift in reef-associated fish and invertebrate composition since coral bleaching occurred in April 1998.

There is a clear trend towards expansion of the trade to include more species (from 139 species in 1985 to over 200 species in 1995); (sources: Wood, 1985, page 86 and Customs returns, respectively) and to export increased numbers of fish (from about 200,000 in 1985 to about 1,000,000 in 1995 (sources: Wood, 1985, p. 80 and Customs returns, respectively). Import of fish is also an increasing trend for transhipment. For example, imports of marine aquarium fish from Maldives to Sri Lanka have increased from 11,940 specimens in 1989 to 203,587 in 1994 (Adam, 1997).

Marine organisms constituted about 80% of exported live organisms in 1984-1985 (Wood, 1985, p.79). In 1995, ten years from this last recorded time, marine fish exports made up 67% of exported fish (data from Customs returns).

Sediment load, pollution and habitat destruction are increasing. These are discussed in greater detail in later Sections (Sections 8 and 9.1.1) of this Report.



<<

SECTION 6

Status of the Freshwater Fish Resources and Habitats

6.1 Exported freshwater fish

Fifty nine species of wild-caught freshwater fish exported from Sri Lanka are presently catalogued in this Report (listed in Table 6.1; see Annex 1 for their commonly used English and Sinhala names).

This number, however, is variable, depending on the quantities that are economically harvestable. Some species will not be collected for export since an export order has to contain a certain minimum number of individuals. The exporter should be able to supply his overseas client on a regular basis. This means reliable supplies of the right quantity have to be ensured. Thus, depending on the period under consideration, statistics on the number of species exported would vary (e.g., number of exported species is 61 in Gunasekera, 1998).

In analyzing the status of exported indigenous freshwater fish, Gunasekera (1998) speaks of the dangerous trend of uncontrolled export which would lead to the possible extinction of some of these species". Any such trend must be arrested to ensure the sustainability of the export trade.

The case of *Puntius bandula* illustrates how the long-term sustainability of the trade depends on a healthy and regenerating population. Although "large numbers (of this species) have been collected live for the aquarium fish trade since its discovery (Gunawardena, 1998), it is now a very rare, critically endangered species (Gunasekera, 1998). Some of its biological and ecological aspects, including aquarium breeding aspects, have been discussed by Gunawardena (1998). It is said that *P. bandula* is not presently exported because numbers found in the wild are low. For this species, "no collecting was reported in 1997 and upto March 1998", although "over 150 individuals have been collected on a single day in February 1995" (Gunawardena, 1998), when its collection was already prohibited **(Viz.,** from 1993: Fauna & Flora Protection Ordinance, Amendment No. 48 of 1993) – illustrating the lack of effective monitoring against unwarranted and illegal collection.

Table 6.1 List of Sri Lankan freshwater wild-caught fish species that are exported from Sri Lanka

1. *Anguilla bicolor*
2. *Chela laubuca*
3. *Danio malabaricus*
4. *Daniopathirana*
5. *Esomus thermoicos*
6. *Garra ceylonensis*
7. *Puntius amphibius*
8. *Puntius asoka*
9. *Puntius bimaculatus*
10. *Puntius chola*
11. *Puntius cumingii*
12. *Puntius dorsalis*
13. *Puntius filamentosus*
14. *Puntius nigrofasciatus*

Contd

<<

15 *Puntius pleurotaenia*

16. *Puntius ticto*

17. *Puntius titteya*

18. *Puntius vittatus*

19. *Rasbora daniconius*

20. *Rasbora vaterifloris*

21. *Lepidocephalichthys thermalis*

22. *Acanthocobitis urophthalmus*

23. *Schistura notostigma*

24. *Mystus gulio*

25. *Mystus keletius*

26. *Mystus vittatus*

27. *Ompok bimaculatus*

28. *Heteropneustes fossilis*

29. *Orzias melastigma*

30. *Aplocheilus dayi*

31. *Aplocheilus parvus*

32. *Aplocheilus werneri*

33. *Microphis brachyurus*

34. *Monodactylus argenteus*

35. *Toxotes chatareus*

36. *Scarophagus argus*

37. *Etroplus maculatus*

38. *Etroplus suratensis*

39. *Butis butis*

40. *Eleotrisfusca*

41. *Glossogobius giuris*

42. *Redigobius balteatops*

43. *Schismatogobius deraniyagalai*

44. *Sicyopterus griseus*

45. *Sicyopus jonklaasi*

46. *Anabas testudineus*

47. *Belontia signata*

48. *Ma/pulutta kretseri*

49. *Pseudosphromenus cupanus*

50. *Channa orientalis*

Contd

<<

51. *Channa striata*

52. *Mastaceinbelus armarus*

53. *Tetraodon fluviarilis*

Fish species ***in limited demand in the aquarium*** *trade* ***(Pethiyagoda. 1991)***

54. *Puntius sarana*

55. *Rasbora caverii*

56. *Clarias brachysoma* - **endemic**

57. *Zenarchopterus dispar*

58. *Sicyopus jonklaasi* - **endemic, rare**

Fish species that are used rarely because of low numbers

59. *Xenentodon cancila*

Although this report lists only 59 species that are exported, lists and statistics in various fishery research institutes name some other species as well. After studying a number of such lists, perusing export lists at Customs and comparing these with other literature, I have excluded some species from Table 6.1. Some of those excluded species, and the reasons for such exclusion, are cited in Table 6.2.

Table 6.2 Freshwater fish species not included as exports in Table 6.1

Species earlier exported in the aquarium trade but now apparently no longer exported		
Puntius bandula	-	endemic, highly threatened, critically endangered
Macrognathus aral	-	has not been recorded in Sri Lanka for the past 10 years, possibly extinct now; is still rarely recorded in export lists but the exported species is probably *Mastacembalus armatus*
Fish whose taxonomic status is unclear, but is used in aquarium trade		
Danio aequipinnatus	-	this species is commonly confused with *Danio malabaricus*
Fish species that have entered export statistics but are probably cases of mistaken identity		
Anguilla nebulosa	-	probably misidentified for *Anguilla bicolor*
Gymnothorax polvuranodon	-	probably mislabelled intentionally for marine moray eel species, since this species is very rare in freshwaters
Garra phillipsi	-	probably misidentified for *Garra ceylonensis*
Microphis ocellatus	-	this is not well known since its habitat is among marginal vegetation, probably misidentified for *Microphis brachyurus*
Some introduced species that are sometimes caught from the wild for use in the export trade		
Xiphophorus helleri		
Trichogaster pectoralis		
Osphronemus goramy		

<<

6.2 Status of exported species

Of the 59 export species listed in Table 6.1, one species *(Xenentodon cancila)* is not exported on a regular basis. Another five species *(viz., Puntius sarana, Rasbora caverii, Clarias brachysoma, Zenarchopterus dispar* and *Sicyopus jonklaasi)* are not in high demand (Pethiyagoda, 1991). That means *53* species are regularly exported and form the mainstay of this industry at present.

Of the 53 species regularly exported, 23 species are in heavy demand and are therefore exported in large numbers (Table 6.3), while 16 species and 14 species are exported in moderate (Table 6.4) and low numbers (Table 6.5), respectively.

The above categorisation of exported species into heavy, moderate and low numbers is based primarily on forms filed with the Customs authorities for 1995 and 1996, where 751,454 individual freshwater indigenous fish were recorded as having been exported. Although it is argued that these may not be accurate figures, they reflect the best estimate available from official records. Admittedly, Customs statistics (like all statistics) are only as good as the returns filed by exporters, and the accuracy with which exporters document their exports. In deciding the categories, these numbers were not the only criterion, discussions with the persons in the trade and with Customs personnel were other criteria.

Accordingly, species that were exported in numbers exceeding 5000 individuals as shown in Customs records over the two years were categorised as "heavily exported" species. Species such as *Rasbora daniconius* did not meet this criterion, but was still classified as a "heavily exported" species based on discussions – which again highlighted the drawback of using only the sheets lodged with Customs. "Moderately exported" species were those that were exported in numbers between 1,000 and 5,000 individuals over the 2-year period. "Low" exports were species that recorded exported numbers below 1,000 individuals.

Freshwater aquarium fish exports during 1995 & 1996

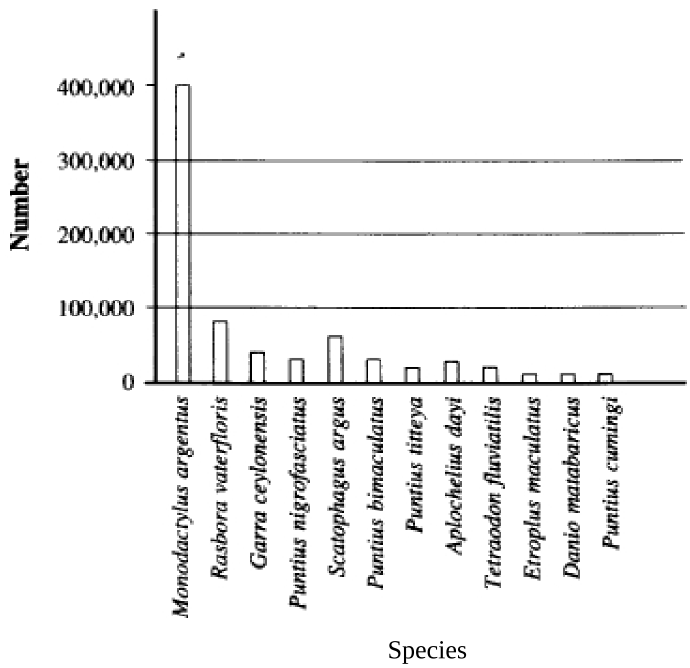


Figure 6.1 Major indigenous fish species exported in the freshwater aquarium trade

The 12 fish species, based on Customs records, that were most heavily exported in 1995 and 1996 are shown, along with exported numbers, in Figure 6.1.

Monodactylus argenteus (a brackish water species) is the single non-endemic species that is exported in the largest quantities. *Rasbora vaterifloris, Puntius nigrofasciatus* and *Puntius titteya* include heavily exported threatened endemics, while *Puntius binwculatus* and *Aplocheilus dayi* are among the threatened indigenous species that are heavily exported. In the case of the heavily exported *Puntius cumingii,* it may be the attractively coloured individuals that could face a threat. The export of endemic protected species is permitted for aquarium-bred individuals.

Gunasekera (1995), used Customs records to analyse indigenous fish species exported by a leading exporter from June to December 1984 and found similar trends in exports. He said the most heavily exported species included *Puntius titteya* (22%), *P. nigrofasciatus* (18%) and *Rasbora vaterifloris* (37%). The other heavily exported species at that time were *P. cumingii* (12%) and *Belontia signata* (11%).

Table 6.3 summarises the status of the heavily utilised fish. It shows that, in addition to the five species that are among the most heavily collected, *Lepidocephalichthys thermalis* is also collected in large numbers. But its populations seem to be satisfactory as of now though *P. asoka* population sizes are said to have thinned. Of the two *Aplocheilus* species, *A. dayi* is collected in larger numbers but seems to be maintaining a satisfactory population; whereas *Aplocheilus werneri* seems to have suffered, with larger individuals becoming less abundant. Similar effects on population structure have been discernible in *Toxotes chatareus, Monodactylus argenteus* and *Scatophagus argus,* although scientific studies would be needed to confirm (or negate) these preliminary observations. It must be kept in mind that the two latter species are also caught in fishing gear used for edible species. The reduction in the more colourful individuals in *Belontia signata, Puntius bimaculatus, P. cumingi, P. nigrofasciatus* and *P. titteya* seems to indicate that population characteristics have changed as a result of the selective fish collection carried out for the export trade (S Gunasekera, pers. corn.).

Table 6.3 Heavily utilised Sri **Lankan wild-caught freshwater fish species, their** status **and notes of interest, such as distribution and indicative population condition.** ***Some details of geographic distribution can be found in the notes for individual species, given in Section 6.5***

1. *Chela laubuca* - a common fish that is easily bred
2. *Danjo malabaricus* - a fish of very common occurrence, very widely distributed
3. *Garra ceylonensis* - common and quite widely distributed
4. *Puntius asoka* - An endemic species that is becoming scarce, very restricted in distribution.
5. *Puntius bimaculatus* - An endemic species that is common, although the more colourful specimens that are selectively collected for export may be under intense threat.
6. *Puntius cumingii* - An endemic species that is not uncommon, but the more colourful specimens that are selecitvely collected for export may be under intense threat.
7. *Puntius dorsalis* - not always caught in large numbers. Only the more colourful individuals are selected for export.
8. *Puntiusfilamentosus* - smaller individuals are used, but it is a common widely distributed species.
9. *Puntius nigrofasciatus* - an endemic species which is very **heavily exploited** in the aquarium trade, particularly its colourful individuals. Since it is easily bred in captivity, popularisation of **breeding** methods for this species would lead eventually to cessation of wild collection of this species in large numbers.

10. *Puntius titteva* - an endemic whose colour varieties are much in demand. Although the species is quite visible, sought-after colour varieties are rapidly declining. Since breeding is not difficult, suitable breeding programmes must be established and popularised without undue delay.

11. *Rasbora daniconius* – is an extremely common widely distributed indigenous species

12. *Rasbora vaterifloris* – is heavily threatened by overfishing and by bad handling after capture. Many juveniles die after capture and some are returned to the water, only adults being selected for sale. Ecological studies, population estimates, conservation measures including better handling and tranport techniques and breeding methods need to be speedily **adopted** for this species.

13. *Lepidocepha/ichthys thermalis* – is a very common indigenous species that appears to be under no apparent threat. It is, however, very heavily collected; its breeding biology is completely unknown; it merits some ecological study.

14. *Acanthobitis urophtha/rnus* – an endemic species that is not widely distributed. Ecological, biological and population data are lacking. It does not appear to be under immediate threat, but **compilation of a data base for** this species is desirable, because its characteristics, so far as is known together, with heavy fishing pressure, do not bode well for the species.

15. *Aplocheilus davi* – an endemic species that is collected in large numbers. *Aplocheilus* species naming in export lists may not be accurate, so that mixed species may be exported.

16. *Aplocheilus werneri* – an endemic fish whose population structure appears to be affected by collections for the aquarium trade. Since it is not widely distributed, it would seem appropriate to conduct population studies to assess its population status.

17. *Monodactylus argenteus* – an indigenous fish collected from estuarine habitats where the size of the exported stock has recorded a decline in recent years (to a 2cm to 5cm size), probably as a direct result of over-collection.

18. *Toxotes chatareus* – an indigenous species under heavy collection pressure, with difficulty now being experienced to find specimens larger than 15cm in size.

19. *Scatophagus argus* – a heavily fished estuarine indigenous species, whose export size seems to have decreased over the years.

20. *Etroplus rnaculatus* – an indigenous species that is common, though perhaps in reduced quantities. No reliable population estimates are available.

21. *Etroplus suratensis* – an indigenous common species whose smaller sizes are exported.

22. *Belonria signata* – an endemic species whose bright colour varieties have decreased greatly due to over collection and requires restriction of collection, as well as popularisation of breeding methods.

23. *Tetraodonfluviarilis* – a heavily fished indigenous puffer that is quite common and found in greateer abundance in estuaries.

Table 6.4. Moderately utilised Sri Lankan wild-caught freshwater fish species

1. *Danio pathirana*
2. *Esomus thermoicos*
3. *Puntius pleurotaenia*
4. *Puntius ticto*
5. *Puntius vittatus*
6. *Schistura notostigma*

Contd

7. *Mystus vittatus*
8. *Heteropneustes fossilis*
9. *Aplocheilus parvus*
10. *Microphis brachyurus*
11. *Redigobius ba/teatops*
12. *Schismatogobius deraniyagalai*
13. *Malpulutta kretseri*
14. *Pseudosphromenus cupanus*
15. *Channa orientalis*
16. *Mastacembelus armatus*

Table 6.5 Sri Lankan wild-caught freshwater fish species that are exported in low numbers

1. *Angui/la bicolor*
2. *Puntius amphibius*
3. *Puntius chola*
4. *Mystus gu/io*
5. *Mystus keletius*
6. *Ompok bimaculatus*
7. *Oryzias melastigma*
8. *Butis butis*
9. *Eleotrisfusca*
10. *Glossogobius giuris*
11. *Sicyopterus grisseus*
12. *Sicyopus jonklaasi*
13. *Anabas testudineus*
14. *Channa striata*

Of the 27 endemic freshwater fish species, 20 are used in the aquarium export trade (Table 6.6)

6.3 Status **of exported endemic species**

Of the Ca. 80 species of indigenous freshwater fish in Sri Lanka, approximately 27 are endemic. Of the 27 endemic freshwater fish species, 20 are presently being used in the aquarium export trade (Table 6.6).

Table 6.6 summarises the status of the exploited endemic species. It is apparent that the lack of quantitative population data restricts any detailed analysis or recommendations that should he made. Even so, some of the available data allow for a broad analysis whereby starting points for future work can be identified.

With regard to some species, only small populations are present (e.g. Gunasekera, 1998 and personal observations). These species require immediate measures to be adopted for their conservation and management: *Danio pathirana*, *Puntius asoka.* In *Aplocheilus werneri* only relatively small populations have so far been discovered, so that conservation

<<

measures are necessary here too. In other species, very low numbers are present in the wild *(Sicyopusjonklaasi).* **In** *Puntius asoka, Puntius cumingii, Punrius nigrofasciatus, Puntius titteya* and *Rasbora vaterifloris* the populations present require management/conservation measures due to the heavy collections that are ongoing. Colour varieties of *Puntius bimaculatus, Puntius cumingii, Puntius nigrofasciatus, Puntius titteya* and *Belontia signata* are being very heavily collected. These would lead to deleterious effects on the gene pool. The effect of size-targeted collections for export are in evidence for populations of species such as *Aplocheilus werneri* and *Malpulutra kretseri.* These could eventually lead to population decline.

Table 6.6 Status of endemic Sri Lankan freshwater fish species that are caught in the wild for utilisation in the aquarium export industry, and notes of interest such as distribution, abundance, threatened status and measures that could be adopted for their sustainable management and conservation

1. *Danio pathirana* – abundant where it occurs, but only in a single area in the Nilwala River basin. Therefore conservation and captive breeding measures and ecological studies are essential.
2. *Esomus thermoicos* – possibly an endemic species, its status is still not fully resolved. This species does not seem to be under threat at present as it is common.
3. *Garra ceylonensis* – commonly found species, especially in the wet zone, not under immediate threat.
4. *Puntius asoka* – Very restricted, heavily fished and under threat. **Requires** conservation measures and studies.
5. *Puntius bimacu/atus* – Although heavily utilised in the aquarium trade, populations of this species are not presently under threat, other than for the more attractively coloured individuals that may require some protective measures..
6. *Puntius cumin gii* – An endemic species that is not uncommon, but the more colourful specimens that are selectively collected for export require management.
7. *Puntius nigrofasciarus* – An endemic species which is **very heavily collected and** exported, especially its colourful individuals.
8. *Puntius pleurotaenia* – An endemic that is caught in moderate numbers for export.
9. *Puntius titteya* – An endemic whose colourful varieties are in high demand; possibly overfished.
10. *Rasbora vaterifloris* – **A much threatened** endemic species facing multiple threats from over-collection for the export trade, deforestation and declining water quality arising from pollution.
11. *Acanthocobitis urophthalmus* – a much sought-after endemic that is common locally, but hitherto has been able to stave off drastic population decline.
12. *Schistura notostigma* – a moderately sought after species that seems not to be in much danger.
13. *Aplocheilus dayi* – heavily fished, but seems able to sutain fishery pressure at present.
14. *Aplocheilus werneri* – heavily fished, populations seem to show the effects of size-specific collections for export.
15. *Schismatogobius deraniyagalai* – this endemic species is moderately fished from its only known locality. Great care must be exercised and conservation measures adopted until new populations are discovered.
16. *Sicyopus jonklaasi* – a rare gobid exported in very low numbers.
17. *Belontia signata* – heavily collected bright colour morphs have almost disappeared and require restriction of collection and the employment of captive breeding methods.
18. *Malpulutta kretseri* – collection for the aquarium trade is hampered by the low numbers of its population which requires protection. Also, smaller sizes are now present in the wild.

19. *Channa orientalis* – it is not collected in large numbers for export, but together withhabitat destruction, its populations are on the decline.

20. *Clarias brachysoma* – this endemic catfish is exported in limited numbers.

6.4 Status of threatened species

IUCN (1994) listed 19 species as threatened. In a later version of the IUCN list (1996), the number of endemic species under the "threatened" status was reduced to eight. A number of persons and organisations have questioned the validity of this reduction (e.g. Ranasinghe and Samarasinghe, 1997) and demanded that IUCN revise this reduced list (Editor's Note in Gunasekera, 1998). It seemed therefore pertinent to consider the species in the 1994 list.

Of the 19 species contained in the 1994 IUCN list, 18 species are exported. Only one of them *(Sicyopterus grisseus)* is not an endemic species. The status of all the 18 exported threatened species is summarised in Table 6.7. The status of all, except *Sicyopterus griseus*, has been discussed further in the previous sub-section and shall therefore not be repeated here. *Sicyopterus grisseus* is exported, if at all, in very low numbers since it is rare in the wild.

The status of freshwater fish species with regard to factors such as availability, distribution and populations has been succinctly reviewed in Gunasekera (1998) and Ranasinghe and Samarasinghe (1997). Although their work is not based on detailed scientific studies, I think it is more useful to take note of it than disregard it. It may induce or stimulate more scientific investigation later by some other researcher or research institution. One should point out that the universally accepted IUCN criteria for risk catergorisation seems to be based on similar guiding principles in accepting practical realities needed for common property resource management (e.g., "An observed, estimated, inferred or suspected reduction) (in population)": IUCN, 1996. NARA is theoretically correct in its stand that "proper studies" are needed for scientific analysis (NARA, 1998).

Table 6.7 Status **of the 18 exported freshwater fish species that are under threat**

1. *Danio pathirana* – abundant where it occurs, but is extremely localised only to a single area in the Nilwala River basin Therefore conservation and captive breeding measures and ecological studies are essential. Is an endemic species.

2. *Garra ceylonensis* – commonly found endemic species, specially in the wet zone, not under immediate threat.

3. *Puntius asoka* – very restricted endemic, heavily fished and under threat. Requires conservation measures and studies.

4. *Puntius bimaculatus* – although this species is heavily utilised in the aquarium trade, populations of this species are not presently under threat, other than for the more attractive **colour varieties that may require some** protective measures.

6. *Puntius cumingii* – an endemic species that is not uncommon, but the more colourful specimens that are selecitvely collected for export may require proper management measures.

7. *Puntius nigrofasciatus* – an endemic species which is very heavily collected and exported, specially its colourful varieties.

8. *Punt/us p/eurotaenia* – a possible endemic that is caught in moderate numbers for export.

9. *Punt/us titteya* – an endemic whose colourful varieties are in high demand and is possibly overfished.

10. *Rasbora vaterifloris* – a much threatened endemic species facing multiple threats from over-collection for the export trade, deforestation and declining water quality arising from pollution.

<<

11. *Acanthocobitis urophthalmus* – a much sought after endemic loach that is not common, but seemingly able to stave off drastic population decline.

12. *Schistura norostigma* – a moderately sought after endemic species which seems not to be in much danger.

13. *Aplocheilus davi* – heavily fished endemic, but seems able to sustain the fishing pressure at present.

14. *Aplocheilus werneri* – heavily fished endemic, populations seem to be beginning to show the effects of size-specific collections for export.

15. *Schismatogobius deranivagalai* – this endemic species is moderately fished from its only known locality. Great care must be exercised and conservation measures adopted until new populations are discovered.

16. *Sicyopterus griseus* – is an indigenous fish that is caught in very low numbers or hardly at all as it very rare.

17. *Belontia signata* – heavily collected bright colour morphs have almost disappeared and require restriction of collection and the employment of captive breeding methods.

18. *Channa orientalis* – it is not collected in large numbers for export, but together with habitat destruction, its populations are on the decline.

Table 6.8 Threatened freshwater fish species of Sri Lanka

(Species included in the 1994 IUCN Red List of Threatened Animals are denoted by * The 1996 IUCN List contains fewer species, denoted by with which some conservationists disagree. See text above for details)

Cypriniformes

*Puntius titteya**

*Puntius nigrofasciatus**

*P. srilankensis**

P. pleurotaenia

P. bimaculatus

*P.asoka**

P.bandula•

P.martenstyni•

*Rasbora vaterifloris**

*R.wilpita**

*Labeofisheri**.

Garra ceylonensis

*G. phillpsi**

Schistura notostigma

Acanthocobitis urophthalmus

Contd

<<

Horadandiya atukorali

*Lepidocephalichthys jonklaasi**

*Danio pathirana**.

Perciformes

Sicyopus jonklaasi

*Schismatogobius deraniyagalai**

Sicyopterus grisseus

*S.halei**

*Malpulutta kretseri**

*Belontia signata**

Channiformes

Channa orientalis

Cvprinodontiformes

Aplocheilus dayi

A.werneri

Siluriformes

Heteropneustes microps - junior synonym of H. fossilis*

Source: IUCN (1994, 1996)

6.5 Biology, ecology, distribution and populations of exported freshwater fish

(numbers 1 to 54 in this Section refer to the 54 species for which data are presented)

1. *Anguilla bicolor*

This is one of two indigenous species belonging to the order Anguilliformes (true eels). This species grows in freshwater. When it is ready to breed, it will undergo a metamorphosis involving the build-up of adipose tissue, enlargement of eyes and loss of its dark colour (thereafter called "silver eels"). Following metamorphosis, it will migrate to the sea where it will breed, producing glassy leaf-shaped leptocephali larvae. Leptocephali will then grow and, in coastal waters, metamorphose into transparent, large-headed eel-like forms called elvers. The elvers enter estuaries and travel upriver into freshwaters.

The detailed biology of Sri Lankan eels is as yet unreported, other than for elvers having been reported in the sea off Manaar (Deraniyagala, 1952) and observed in the estuaries at Panadura, Kalutara and Rekawa (personal observations). The University of Ruhuna is conducting studies on the biology of Sri Lankan eels (R. Kumaranatunga, pers. comm.).

<<

The eel is nocturnal and carnivorous, feeding on fish, crustaceans and molluscs. It is a pest in lagoon prawn fisheries where eels will prey heavily on prawns caught in gill nets (personal observations, Rekawa lagoon). It prefers marshy habitats. It is very common and widely distributed especially in the coastal areas.

The species and larvae are discussed by Deraniyagala (1929, 1931) and various aspects are summarised by Pethiyagoda (1991).

Only small numbers of smaller-sized specimens of *Anguilla bicolor* are used in the aquarium trade. This species is not presently under threat.

2. *chela laubuca*

Chela laubuca is an indigenous, common, widely distributed species. It is distributed almost throughout the dry zone, except perhaps the Walawe basin (Pethiyagoda, 1991). It also extends into the lowland parts of the wet zone. It occupies an upper to mid-depth position in both shallow and deeper slow to fast-flowing streams and also occurs in ponds and tanks. Commonly shoals in schools of 15 to 30 individuals.

It is a hardy species that feeds mainly on insects (Costa and Fernando, 1967) while taking also stems and leaves (Pethiyagoda, 1991). They spawn easily and mating takes place at dusk or dawn in shallow waters. The 30 or so eggs that are spawned hatch in about 24 hours.

Although wet zone specimens of this species are heavily utilised in the aquarium trade (Pethiyagoda, 1991), populations of this species are not presently under threat.

3. ***Danio malabaricus***

Dania inalaharicus is a common, indigenous species that enjoys a very wide distribution from the dry and wet zone lowlands upto the central highlands. It is common in flowing waters but is found in various habitats from tanks, reservoirs and small pools in streams to torrential mountain streams. It is a fast swimmer, preferring the mid-waters.

It is a hardy fish, feeding on terrestrial insects and detritus (Moyle and Senanayake, 1984). Over 200 light orange-coloured slightly sticky eggs are spawned among marginal weeds and roots, usually after heavy rains. They hatch in one to two days and become free-swimming in about five days (Pethiyagoda, 1991).

Although heavily utilised in the aquarium trade, populations of this species are not presently under threat.

4. ***Danio pathirana***

Danio pathirana is a recently described (in 1990) endemic species that has a very restricted distribution in the Nilwala River basin and is not sympatric with the very widely distributed *Danio ma/abaricus.* It occurs in pools and in swift-flowing areas of streams with a pebble or boulder substrate frequenting near-surface waters and swimming slowly in groups of between three to five individuals (Pethiyagoda, 1991; Kottelat and Pethiyagoda, 1990).

Its food habits are not known. Pethiyagoda (1991) has expressed the opinion that it is probably an insectivore. Its breeding biology and ecology are not well known either. It could be adversely impacted by high loads of silt.

It is said (Pethiyagoda, 1991) that aquarium fish exporters voluntarily refrained from collecting this species earlier. But it is now collected in “moderate numbers”.

Since the species is found in very restricted locations, it is necessary to breed it in captivity for the aquarium trade as well as to adopt conservation measures for its protection (Pethiyagoda, 1991). Ecological studies on this species need to be carried out.

5. *Esomus thermoicos*

This is a widely distributed fish preferring to inhabit muddy pools of the low country dry and wet zones, though it is said to be more abundant in the north eastern dry zone waters (Pethiyagoda, 1991). It is a fast swimmer and has a tendency to leap out of aquaria.

Esomus thermoicos feeds on insect larvae, small worms and crustaceans. It is bred easily and spawns about 150 light grey-coloured semi-adhesive eggs in several batches onto floating or marginal vegetation within a period of about one hour (Pethiyagoda, 1991).

The species is moderately utilised in the aquarium trade but appears to be in no danger as large populations are reported to be widely distributed.

6. *Garra ceylonensis*

It is an endemic species that frequents the bottoms of rocky or pebble-laden pools or streams. It is widely distributed in both dry and wet zones but is common in the wet zone. It is the only species recorded from many high-elevation hill streams (Pethiyagoda, 1991).

The diet of *Garra ceylonensis* consists mainly of diatoms and detritus (Costa and Fernando, 1967) that it probably scrapes off rocks. The breeding biology of the species is not well known, other than that it ascends small rocky streams to breed and that young fish are free-swimming until they reach about 5cm in length, at which stage they become benthic (Pethiyagoda, 1991).

Garra ceylonensis is used in moderate to heavy numbers in the aquarium trade, but it is common and does not appear to be under immediate threat.

7. *Puntius amphibius*

This indigenous species is distributed mainly in the wet zone and extends into the coastal dry zone also where it is not uncommon, though not found in large-sized populations (Pethiyagoda, 1991). It is said to tolerate salinity, occurring in coastal marshes. It occurs in streams and tanks in the dry zone and in gravel or pebble lined streams in the wet zone.

Puntius amphibius feeds on detritus, algae (Prem Kumar et al., 1987) and other vegetation. It breeds after the rains, spawning among vegetation in shallow water.

The species is sparingly used in the aquarium trade and its populations are not under threat.

8. *Puntius asoka*

Puntius asoka is an endemic species whose numbers have declined in the recent past. It is highly restricted in distribution and occurs only in a few locations in and around the Sitawaka River and in a restricted part of the Kelani River. It is a fast swimmer. Juveniles shoal only in shallow, shaded, sand-substrate parts of the river. Adults prefer 1 to 2m depths having sandy or gravelly substrates whereas schools of juveniles comprising 30 to 100 individuals frequent very shallow water.

The diet and breeding biology of the species are not known.

Puntius asoka is popular with the aquarium fish exporters. In view of its dwindling population, it requires conservation measures and studies into its biology and ecology.

9. Puntius bimaculatus

Puntius bimaculatus is not considered to be an endemic species. It is common, widely distributed throughout the island but is common in the wet zone, being recorded as one of the few fish that ascends montane streams above 1,500m elevation (Pethiyagoda, 1991). It frequents all types of habitats, from tanks and rivers to hill streams.

In food habits, it is a substrate feeder, feeding on diatoms, filamentous algae, green algae and detritus (Geisler, 1967; De Silva, Kortmulder and Wijeratne, 1977; Moyle and Senanayake, 1984). It spawns several batches of about 100 eggs amongst weeds in shallow water after the onset of rains. The eggs hatch after about 48 hours, and fry are free-swimming after one or two days (De Silva et al., ***1985).***

The more colourful individuals are heavily used in the aquarium trade. Even though the species itself is evidently not under threat, some have expressed concern that such individuals would be lost from the gene pool if remedial measures are not speedily adopted.

10. Punlius chola

This indigenous species is found in streams, rivers and tanks in both dry and wet zone lowlands, though it is now common in the dry zone. It is a shallow water dweller, preferring a silty substrate and is abundantly found at dry zone tank sluices.

It is an omnivorous browser in feeding habits, preferring zoobenthos (Schiemer and Hofer, 1983) and adult insects, zooplankton, insect larvae, fish eggs and micro-benthos (Piet and Guruge, 1997). It breeds following the rains and spawns among the vegetation.

Puntius Chola is a hardy fish that is utilised in small numbers in the aquarium trade.

11. Puntius cumingii

Puntius cumingii is an endemic species found in the Kelani and Kalu Rivers only, preferring flowing waters, with the red-finned (Kelani) morphs occurring in slow flowing water in mud or silt substrates of marshy areas adjacent to the Kelani valley foothills. The yellow finned variety prefers flowing waters with sand to boulder substrates. It is found in the Kalu River and in more southerly areas. *Puntius cumin*gii inhabits the water layer near the bottom where it is present in medium-sized shoals.

It is a hardy species, feeding on green algae, plankton and detritus (Giesler, 1967). *Puntius cumingii* matures at about a 3cm length (De Silva and Kortmulder, 1977) with yellow individuals being larger than red individuals, spawning after the rains where the spawn of 100 eggs hatch in about one day and develop into free-swimming fry after about 24 hours (De Silva et al., 1985).

The introduction of this fish, along with three other species, to the Mahaweli at Ginigathhena by Moyle and Senanayake (on 4th February 1981: Evans, 1981) is highly questionable and illustrates the dangers of short sighted translocation experiments, where the long-term conservation interests of a species assemblage had not been properly addressed.

The species is caught heavily for the aquarium trade. Though it is not uncommon, the selective harvesting of the more colourful varieties, such as the red-finned varieties, imposes a threat to their gene pooi.

12. *Puntius dorsalis*

This an indigenous common species which is widely distributed in the island, except in the montane area. It prefers flowing waters having pebbles where it stays close to the bottom layers. Its diet consists of algae, diatoms, detritus, higher plants, insects and zoobenthos (Fernando, *1965;* Costa and Fernando, 1967; Giesler, 1967; Schiemer and Hofer, 1983; Moyle and Senanayake, 1984; Piet and Guruge, 1997). Spawning occurs after the rains when up to 700 small eggs are spawned among vegetation.

Smaller-sized more colourful varieties are collected for the aquarium trade in moderate and sometimes high numbers.

13. *Puntius filamentosus*

This indigenous Puntius species is widely distributed up to about 600m elevation, occurring mainly in flowing water but extending into still and brackish waters (Pethiyagoda, 1991). Its diet consist of crustaceans, diatoms and filamentous algae (Moyle and Senanayake, 1984). In breeding, 500 to 1,000 eggs are spawned around shallow-water vegetation which hatch in about 48 hours and develop into free swimming fry after two days.

Smaller specimens are heavily utilised for the export trade, but it is a common, widely distributed species not requiring stringent protective measures at present.

14. *Puntius nigrofasciatus*

Puntius nigrofasciatus is an endemic species that is not widely distributed since it is restricted to forest streams from Kelani to Nilwala basins, with a preference for hilly areas up to about 300m elevation (Pethiyagoda, 1991). It requires clear, cool shaded stream waters with sandy or gravely bottoms and may sometimes be found in quiet pools of streams and rivers.

It feeds on filamentous algae and detritus (De Silva and Kortmulder, 1977; Moyle and Senanayake, 1984). Eggs, numbering about a hundred, are spawned onto marginal plants which hatch in one to two days, developing into free-swimming fry a day later (Pethiyagoda, 1991). It is easily bred in captivity (Axelrod, 1967).

This species is very heavily used in the export freshwater fish trade. Although its populations are still abundant in some locations, it should be considered as an endemic species facing risk, particularly with regard to the colour varieties, such as deep red and black varieties, that are collected selectively from some locations. Since *Puntius nigrofasciatus* can be bred easily, popularisation of breeding techniques should take pride of place in evolving conservation measures for this species so that the market for collection of large numbers from the wild would gradually dry up.

15. *Puntius pleurotaenia*

This too is an endemic and not uncommon species, confined to the lower south western hills within the Kelani and Nilwala catchment areas (Pethiyagoda, 1991). It prefers middle layers of the water column and requires clear, heavily shaded streams exceeding 1m in depth, where it tends to form small shoals.

<<

The diet of *Puntius pleurotaenia* consists of filamentous algae, terrestrial insects and detritus (Moyle and Senanayake, 1977). Its breeding habits are unknown, except that maturity is reached at about 64cm (De Silva and Kortmulder, 1977).

The species is caught in moderate numbers for the aquarium trade.

16. Puntius ticto

Puntius ticto is indigenous and is distributed widely in tanks and smaller rivers of the northern and eastern dry zone where it frequents the still and shallow marginal areas (Pethiyagoda, 1991). It feeds on crustaceans, insects and plankton and has been bred in captivity where about 150 eggs are laid in batches of about 20. The eggs hatch in a day and develop to free-swimming fry in another day (Axelrod, 1980).

This commonly found species is exploited by the aquarium trade in moderate numbers.

17. Puntius titteya

This endemic species is not widely distributed and is confined to heavily shaded, shallow, slow-flowing waters with silty and leaf-debris substrates in the low country wet zone, up to about 300m in elevation (Pethiyagoda, 1991). It has an omnivorous diet consisting of detritus, algae, diatoms, dipterans and animal matter. It has been easily bred in captivity for many years (Axelrod, 1967). It is not a hardy fish. Eggs, numbering about 200, are scattered among marginal vegetation. Hatching occurs in one to two days and free-swimming fry develop two days after hatching. Fry rearing requires careful feeding (with infusoria).

Puntius titteva is very popular among exporters. Specially so are the more colourful individuals, such as the males of the red variety from Nilwala basin. Although the species itself is still not rare, certain colour forms, such as the all red individuals, are extremely difficult to find, and have become rare due to over-collection (S Ghunasekera, pers. corn.). The species is rapidly being overfished. Exports therefore should ideally be confined to hatchery-reared individuals. Breeding programmes should be tested with fry food available in Sri Lanka and popularised.

18. Puntius vittatus

Puntius vittatus is a very common indigenous species, occurring in water bodies, including brackish waters, in wet and dry zones up to about 300m in elevation. It is an algal feeding herbivore, feeding on filamentous and blue-green algae. This fish species breeds easily and prolifically, spawning about 1,000 eggs that hatch the next day and develop into free swimming fry after one more day.

19. Rasbora daniconius / caverii

Rasbora daniconius is very common, widely distributed and one of the most abundant indigenous fishes, occurring mainly in sandy streams and rivers and extending to almost saline water. In distribution it occurs throughout the island at elevations below 500m. It feeds mainly on aquatic insects and detritus and small quantities of macrophytes (Fernando, 1956; Costa and Fernando, 1967; Moyle and Senanayake, 1984; Piet and Guruge, 1997). This species lays about 500 non-adhesive eggs which sink to the bottom to hatch in 36 to 48 hours, the fry becoming free-swimming about two days later (Pethiyagoda, 1991).

Rasbora daniconius is a popularly exported fish species for the aquarium trade, but it is so abundant that no threat is envisaged through aquarium exports.

20. *Rasbora vaterifloris*

Rasbora vaterifloris is an attractive endemic species with restricted distribution in streams of the Kalu River to Nilwala River basins. It requires heavy shade and shallow, cool, clear streams with leaf debris on a silty substrate, and is found in forested areas (Pethiyagoda, 1991). A quiet, retiring fish, it tends to avoid light and frequents mid-regions of the water column.

R. vaterifloris feeds on dipterans, coleopteran larvae, other insects and detritus (Giesler, 1967; Moyle and Senanayake, 1984). It is a prolific breeder, laying several batches of about 20 eggs among submerged marginal vegetation within about a 30-minute period. The eggs sink and hatch in about 36 hours, developing into free-swimming fry on the following day. The young, as are the adults, are very sensitive to water conditions.

This species has several colour varieties. The red, orange, yellow-finned colour varieties are very heavily sought alter for the export aquarium trade. It is under heavy threat through over-exploitation by the export trade and requires immediate study and the adoption of conservation measures. Animals that are caught are very sensitive to stress, handling and water conditions, so much so that it is said (Pethiyagoda, 1991) that only about 10% of captured fish survive to the retailing point.

21. *Lepidocephalichthys thermalis*

This indigenous hardy loach is widely distributed in quiet, flowing, unshaded waters with sandy to muddy substrates ranging from coastal areas to elevations of around 600m. It feeds on algae, leaf debris and detritus while its breeding biology is completely unknown.

Collection of this species for the aquarium industry is heavy. But its populations are sufficiently large and widely dispersed, so pressure on the resource can be borne without any apparent signs of population stress.

22. *Acanthocobitis urophthalmus*

Acanthocobitis urophthalmus is an endemic loach that is not very common. Its distribution is restricted to shallow, flowing pebble-bottomed waters of the south western lowlands, upto an elevation of about 300m. Its diet and breeding biology are not known, but it probably feeds on detritus and invertebrates (Pethiyagoda, 1991).

Its body colouration of tiger-like stripes has made it a sought after species for the aquarium trade. Consequently, it is heavily fished. The population status of *Acanthobitis urophthalmus* is not known, though existing populations seem to support the view that it is not under serious threat right now.

23. *Schistura notostigma*

This endemic banded loach is not uncommon in its shallow flowing water habitat which is mainly in the central hills, going up to 1,500m in elevation. It ascends steep inclines and is found in high mountain streams. It is a benthic feeder, taking also trichopterans, ephemeropterans, algae, vegetable matter and detritus (Costa and Fernando, 1967; Moyle and Senanayake, 1984; Pethiyagoda, 1991). Its breeding habits are not known.

Moderately fished for the aquarium trade, the species does not seem to be in imminent danger.

24. *Mystus gulio*

Mystus gulio is an indigenous catfish that is primarily a brackishwater species, extending its range successfully into freshwater. It is found mainly on the coastal plains, up to distance of about 30km inland. It feeds on an invertebrate diet (Piet and Guruge, 1997) and spawns eggs that are attached to vegetation, beyond which its biology is unknown.

The species is collected for the aquarium trade only in small numbers.

<<

25. *Mystus keletius*

This indigenous catfish species is widely distributed in muddy substrates of pools and tanks in the Anuradhapura-Polonnaruwa area (Pethiyagoda, 1991). It also occurs near coastal areas but does not extend into the hills. It is nocturnal and feeds on plants, insects, detritus and benthic animals (Fernando, 1965). Its breeding biology is unknown.

Mystus keletius is collected regularly for the aquarium trade, though in small numbers.

26. *Mystus vittatus*

This is an indigenous nocturnal catfish distributed widely throughout the low country, and is commonly found among marginal vegetation in lakes and swamps having a muddy substrate (Pethiyagoda, 1991). It feeds on plants, insects, detritus and benthic animals (Fernando, 1965; Piet and Guruge, 1997). Its breeding biology is unknown.

Mystus vittatus is collected for the aquarium trade in moderate to heavy numbers.

27. *Ompok bimaculatus*

Ompok bimaculatus is a common, indigenous catfish having a wide distribution in tanks and small streams of the low country having shallow, quiet muddy to sandy bottoms. It is nocturnal and feeds on vegetable matter and fish (Fernando, 1965). Its reproductive biology is hardly known.

Limited numbers of the species are caught for export.

28. *Heteropneustes fossilis*

This stinging catfish is widely distributed and indigenous. It is found throughout the low country, inhabiting swampy, turbid waters and forming schools of about 10 similar-sized individuals. It extends into brackish waters. It is omnivorous. It bays light green eggs in a muddy depression in shallow waters excavated by both parents. Eggs hatch in about two days and the young are cared for by the parents until they are about a month old. *Heteropneustesfossilis* can tolerate temperatures up to almost 40^{0} C (Vasal and Sudara Raj, 1978) and can stay out of water for extended periods since it is able to breathe air.

There is a moderate to heavy collection of this species for the aquarium trade, but it seems able to withstand the pressure at present.

29. *Oryzias melastigma*

This is a common, quite widely distributed small-sized fish inhabiting swampy brackish waters of the coastal wet zone. They are found in shallow waters among roots and mangroves. *Oryzias melastigma* feeds on small animals such as insects, larval forms and fry. It is easily spawned in captivity where eggs of up to a dozen per batch are attached to the underside of surface vegetation by adhesive filaments. Eggs take about 10 days to hatch (Pethiyagoda, 1991).

A few of these fish are collected for export.

30. *Aplocheilus dayi*

Aplocheilus dayi is a common endemic species. Distribution is confined to the Kelani River basin and its adjacent coastal areas. They occur in shallow, heavily shaded shallow forest streams with a silt substrate, extending into less saline parts of mangrove swamps. It feeds on small-sized prey such as insects, larval forms and fry. Spawned eggs hatch in about two weeks, and the species is easily bred in captivity.

Large numbers of *Aplocheilus dayi* are collected for export, but its population does not seem to have suffered any large-scale decline.

31. *Aplocheilus parvus*

This is an indigenous fish that is common in coastal fresh and brackishwater habitats of the low-country, including paddy fields. It is a slow swimmer, preferring to stay just under the cover of surface vegetation. It is a shoaling species inhabiting shallow to deep waters. Like the previous species, it feeds on small animals such as insects, larval forms and fry. About a hundred adhesive eggs that are deposited on submerged vegetation hatch in about 10 to 14 days.

Aplocheilus parvus is collected for the aquarium trade in moderate to heavy numbers, but continues to be a commonly available fish species.

32. *Aplocheilus werneri*

This endemic kilifish is still quite abundant within the restricted areas in which it is found. It is distributed from the Kalu River to Nilwala basins, up to about 200m in elevation where it frequents shallow, slow-flowing heavily shaded streams having a silt or clay substrate. It feeds on small insects, larvae and fry. Its breeding biology is not clearly known but would probably be similar to the previous species.

Aplocheilus werneri is intensively collected for the aquarium trade. It is reported that large-sized individuals are now hard to find (Pethiyagoda, 1991), so that collections would seem to have some impact on its population structure.

33. *Microphis brachyurus*

This is an indigenous pipefish that has a wide regional distribution, though it is not very common. It occurs in margins of estuaries of wet zone rivers among vegetation in shallow, still to slow-flowing waters (Pethiyagoda, 1991). It is believed to lay about 250 minute eggs that are carried on the ventral side of the male.

It is caught in low-to-moderate numbers for export.

34. *Monodactylus argenteus*

Monodactylus argenteus is a common indigenous estuarine fish found in coastal water bodies including coastal reef areas. It is found specially in rivers with a low flow and prefers to frequent undersides of floating vegetation. Its natural diet is not known. Eggs of the species are demersal, and are attached to stones, etc.

The species is heavily fished for the export trade using a variety of methods, including brush piles. The size for export has decreased in recent years, making the fishery more intensive. This seems to be impacting its population structure.

35. *Toxotes chatareus*

The archer fish is indigenous and is mainly recorded from estuaries of the smaller coastal basins (Pethiyagoda, 1991), particularly the Bentota River basin. It feeds predominantly on insects and is said to lay from 20,000 to 150,000 eggs.

The species is in heavy demand for export. Heavy collections may have led to the rarity of specimens larger than 15cm.

36. *Scatophagus argus*

Scatophagus argus is a moderately common indigenous species frequenting most coastal lagoons and estuaries, but sometimes extending into freshwaters. It is an omnivore whose reproduction is not recorded. One instance of its captive breeding has been recorded.

The species is fished heavily for the aquarium trade, its export size seems to have decreased over the years.

37. *Etroplus maculatus*

This is a common indigenous fish distributed throughout the low country in estuaries, tanks and small streams, though not in large rivers. It is now rare in the dry zone tanks. It is a hardy fish that frequents marginal vegetation. *Etroplus maculatus* feeds on zooplankton, fish fry and algae. It spawns about 200 eggs into a soft, shallow depression in shallow water. Though the eggs hatch in about five days under the guardianship of the parents, the fry remain attached to the eggs for a further week and are thereafter tended by the parents until they become free-swimming.

The species is collected in large numbers for the aquarium trade. Its rarity in the dry zone tanks is probably a result of competition from introduced exotic species.

38. *Etroplus suratensis*

Etroplus suratensis is also a common indigenous cichlid that is abundant throughout the lowlands in large rivers, reservoirs, lagoons and estuaries. Adults are relatively herbivorous in feeding habits and will take some insects (Fernando, 1965; Pethiyagoda, 1991). The 500 or so attached eggs are guarded by the parents and hatch in about four days. Thereafter, the parents will tend the young until they are about 3 cm in body length, feeding them during the first week on a mucus secreted by the parents.

Small individuals are utilised heavily for the export trade.

39. ***Butis*** *butis*

This is an indigenous species that is not uncommon in the brackish waters of the south western coastal region. Called the "upside down sleeper", it is found in still water on or under submerged vegetation or a branch and would hardly move other than to catch its food. Although it was common in the Dehiwela and Wellawatta canals earlier, pollution seems to have displaced them (Pethiyagoda, 1991). It feeds on small fish and crustaceans. Its breeding biology is not recorded.

The species is caught in small quantities for export.

40. *Eleofrisfusca*

Eleotrisfusca is indigenous and is not a common species. It is distributed throughout the coastal areas of the south west, from Lunawa to Matara, particularly among mangrove roots with smaller individuals often found perched on the mangrove roots. Adults are benthic on silt or muddy bottoms having marginal vegetation. Like the earlier species, pollution has removed it from its earlier known localities. It is a carnivorous fish. The eggs are spawned onto submerged, small leaves. Eggs and newly hatched fry receive parental care.

The species is exported in small numbers (Pethiyagoda, 1991).

<<

41. Glossogobius giuris

This is a common, indigenous species that is primarily an estuarine species that has extended into freshwater habitats. It is widely distributed throughout the lowland areas and is very common in the dry zone rivers and tanks, preferring sandy or muddy substrates where it leads a benthic existence (Pethiyagoda, 1991). It is a carnivore feeding on live food. Green eggs are laid that are firmly attached to a submerged substrate.

The species is fished in low to moderate numbers for export.

42. Redigobius balteatops

This indigenous goby is not common. Its adult numbers in freshwaters show a seasonality, with a peak in October/November. It is found in sluggish, shallow, swampy, coastal fresh and brackish waters along the south western coastal belt (Pethiyagoda, 1991). It is said to feed on algae and small worms. Its breeding biology is not known, but probably breeds after heavy rains.

The species is exported from wild collected stock in moderate-to-high numbers.

43. Schismatogobius deraniyagalai

This is an endemic species that was described in 1989. It is recorded only from the We River of the Kelani basin, where it is common. The habitat is shallow coarse sand or gravel wherein the goby lies buried. Its natural food is not known. It has been bred in captivity. Several hundred adherent eggs are deposited in a small nest constructed by the male. The eggs hatch in four days.

The species is exported in moderate numbers.

44. Sicyopterus grisseus

Sicyoprerus grisseus is an indigenous goby that is known only from one locality in the Sitawaka River. It is common in marginal areas of the deep, fast-flowing waters of this river. Its natural diet or breeding biology is unknown.

The species is exported in very small quantities. It is possibly wrongly identified in some export lists.

45. Sicyopus jonklaasi

This endemic goby is very rare and is found in rocky hill streams with fast-flowing water. It is found only in four or five locations. Its natural diet or natural breeding is unknown.

A few numbers of the species are exported during the dry season (Pethiyagoda, 1991).

46. Anabas testudineus

Anabas testudineus is a very common indigenous fish that is widely distributed in Sri Lanka, except in the central hills. It is a very hardy species found in turbid and stagnant waters. It is able to live out of water for considerable periods and is able to travel short distances overland using its pelvic fins and gill covers. It is a predatory carnivore and a prolific breeder. The yellow floating eggs that are spawned at the onset of rains hatch in about a day and develop into free swimming fry by the third day, following hatching.

Small numbers are collected for export.

<<

47. Belontiasignata

The endemic *Belontia signata* is common in the south west and mid-hill regions of the Mahaweli basin, up to about 800m. In the coastal belt is found the brown colour morph while the red-finned variety is found in the south west of Ratnapura. It inhabits shaded margins of shallow clear streams with pebble or sand substrates. It is carnivorous on insects and also takes detritus (Costa and Fernando, 1967; Geisler, 1967; Moyle and Senanayake, 1984). In breeding, the male builds a bubble nest under a leaf or an overhang which holds the 500 or so light pink demersal eggs that are guarded by the male. Hatching takes place in about two to three days and fry swim freely after about two days thereafter. Both parents tend the young for a few weeks.

Belontia signata is used heavily for the export trade. Though the species is still not a rarity, the brightly coloured varieties, such as rust coloured and neon blue-finned *B. signata*, have decreased greatly so that collection requires to be restricted. Since it breeds easily, captive breeding programmes should also be popularised (Pethiyagoda, 1991).

48. *Malpulutta kretseri*

This endemic species is now not at all common and is considered a rarity by some. It is restricted to slow-flowing shallow forested streams and pools having rich marginal vegetation with silt and leaf-debris-laden substrates of south western Sri Lanka within the Colombo-Galle-Ratnapura triangle. It feeds on plankton, insect larvae and fish fry. The male builds a bubble nest in which the 100 to 200 white eggs that are spawned in several batches hatch after about two days. The male parent guards the free swimming young until they are about a week old.

The species is caught for the aquarium industry but not in large numbers because of low availability.

49. Pseudosphromenus cupanus

Pseudosphromenus cupanus is an indigenous species that is common in shallow stagnant to slow-flowing streams, ditches and marshes having thick vegetation. It is restricted to the south western wet zone lowlands between Chilaw and Matara (Pethiyagoda, 1991). It feeds on zooplankton and insects. Breeding is as for the earlier species where the male builds and guards a bubble nest in which eggs hatch in about one day and the fry become free swimming in about a week.

This species is collected in moderate to high numbers for export.

50. Channa *orientalis*

This endemic relatively small snake-head species frequents very shallow, quiet, clear, shaded, flowing streams in forested areas of the south western wet zone, extending up to the lower south western hills. It is declining in numbers, more due to habitat destruction than over-collection. *Channa orienta/is* feeds principally on insects and sometimes on fish (Senanayake and Moyle, 1984). The oily, floating eggs are mouth brooded by the male and after hatching, both male and female parents protect the fry in their oral chambers (Pethiyagoda, 1991).

This species is collected in small to moderate numbers for export.

51. Channa striata

Channa striata is a common indigenous snake-head inhabiting swampy as well as relatively deep still water and river habitats of the lowlands of Sri Lanka. It also occurs in brackish water habitats so that it has a wide distribution.

It is a carnivore, predating on fish and crustaceans. For breeding, it builds a nest of weeds in which the floating eggs are laid. Hatching takes about three days and the fry soon turn bright orange, the young remaining with the mother for about a month and losing the orange colour from about the second month, but remaining under the mother's care until it is old enough to be able to hunt independently.

Small to moderate numbers are exported.

52. *Macrognathus aral*

This indigenous eel inhabits still waters having a silt or muddy substrate of tanks, ponds and slow rivers of the lowlands. Once very common, it is now rare. It feeds on insects and worms and its breeding biology is not well known, except that the pale green demersal eggs that are laid on algal masses hatch in a day or two (Pethiyagoda, 1991).

The species is not found in numbers sufficient for export.

53. Mastacembelus armatus

This is a common indigenous spiny eel occurring in streams and rives having a sandy to boulder substrate. It is distributed widely from the coastal area to an elevation of about 600m. Its main diet consists of insect matter, and its breeding biology is unknown.

Smaller specimens are collected in low to moderate numbers for the export trade.

54. Tetraodon flu*viatilis*

Tetratodon fluviatilis is an indigenous puffer fish found in slow water bodies such as rivers, estuaries and backwaters and prefers shaded areas. It is recorded as being more abundant in the estuaries of the south west (Pethiyagoda, 1991). It appears to be predominantly carnivorous in food habits and may possibly take some plant matter. It is said to lay about 200 attached eggs in shallow waters and guard them until hatching or even thereafter.

The species is used in large numbers in the export trade.

6.6 Status of related freshwater habitats

The physical quantity as well as the quality of freshwater habitats that constitute the living medium of fish have been affected over the years (e.g. Costa, 1989; Pethiyagoda, 1994).

The construction of water diversion and storage schemes, including large dams and reservoirs to meet the increased need for water extraction and hydropower generation has had ecological implications on the freshwater habitat. Rivers, lakes, and wetlands, along with the life they support, have declined in health because large dams and river diversions have destroyed their vital ecological functions. The number of large dams has increased and several hundred kilometers of canals divert water from natural systems to agricultural lands and cities. The resulting ecological implications are diverse and include loss in river area and volume with attendant economic decline (Ekaratne and Jinendradasa, 1997).

Deforestation, improper use of agrochemicals, increased silt load (e.g.,Gunawardena, 1998) habitat alteration and destruction, introduction of exotic species including *Orechromis mossambicus,* infrastructure development, gemming, etc., affect species well-being and survival. Some of these are discussed by Pethiyagoda (1994). The quality of freshwater habitats is also believed to have changed, or threatened with modification, in terms of biological diversity

(Bamabardeniya et al., 1998). This is certainly so when the introduction of exotics (e.g., tilapias, Clown Knife fish, tank cleaner fish, golden apple snail) is considered for Sri Lanka (Gunawardena, 1994; Gunawardena, 1996; Bamabardeniya et al., 1998) or globally (Clout, 1995). But the widely-held assumption that such a change is also due to the collection or overcollection of freshwater fish (Hoffmann, 1990) does not yet have corroborative evidence.

The status of 25 selected freshwater and brackishwater habitats, together with management plans for some of them, is reviewed in the Site Reports and Conservation Management Plans of the CEA (e.g., CEA, 1997. l998a, l998b).

<<

SECTION 7

Status of the Marine Fish Resources and Habitats

Marine habitats and their inhabitants have received considerably less attention by way of research and study than freshwater habits. Therefore, there is considerably less information available on marine aquarium fish resources than on freshwater fish resources.

7.1 Exported marine fish

Aquarium marine fish that are exported from Sri Lanka are mostly those caught from waters around our coasts. Some fish caught in seas around other countries (such as from the Maldive Islands and the Red Sea) have found their way to Sri Lanka to be transhipped as exports from Sri Lanka. Export statistics have to be viewed with this factor in mind.

In a survey published over 10 years ago, Wood *(1985)* said that 139 species of marine fish were exported from Sri Lanka. This list included sharks, rays, catfishes, eels, squirrelfishes, seahorses, groupers, seabasses, cardinal fishes, snappers, grunts, remoras, goatfishes, batfishes, buttertlyfishes, angelfishes, anemonefishes, damselfishes, wrasses, hawkfishes, moorish idol, surgeonfishes, blennies, lionfishes, filefishes, triggertishes, boxfishes, puffers, porcupinefishes and anglerfish. Aquarium exporters and Customs returns indicated that present exports deal with species numbers exceeding 200. This is a significant increase over Wood's. The present-day exports appear to have expanded to include parrotfishes, flatfishes, jacks and further species from among the fish groups exported in 1985.

Recorded exports reveal that over 400 species names are included as aquarium exports from Sri Lanka. This however, would include incorrect names (e.g., mistaken identifications) and also transhipped fish species. A list of exported aquarium fish species is given in Annex 2.

7.2 Status **of exported species, including threatened species**

Table 7.1 indicates the diversity of taxonomic groups that are exported in the marine aquarium trade. They have been compiled from Customs returns for two years (1995 and 1996) which include transhipped species or re-exports, showing that around 55 taxonomic groups are being exported. From among these taxa, in terms of the numbers of species, some groups are exploited to a much larger extent. This is shown in Table 7.2, which arranges taxonomic families in descending order of magnitude of numbers being exploited. The arrangement in this table enables us to see the fish families that are exploited more popularly. Thus, as families of fish, wrasses, damsels, anemone fish, butterfly fishes, gobies, groupers, basslets, angel fish, trigger fish, surgeon fish, moray eels, blennies, scorpion/lion fish and tangs are the more popularly exported fish groups. Some experts contend that it is not possible to prepare a list of fish species from export lists (NARA, 1998). Since no other reasonable suggestion or corrective action has been forthcoming from those mandated to compile an export fish list, it seems counterproductive not to use available data for this purpose. Although no list can claim to be completely flawless and fully accurate, it is hoped that the physical examination of every return on export data lodged with Customs over a period as long as two years (as done for in this report) is a reasonable and progressive starting point for compiling an export list. The list can of course be modified or refined later.

Table 7.3 lists the commonly exported fish species, in order of descending preference, that are used in the export trade. It shows that Groupers, blue-streak cleaner wrasse, powder/blue surgeonfish, three-spot damsel, Seba's anemone fish, lyre-tail coral fish, sea horses, Clark's anemone or clown fish, emperor angel / imperator, pretty prawn goby, lyre tail coral fish, damsels, gobies, blennies, angelfish and butterflyfish are the popular species. It must, however, be kept in mind that groupers that head this list are exported also for the food-fish trade. Preferences are dictated by demand which would vary with the year and the season as well as, of course, on availability from the natural habitat. From among the groupers, it has been pointed out (NARA, 1998) that only a few species such as *Cephalopholis miniatus*,

<<

C. argus, C. formosa are exported for the aquarium trade. The exploitation of edible fish from reef-associated habitats also impacts the marine habitat and is therefore important for our study.

Although *Chaetodon trifaciatus* is ranked quite high as a popularly exported fish in Table 7.3 of this **report,** NARA (1998) in commenting on the draft version of this report stated: "This is incorrect, as this is not a popular fish and only rarely exported". Such strong disagreement merited a closer look at the statistics collected from Customs returns. These confirmed that this species ranked as the 2nd and 5th most popular marine fish species to be exported from Sn Lanka in 1996 and 1995, respectively, with 14.0% and 6.8% of the Chaetodon species being made up of this species. The Customs records from 11 exporters (in 1996) and 13 exporters (in 1995) contributed to the reported high popular ranking of *Chaetodon trifaciatus* as a popularly exported species.

In the collection of fish, shallow reefs (0-6 m) are usually fished by skin divers, while deeper areas (25 or 30 m) are harvested by using SCUBA. Collection is seasonal and dependent on the monsoons which dictate the water clarity and the turbulent nature of the waters. The west and southwest coasts are fished from November to March or April, and the east and north-east from May to October.

Table 7.1 Taxonomic groups of marine fish exported from / through Sri Lanka as compiled from exporters' returns with the Customs

Common Name (with numbers of recorded species)	*Ta.xonomic Group (Family)*
Surgeon fish *(15* spp.)	Acanthundae (23 + spp.)
Unicorn fish (3+spp.)	
Tangs *(5+* spp.)	
Glass fish (1 sp.)	Ambassidae (1 sp)
Frog Fish (2+ spp.)	Antennariidae (2+ spp.)
Cardinal fish (2+ spp.)	Apogonidae (2+ spp.)
Triggerfishes (16+spp.)	Balistidae (16+spp.)
Needle fishes (1 sp?)	Belonidae (1 sp?)
Blennies (lO+spp.)	Blennidae (10+ spp.)
Flounders *(5* spp.)	Bothidae *(5* spp.)
Dragonets (1+ sp.)	Callionymidae (1+ sp.)
Trevallies (2 spp.)	Carangidae (2 spp.)
Sharks (1+ sp.)	Carcharhinidae (1+ sp)
Butterfly fishes (34+ spp.)	Chaetodontidae (34+spp.)
Hawkfishes *(5* spp.)	Cirrhitidae (5 spp.)
(1 sp.)	Clinidae
(1 sp.)	Dactyloptidae
Rays (1 sp.)	Dasyatidae
Porcupinefishes (3 spp.)	Diodontidae

Contd

Bat / Spade fishes (2 spp.)	Ephippidae/Platicidae
Cornet fishes (1 sp.)	Fistularidae
Mojarras (1 sp.)	Gemdae
Gobies (28 +spp)	Gobiidae
Soap Fish (1 sp.)	Grammistidae
Sweetlips (8 spp.)	Haemulidae
(1 sp.)	Haloclavidae
Hailbeaks (1 sp.)	Hemiramphidae
Sea Horses (2 spp)	Hippocampidae
Squirrel/soldier fishes (9 spp.)	Holocentridae
Flagtails (1 sp.)	Kuhliidae
Wrasses(/Diesel) (44+ spp.)	Labridae
Emperor fish (2 spp)	Lethrinidae
Snappers (4 spp.)	Lutjanidae
(1 sp.)	Microdesmidae
File fishes (3 spp)	Monacanthidae
Mullets (1 sp.)	Mugilidae
Goat fishes (5 spp.)	Mullidae
Moray Eels (1 1+ spp.)	Muraemdae
Sandperches (3 spp.)	Mugiloididae / Pinguipedidae
Snake eels (2 spp.)	Ophichthidae/Muraenidae
Cat sharks (1 sp.)	Orectolobidae
Cowfish (1 sp.)	Ostracidae
Boxfish (3 spp.)	
Catfish (3 spp.)	Plotosidae
Angelfish (20+ spp.)	Pomacanthidae
Damsels, anemone fish (37 spp.)	Pomacentridae
Dottyback fishes (4 spp.)	Pseudochromidae
Sting Rays (1 sp.)	Rajidae
Parrotfishes (6 spp)	Scaridae
Scats (5 spp.)	Scatophagidae
Scorpion/lion fish (8 spp.)	Scorpaenidae
Groupers,Basslets(22+ spp.)	Serranidae
Sharks(1 sp.)	Sharks
Rabbit fishes (3 spp.)	Siganidae
Barracudas (2 spp)	Sphyraenidae

Contd

Pipe fish (3 spp.)	Syngnathidae/Solenostomidae
Grunters (1 sp.)	Teraponidae
Puffers (8÷spp.)	Tetraodontidae
Electric Rays (1 sp.)	Tropedinidae
Moorish Idol/Tobies (2 spp.)	Zanclidae

Table 7.2 **Marine fish families and numbers of species that are popularly exported from / through Sri Lanka – as compiled from exporters' returns with Customs**

Common Name (and numbers of recorded spp.)	*Family Name*
Wrasses (44+ spp.)	Labridae
Damsels, anemone fish (37 spp.)	Pomacentridae
Butterfly fishes (34+ spp)	Chaetodontidae
Gobies (28 +spp.)	Gobiidae
Groupers, Basslets (22+ spp.)	Serranidae
Angel fish (20+ spp.)	Pomacanthidae
Trigger fish (16+ spp.)	Balistidae
Surgeon fish *(15* spp.)	Acanthuridae (23 + spp)
Moray Eels (11+ spp.)	Muraenidae
Blennies (10+spp.)	Blenniidae (1 0+spp.)
Squirrel/soldier fishes (9 spp.)	Holocentndae
Sweetlips (8 spp.)	Haemulidae
Scorpion/lion fish (8 spp.)	Scorpaenidae
Puffers (8+ spp.)	Puffers
Parrot fishes (6 spp.)	Scaridae
Tangs (5+ spp.)	Acanthuridae
Flounders *(5* spp.)	Bothidae *(5* sp)
Hawkfishes (5 spp)	Cirrhitidae (5 sp)
Goat fishes (5 spp.)	Mull idae
Scats (5 spp.)	Scatophagidae
Snappers (4 spp.)	Lutjanidae
Dottyback fishes (4 spp.)	Pseudochromidae
Unicorn fish (3+spp.)	Acanthuridae
Porcupine fishes (3 spp.)	Diodontidae
File fishes (3 spp)	Monacanthidae

Contd

<<

Sandperches (3 spp.)	Mugiloididae / Pinguipedidae
Boxfish (3 spp.)	Ostracidae
Cat fish (3 spp.)	Plotosidae
Rabbit fishes (3 spp.)	Siganidae
Pipe fish (3 spp.)	Syngnathidae/Solenostomidae
Frog Fish (2+ spp.)	Antennariidae(2+ sp)
Cardinal fish (2+ spp)	Apogonidae (2+ sp)
Trevallies (2 spp.)	Carangidae(2 sp.)
Bat / Spade fishes (2 spp.)	EphippidaefPlaticidae
Sea Horses (2 spp.)	Hippocampidae
Emperor fish (2 spp.)	Lethrinidae
Snake Eels (2 spp.)	OphichthidaefMuraenidae
Barracudas (2 spp)	Sphyraenidae
Moorish Idol/Tobies (2 spp)	Zanclidae

Table 7.3 Marine fish species commonly exported from / through Sri Lanka. (Arranged in order of decreasing popularity, which may vary annually. Data were compiled from two years of exporters' returns with Customs; note that multiple names are sometimes used for the same species and that some species whose names appear in exporters' lists do not occur around Sri Lanka. Groupers, heading the list, would include specimens exported as live food fish. These and other problem areas are discussed in the text)

Scientific name (or group name)	*Common name*
Groupers	Groupers
Labroides dimidiatus	Blue-streak Cleaner WrasseIDiesel
Acanthurus leucosternon	Powder/Blue Surgeonfish
Dascyllus trimaculatus	Three-spot Damsel
Amphiprion sebae	Seba's Anemone Fish
Anthias squamipinis	Lyre Tail Coral Fish
Hippocampus kuda	Sea Horse
Ampriprion xanthurus/clarkii	Clark's Anemone or Clown Fish
Pomacanthus imperaror	Emperor Angel / Imperator
Valencianea puellaris	Pretty Prawn Goby
Anthias squamipinis	Lyre Tail Coral Fish
Abudefduf saxatilis	Sergeant Major
Consformosa	Clown Coris / Red White Wrasse

Contd

<<

C. rafflesi

C. guttatissimus

C. semeion

C. benetti

Anthias evensi

Forcipigerflavissimus

Parachaetodon ocellatus

Hemitauricththys zoster

H. pleurotaenia

Oxycirrhites typus

Paracirrhitus arcuatus

Nematel eotris menateleotris

Plectorhychus obscurus

Gaterin albovittatus

Labroides bico/or

L dimidiatus

Corisformosa

Bodianus diana

Lutianus sebae

Poinacanthus annularis

P.semicirculatus

P. imperator

Centropyge eibli

Apolemichthys trimaculatus

Amphiprion clarkii

A. nigrepes

Pterois volitans

P. antennata

P. radiata

Dendrochirus zebra

D. trachypterus

D. biocellata

Epinephelus flavocaeruleus

E. lanceolatus *

Plectropomus laevis

Variola louti

Contd

<<

Zanclus cornutus

Oxymonocanthus longirostris

Paraluteres prianurus

Balistoides conspicillum

Pseudobalistes fuscus

Canthigaster tenneti

C. valentini

Ostracion cubicum

Lactoria cornuta

L. fornasini

Diodon hystrix

Histrio histrio

Echidna nebulosa

E. zebra

Plotosus lineatus

Hippocampus kuda *

The **population** densities of certain species are naturally low. Such fish are particularly vulnerable to adverse impact and number depletion. Anemone fish is an example. These fish are easy to capture and, being also popular, are fished in large numbers. Other species that have low population densities are similarly susceptible to depletion if high fishing pressure is exerted on their populations or if habitat change or destruction is brought about. An example of such species is the case where certain butterflyfish which were previously present in Trincomalee Bay have become rare (Lubbock and Polunin, 1975). Another example is Indian Bannerfish, around Weligama. They were discovered to be rare, and have not recovered up to 1998 (NARA, 1998). Therefore, particular care must be taken in ensuring that species with vulnerable characteristics are not subjected to heavy fishing pressure or habitat impacts.

Fish that are ecologically very important should also merit extreme care in collection. For example, some species that are among the most popular fish for export, play an important ecological role by cleaning the gills, oral cavities, etc., of many species of fish inhabiting the reef environment. The very fact that “cleaning stations” have evolved that attract large-sized fish to queue up to be cleaned by these small brightly-coloured cleanerfish demonstrates the importance of these fish within the reef ecosystem as well as the importance of this cleaning symbiotic relationship. The reef ecosystem is rich in such mutually beneficial symbiotic relationships. The removal of one partner from such an association will disrupt the ecosystem relationships and lead to often unfavourable ecosystem changes. In these interlinked reef ecosystems, the abundance of some species has been shown to be related to that of others (Bakus, 1994). Although data are lacking for Sri Lanka, some of the population and ecosystem effects brought about by reef fishing have been documented for other reefs (e.g. Jenings and Lock, 1996).

7.3 Biology, ecology, distribution and populations of exported marine fish

Unlike with freshwater fish species, there are no detailed studies that specifically deal with Sri Lankan marine fish species used in the aquarium export trade. Information presented below is based on whatever literature is available, and on interviews with divers and aquarists. The reader may, however, refer to some of the general literature listed in Section 10.

Fluctuations in population numbers are quite common with nektonic marine animals and are attributable to natural as well as man-made causes. In some reef-associated fish, their populations may be relatively unstable and may undergo considerable changes with time (Sale, 1980; Sale & Dybdahl, 1975; Russell *et al.*, 1977; Sadovy, 1996), Any population studies that address assessment of fish numbers and the effect of fish collection by the export trade must therefore take natural fluctuations into account. In the absence of any such data for Sri Lanka's marine aquarium fish, studies are first necessary to document such phenomena. Some of the environmental and biological factors that are known to affect reef fish species composition and distribution and their population densities are habitat quality and area, food supply, habitat selection, recruitment patterns and predation (Smith & Tyler, 1972; Sale, 1977, 1980; Sale, 1980b; Doherty, 1982; Williams, 1983; Shulman, 1984; Sale et al 1984; Sale and Ferrel, 1988).

Although detailed studies on marine fish population numbers in Sri Lanka do not exist, fish collectors possess knowledge on available abundance, and on places and periods of high and low availability. Even though many divers in the aquarium trade did say that they were capable of assessing numbers, and argued for the collection of numerically abundant species, their stand is contested by many others. NARA (1998) said that "they (i.e. fish collectors) are unable to calculate the abundance in numbers in a population of a given species. Therefore it is incorrect to state that the collectors possess knowledge on available numbers". Such differences of opinion illustrate the uncertainties that bedevil knowledge and highlight the urgent need for numerical data to manage the aquarium trade.

Since collection is competitive, collectors are quite loathe to part with this valuable information although a few will let you have some information. For example, the young stages of some Butterfly fish and of *Heniochus* (Bannerfish) were said to be common around estuarine mouths. Some collectors said that these fish are abundant even within estuaries at specific periods.

Several examples concerning seasonal availability of fish are given by Jonklaas *(1985).* These are valuable though some may argue that these do not constitute scientifically validated data. But then, we are short of such data.

> The lionfish, *Pterois volirans,* appears from 2 to 6cm in September, often in sheltered rocky estuaries and river mouths and boulder-strewn shores. Juvenile blue-ring Angelfish, *Pomacanthus semicirculatus,* appear in large numbers in May, off the east coast. Juvenile Emperor Angelfish, *Pomacanthus imperator,* around 2 cm long, appear off the east coast in early September. Some are collected then, before the season ends, others in March, when they have grown to over 5cm in length. In 1972 there was a sudden occurrence of the boxfish, *Diodon holacanthus,* off the west coast, with specimens about 6 to 10 cm being found all over reefs and sandy bottoms. Such an aggregated recruitment to inshore reefs has been reported as of typical occurrence for *Diodon spp.* which first spend a 4 to 5 month period in the plankton (Ogden, *1965).* In 1975, unusually large concentrations of young triggerfish, *Odonus niger,* appeared off both coasts in depths of 8 m or more. This was followed in 1976 by an inexplicable sudden mass mortality. In 1981, relatively large numbers of juvenile clown triggerfish, *Balistoides niger,* appeared on reefs off the east coast at depths of 10 to 20 m. This enhanced recruitment, again inexplicable, resulted in a yield of over 500 individuals for the collectors which was about 10 times the usual collection for this time (Jonklaas, 1985).

Ornamental marine fish are distributed all round the coasts of Sri Lanka, though their specific distribution patterns have not been fully documented. The areas and locations from where fish species are collected may, however, indicate some distributional preferences of fish species, though it must be kept in mind that collection may also be influenced by accessibility and ease of fish collection at specific locations rather than by fish distribution patterns alone.

Fish for the export trade are collected from most of the inshore areas where corals occur. There are few, pure limestone reefs in Sri Lanka, but corals grow on ancient sandstone largely along the west coast, or gneiss or granite outcrops along the east coast (Salm, 1975; Wood, 1985).

<<

In the West Coast, ornamental species are collected from reefs in the vicinity of Kalpitya to Negombo, and others to the south of Colombo, for example off Dehiwala and Beruwala (Madhu, 1996). In the South Coast, the main collection areas are around Galle, Weligama and Tangalle. Although Wood (1985) names Kirinda also as a collection area, NARA (1998) is of the view that such an identification “is completely wrong”. The Hikkaduwa Marine Reserve used to be an important collecting site, but is no longer a site for fish collection since it is now well protected, particularly by the local stakeholder community. The Basses reefs, although reputed to support large fish populations, are not popular collecting locations since they are too far offshore and are subjected to strong currents and heavy seas for much of the year (Wood, 1985).

In the East Coast, the important collection area in Sri Lanka is in the vicinity of Trincomalee. The harbour itself is a good source and the area just to its north, off Kuchaveli and Nilaveli, and around Pigeon Island, Kalmunai are also heavily utilised. There are similar collecting areas just to the south of Trincomalee, and also off Passedukah (Thannadi Bay) and Kaldukah where there are reported to be well developed reefs, though the security situation has restricted collections somewhat. In the North Coast, the Jaffna area contains relatively shallow, turbid water, but it had in the past been an important collecting area particularly for species that did not occur elsewhere in the seas around Sri Lanka.

The keeping of species in home aquaria depends on the ecology, including feeding biology, of the fish species. For example, it is impossible to maintain coral-eating species unless coral is also cultivated in aquaria – which is not possible without stringent water quality controls. Even so, the export trade does catch and export coral-eating fish such as some butterfly fish. Since it is impossible to maintain them in home aquaria for long periods, the trade itself refers to these species as ‘cut flower’ species (J Gunawardena, pers. corn.). These species are shown in the table below. The export of such species should not be allowed as it only leads to habitat disturbance and destruction.

Table 7. 5 “Cut-Flower” marine fishes currently exported from Sri Lanka

Source An overview of the ornamental aquatic sector in Sri Lanka - Jonathan K.L.Mee (1993)

Species	*Common Names*
Chaetodon bennetti	Bennett’s Butterflyfish
Chaetodon citrinelius	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

74 Status of related marine habitats

The marine habitat with which marine fish collection for the export aquarium trade is most closely associated, and indeed dependent directly, is undoubtedly the reef habitat. It is recorded that most coral reefs in Sri Lanka have been degradedor destroyed by a multitude of causes including coral mining, fishing with explosives, sedimentation, pollution, removal of reef organisms, anchoring and removal of coral for the curio trade (e.g., De Bruin, 1972; Salm, 1975;

Jonklans, 1985; Ekaratne, l989a, 1989b, l990b, 1997c, Wood, 1985; Costa, 1989; Ohman *etal.,* 1993; Dassanayake, 1994; Rajasuriya et al., 1995; Rajasuriya and White, 1995).

Most of the known reefs, particularly readily accessible near-shore reefs, are degraded due to human-induced damage (Ekaratne, l990b, 1997c). Reefs in better condition, with over *50%* of live hermatypic cover, are present at the Bar Reef off the north west coast, at the Great and Little Basses which are located off the south east coast and a few reefs in the southern coast, including Hikkaduwa in the south-west. Reef sites at Hikkaduwa and Bar Reef constitute the only two legally protected marine sanctuaries in Sri Lanka, the former having been accorded sanctuary status in 1979, the latter in 1992 (Pernetta, 1993). Although legal enactments for reef and reef-related protection are well in place, implementation and monitoring are grossly inadequate, on account of which reef degradation practices continue. (Ekaratne, 1990b, 1997c; Nakatani *et al,* 1994; White and Ekaratne, 1995). However NARA (1998), expressed a different viewpoint while commenting on the draft of this report. It said “It is grossly incorrect to state that lack of monitoring is one of the main reasons for the continuation of reef degradation practices”.

The reef habitat in Sn Lanka suffers from a high sediment and particulate matter load as well as pollution from land-based sources (Ekaratne, 1997c). In July 1998, coastal habitats including reefs near Colombo experienced crude-oil pollution through a severed pipeline. What effects this has had on coastal habitats has not been looked at in detail. However, oil pollution is now a realistic impact that needs to be considered. Although high sediment and particulate matter loads were said to affect reef habitats (e.g., Rajasuriya and White, 1995; Ekaratne, 1990b, 1997a), it was only in 1996 that data gathering by the University of Colombo commenced. This data, limited to Hikkaduwa Marine Reserve, demonstrated that the reef at the south-west of Sri Lanka experienced high loads of particulate matter, including sandy material, from May to November, with maximum loads of up to 3.2 kg day’ m^2 (Ekaratne, 1997c).

In April 1998, an event of profound influence occurred in the coral reefs of Sri Lanka. This was the incidence of widespread and severe coral bleaching. It was not restricted to Sri Lanka, but occurred throughout the region, due to an exceptional increase in sea surface temperatures. This resulted in extensive coral bleaching and mortality of about 80 per cent in studied sites of the south west coast (Ekaratne and Jinendradasa, 1998).

Along with the temperature increase, symbiotic zooxanthellae were lost in over 60 scleractinian and octocoral species inhabiting the reef habitat. The highest number of species affected were of the genus *Acropora* where over 15 species were bleached including the common stag-horn coral, *Acropora* formosa and the tabulate coral *A. hyacinthus.* Other coral genera that have suffered loss of zooxanthellae and mortality included *Pocillopora, Porites, Gardineroseris, Galaxea, Fungia, Symphyllia, Montastraea, Sinularia, Sarcophylon* and *Lobophyton.* Some species that showed resistance to bleaching have also been identified (Ekaratne and Jinendradasa, 1998).

The damage and changes to habitat quality brought about by the above changes will have serious effects on fish population numbers and structure as well as on species composition. Such factors have been known to bring about changes in reef structure, biodiversity, succession and ecosystem functions.

Over the years, many experienced collectors and exporters in Sri Lanka involved in the trade, as also several conservationists, referred to the changing status of reef habitats when they spoke of coral reef fish collected for the aquarium trade having become less abundant now. The lack of quantitative data, however, makes these statements non-verifiable. Whether this trend towards fish reduction is because of over-collection – either by itself or in concert with other causes such as pollution – cannot be verified because of paucity of data.

C. rafflesi

C. guttatissimus

C. semeion

C. benetti

Anthias evensi

Forcipigerflavissimus

Parachaetodon ocellatus

Hemitauricththys zoster

H. pleurotaenia

Oxycirrhites typus

Paracirrhitus arcuatus

Nematel eotris menateleotris

Plectorhychus obscurus

Gaterin albovittatus

Labroides bico/or

L dimidiatus

Corisformosa

Bodianus diana

Lutianus sebae

Poinacanthus annularis

P.semicirculatus

P. imperator

Centropyge eibli

Apolemichthys trimaculatus

Amphiprion clarkii

A. nigrepes

Pterois volitans

P. antennata

P. radiata

Dendrochirus zebra

D. trachypterus

D. biocellata

Epinephelus flavocaeruleus

E. lanceolatus *

Plectropomus laevis

Variola louti

Contd

<<

Zanclus cornutus

Oxymonocanthus longirostris

Paraluteres prianurus

Balistoides conspicillum

Pseudobalistes fuscus

Canthigaster tenneti

C. valentini

Ostracion cubicum

Lactoria cornuta

L. fornasini

Diodon hystrix

Histrio histrio

Echidna nebulosa

E. zebra

Plotosus lineatus

Hippocampus kuda *

The **population** densities of certain species are naturally low. Such fish are particularly vulnerable to adverse impact and number depletion. Anemone fish is an example. These fish are easy to capture and, being also popular, are fished in large numbers. Other species that have low population densities are similarly susceptible to depletion if high fishing pressure is exerted on their populations or if habitat change or destruction is brought about. An example of such species is the case where certain butterflyfish which were previously present in Trincomalee Bay have become rare (Lubbock and Polunin, 1975). Another example is Indian Bannerfish, around Weligama. They were discovered to be rare, and have not recovered up to 1998 (NARA, 1998). Therefore, particular care must be taken in ensuring that species with vulnerable characteristics are not subjected to heavy fishing pressure or habitat impacts.

Fish that are ecologically very important should also merit extreme care in collection. For example, some species that are among the most popular fish for export, play an important ecological role by cleaning the gills, oral cavities, etc., of many species of fish inhabiting the reef environment. The very fact that "cleaning stations" have evolved that attract large-sized fish to queue up to be cleaned by these small brightly-coloured cleanerfish demonstrates the importance of these fish within the reef ecosystem as well as the importance of this cleaning symbiotic relationship. The reef ecosystem is rich in such mutually beneficial symbiotic relationships. The removal of one partner from such an association will disrupt the ecosystem relationships and lead to often unfavourable ecosystem changes. In these interlinked reef ecosystems, the abundance of some species has been shown to be related to that of others (Bakus, 1994). Although data are lacking for Sri Lanka, some of the population and ecosystem effects brought about by reef fishing have been documented for other reefs (e.g. Jenings and Lock, 1996).

7.3 Biology, ecology, distribution and populations of exported marine fish

Unlike with freshwater fish species, there are no detailed studies that specifically deal with Sri Lankan marine fish species used in the aquarium export trade. Information presented below is based on whatever literature is available, and on interviews with divers and aquarists. The reader may, however, refer to some of the general literature listed in Section 10.

Fluctuations in population numbers are quite common with nektonic marine animals and are attributable to natural as well as man-made causes. In some reef-associated fish, their populations may be relatively unstable and may undergo considerable changes with time (Sale, 1980; Sale & Dybdahl, 1975; Russell *et al.*, 1977; Sadovy, 1996), Any population studies that address assessment of fish numbers and the effect of fish collection by the export trade must therefore take natural fluctuations into account. In the absence of any such data for Sri Lanka's marine aquarium fish, studies are first necessary to document such phenomena. Some of the environmental and biological factors that are known to affect reef fish species composition and distribution and their population densities are habitat quality and area, food supply, habitat selection, recruitment patterns and predation (Smith & Tyler, 1972; Sale, 1977, 1980; Sale, 1980b; Doherty, 1982; Williams, 1983; Shulman, 1984; Sale et al 1984; Sale and Ferrel, 1988).

Although detailed studies on marine fish population numbers in Sri Lanka do not exist, fish collectors possess knowledge on available abundance, and on places and periods of high and low availability. Even though many divers in the aquarium trade did say that they were capable of assessing numbers, and argued for the collection of numerically abundant species, their stand is contested by many others. NARA (1998) said that "they (i.e. fish collectors) are unable to calculate the abundance in numbers in a population of a given species. Therefore it is incorrect to state that the collectors possess knowledge on available numbers". Such differences of opinion illustrate the uncertainties that bedevil knowledge and highlight the urgent need for numerical data to manage the aquarium trade.

Since collection is competitive, collectors are quite loathe to part with this valuable information although a few will let you have some information. For example, the young stages of some Butterfly fish and of *Heniochus* (Bannerfish) were said to be common around estuarine mouths. Some collectors said that these fish are abundant even within estuaries at specific periods.

Several examples concerning seasonal availability of fish are given by Jonklaas *(1985).* These are valuable though some may argue that these do not constitute scientifically validated data. But then, we are short of such data.

> The lionfish, *Pterois volirans,* appears from 2 to 6cm in September, often in sheltered rocky estuaries and river mouths and boulder-strewn shores. Juvenile blue-ring Angelfish, *Pomacanthus semicirculatus,* appear in large numbers in May, off the east coast. Juvenile Emperor Angelfish, *Pomacanthus imperator,* around 2 cm long, appear off the east coast in early September. Some are collected then, before the season ends, others in March, when they have grown to over 5cm in length. In 1972 there was a sudden occurrence of the boxfish, *Diodon holacanthus,* off the west coast, with specimens about 6 to 10 cm being found all over reefs and sandy bottoms. Such an aggregated recruitment to inshore reefs has been reported as of typical occurrence for *Diodon spp.* which first spend a 4 to 5 month period in the plankton (Ogden, *1965).* In 1975, unusually large concentrations of young triggerfish, *Odonus niger,* appeared off both coasts in depths of 8 m or more. This was followed in 1976 by an inexplicable sudden mass mortality. In 1981, relatively large numbers of juvenile clown triggerfish, *Balistoides niger,* appeared on reefs off the east coast at depths of 10 to 20 m. This enhanced recruitment, again inexplicable, resulted in a yield of over 500 individuals for the collectors which was about 10 times the usual collection for this time (Jonklaas, 1985).

Ornamental marine fish are distributed all round the coasts of Sri Lanka, though their specific distribution patterns have not been fully documented. The areas and locations from where fish species are collected may, however, indicate some distributional preferences of fish species, though it must be kept in mind that collection may also be influenced by accessibility and ease of fish collection at specific locations rather than by fish distribution patterns alone.

Fish for the export trade are collected from most of the inshore areas where corals occur. There are few, pure limestone reefs in Sri Lanka, but corals grow on ancient sandstone largely along the west coast, or gneiss or granite outcrops along the east coast (Salm, 1975; Wood, 1985).

In the West Coast, ornamental species are collected from reefs in the vicinity of Kalpitya to Negombo, and others to the south of Colombo, for example off Dehiwala and Beruwala (Madhu, 1996). In the South Coast, the main collection areas are around Galle, Weligama and Tangalle. Although Wood (1985) names Kirinda also as a collection area, NARA (1998) is of the view that such an identification "is completely wrong". The Hikkaduwa Marine Reserve used to be an important collecting site, but is no longer a site for fish collection since it is now well protected, particularly by the local stakeholder community. The Basses reefs, although reputed to support large fish populations, are not popular collecting locations since they are too far offshore and are subjected to strong currents and heavy seas for much of the year (Wood, 1985).

In the East Coast, the important collection area in Sri Lanka is in the vicinity of Trincomalee. The harbour itself is a good source and the area just to its north, off Kuchaveli and Nilaveli, and around Pigeon Island, Kalmunai are also heavily utilised. There are similar collecting areas just to the south of Trincomalee, and also off Passedukah (Thannadi Bay) and Kaldukah where there are reported to be well developed reefs, though the security situation has restricted collections somewhat. In the North Coast, the Jaffna area contains relatively shallow, turbid water, but it had in the past been an important collecting area particularly for species that did not occur elsewhere in the seas around Sri Lanka.

The keeping of species in home aquaria depends on the ecology, including feeding biology, of the fish species. For example, it is impossible to maintain coral-eating species unless coral is also cultivated in aquaria – which is not possible without stringent water quality controls. Even so, the export trade does catch and export coral-eating fish such as some butterfly fish. Since it is impossible to maintain them in home aquaria for long periods, the trade itself refers to these species as 'cut flower' species (J Gunawardena, pers. corn.). These species are shown in the table below. The export of such species should not be allowed as it only leads to habitat disturbance and destruction.

Table 7. 5 "Cut-Flower" marine fishes currently exported from Sri Lanka

Source An overview of the ornamental aquatic sector in Sri Lanka - Jonathan K.L.Mee (1993)

Species	*Common Names*
Chaetodon bennetti	Bennett's Butterflyfish
Chaetodon citrinelius	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

74 Status of related marine habitats

The marine habitat with which marine fish collection for the export aquarium trade is most closely associated, and indeed dependent directly, is undoubtedly the reef habitat. It is recorded that most coral reefs in Sri Lanka have been degradedor destroyed by a multitude of causes including coral mining, fishing with explosives, sedimentation, pollution, removal of reef organisms, anchoring and removal of coral for the curio trade (e.g., De Bruin, 1972; Salm, 1975;

<<

Jonklans, 1985; Ekaratne, l989a, 1989b, l990b, 1997c, Wood, 1985; Costa, 1989; Ohman *etal.,* 1993; Dassanayake, 1994; Rajasuriya et al., 1995; Rajasuriya and White, 1995).

Most of the known reefs, particularly readily accessible near-shore reefs, are degraded due to human-induced damage (Ekaratne, l990b, 1997c). Reefs in better condition, with over *50%* of live hermatypic cover, are present at the Bar Reef off the north west coast, at the Great and Little Basses which are located off the south east coast and a few reefs in the southern coast, including Hikkaduwa in the south-west. Reef sites at Hikkaduwa and Bar Reef constitute the only two legally protected marine sanctuaries in Sri Lanka, the former having been accorded sanctuary status in 1979, the latter in 1992 (Pernetta, 1993). Although legal enactments for reef and reef-related protection are well in place, implementation and monitoring are grossly inadequate, on account of which reef degradation practices continue. (Ekaratne, 1990b, 1997c; Nakatani *et al,* 1994; White and Ekaratne, 1995). However NARA (1998), expressed a different viewpoint while commenting on the draft of this report. It said "It is grossly incorrect to state that lack of monitoring is one of the main reasons for the continuation of reef degradation practices".

The reef habitat in Sn Lanka suffers from a high sediment and particulate matter load as well as pollution from land-based sources (Ekaratne, 1997c). In July 1998, coastal habitats including reefs near Colombo experienced crude-oil pollution through a severed pipeline. What effects this has had on coastal habitats has not been looked at in detail. However, oil pollution is now a realistic impact that needs to be considered. Although high sediment and particulate matter loads were said to affect reef habitats (e.g., Rajasuriya and White, 1995; Ekaratne, 1990b, 1997a), it was only in 1996 that data gathering by the University of Colombo commenced. This data, limited to Hikkaduwa Marine Reserve, demonstrated that the reef at the south-west of Sri Lanka experienced high loads of particulate matter, including sandy material, from May to November, with maximum loads of up to 3.2 kg day' m^2 (Ekaratne, 1997c).

In April 1998, an event of profound influence occurred in the coral reefs of Sri Lanka. This was the incidence of widespread and severe coral bleaching. It was not restricted to Sri Lanka, but occurred throughout the region, due to an exceptional increase in sea surface temperatures. This resulted in extensive coral bleaching and mortality of about 80 per cent in studied sites of the south west coast (Ekaratne and Jinendradasa, 1998).

Along with the temperature increase, symbiotic zooxanthellae were lost in over 60 scleractinian and octocoral species inhabiting the reef habitat. The highest number of species affected were of the genus *Acropora* where over 15 species were bleached including the common stag-horn coral, *Acropora* formosa and the tabulate coral *A. hyacinthus.* Other coral genera that have suffered loss of zooxanthellae and mortality included *Pocillopora, Porites, Gardineroseris, Galaxea, Fungia, Symphyllia, Montastraea, Sinularia, Sarcophylon* and *Lobophyton.* Some species that showed resistance to bleaching have also been identified (Ekaratne and Jinendradasa, 1998).

The damage and changes to habitat quality brought about by the above changes will have serious effects on fish population numbers and structure as well as on species composition. Such factors have been known to bring about changes in reef structure, biodiversity, succession and ecosystem functions.

Over the years, many experienced collectors and exporters in Sri Lanka involved in the trade, as also several conservationists, referred to the changing status of reef habitats when they spoke of coral reef fish collected for the aquarium trade having become less abundant now. The lack of quantitative data, however, makes these statements non-verifiable. Whether this trend towards fish reduction is because of over-collection – either by itself or in concert with other causes such as pollution – cannot be verified because of paucity of data.

SECTION 8

Activities Affecting Species Survival, Habitat Integrity and Management

Sustainability of fish populations, as well as the continued existence of fish species, is closely linked to habitat quality and integrity. If fish harvests exceed the numbers that are recruited to the population based on the reproductive capacity of that species and the supporting capacity of the habitat, then such harvests would exceed the sustainable yield. The population would then gradually decline in the presence of continued fishing pressure. Eventually the very survival of that species would be threatened. The loss of habitat quality would accelerate population decline and species extinction through effects on recruitment, mortality, growth and other life functions. It is less difficult to relate population fluctuations of freshwater fish populations to their causal factors, compared to the situation in reef fishes. This is because the logistics of fish sampling and habitat heterogeneity make it easier to census and monitor most freshwater fish populations than reef fish populations.

Both human-induced and natural causes are known to affect freshwater and reef fish populations. Given this complexity, it becomes particularly difficult to assess the impact of outside influences, such as collection for the aquarium trade, on natural fish populations.

8.1 Export-trade related activities affecting species survival, habitat integrity and management

Improper collection, over-collection, selective collection of the more attractively coloured individuals, improper holding and transport as well as packing methods – all these directly affect species survival.

Collection by the aquarium trade seems to have some impact on fish numbers, both freshwater and marine. It cannot yet be ascertained whether fish numbers depleted for aquarium collections recover over time, such as by the following season, particularly since sea conditions do not permit continuous fishing at any one location over the entire year. Also, recruitment processes are not well understood. The depletion of fish numbers is borne out by persons in the trade itself since some state that populations and required sizes of many species get significantly depleted over the collecting season as it progresses, because specific sites are heavily exploited for up to six months at a time. Collectors also admit that they have had to gradually go further deep using SCUBA gear in their collection for fish. The tendency to capture all specimens of high value during collection would also contribute to population depletion.

Improper collection techniques damage the fish and also destroy the habitat. Fish are sometimes captured by collectors breaking off pieces of coral (especially *Acropora)* in which the fish are hiding. The “moxy net” which is used to collect fish by snorkel divers is destructive.

The umbrella-shaped moxy net is closed at the top, and is open at about lm or more below. Small lead weights are attached along the open perimeter. The net is opened and positioned over corals or other places where fish are located and are in hiding. Thereafter, the collector bangs on the coral with an iron rod or similar object to frighten the fish out of their refuge and into the net. Most often, this process damages the coral.

Although the destructive nature of fish collection methods has been mentioned in many places, no description is found in any literature about the various collection methods used in Sri Lanka, and the advantages and disadvantages of each method used in the freshwater and marine sub-sectors. That would have provided some guidelines regarding the methods to be licensed for this fishery (Sivasubramaniam, 1998: comments on Draft Report).

The serious consequences of the shortfalls in the assessment and monitoring of the collection, aquaculture and export of aquatic animals and plants, and the difficulties faced by the Customs in Sri Lanka, were highlighted by Gunasekera

<<

(1995), and also when Mr S Gunasekera of the Sri Lanka Customs presented a paper on “Effects of export promotion on aquatic resources conservation” (Theme seminar: conservation of aquatic resources for the 21st Century. Sri Lanka Association for Fisheries and Aquatic Resources, SLAFAR, 25 & 26 June 1997). These problems and issues which cause loss of revenue and loss of valuable species and also probably affect biodiversity, included:

- the absence of appropriate laws/ regulations requiring exporters to use accepted and correct scientific names resulting in the illegal export of protected or valuable endemic species under numerous names. This was in evidence when exporters used a variety of names to describe the same species such as Redfin or Melon or Purple Butterflyfish to describe *Chaetodon trifaciatus.* The use of names of fish in Customs returns such as *Neopomacentrus nemurus* that does “not even occur in Sri Lanka” (NARA, 1998) could similarly be the use of incorrect names
- the lack of regulations requiring exporters to declare whether exported stock was collected from the wild, from aquaculture activities or was imported for re-export. This created problems for record keeping and monitoring. Example, when a re-exported species such as *Acanthurus sohal* which is found in the Arabian Sea, Red Sea and the Persian Gulf region (NARA, 1998) is not demarcated clearly as a re-export (see Table 7.3)
- the lack of regulations with regard to conditions for export of various vertebrates, invertebrates and plants, resulting in poor handling and packaging leading to heavy mortality among the animals. For example, space and water volume in the export pack are sometimes reduced in order to decrease freight charges
- insufficient coverage of all valuable endemic species in the country
- absence of established market values and floor prices for each species, creating problems in establishing levels of punishment or penalty for offences
- difficulty in finding sufficient time for Customs officials to check every shipment for characteristics that require monitoring such as size measurements of fish or parts of the fish and the spawning conditions of the fish
- illegal shipment and under-invoicing or under-valuation of shipments

Although excessive pre-export starvation may lead to weakening and mortality of exported fish, the practice of starving the fish prior to export or transport for 1-2 days is a normal practice adopted by aquaculturists. This is done in order to reduce or minimize fecal matter which pollutes the water used for transport of fish, thus reducing ammonia and other toxic compounds produced during breakdown of fecal matter. Presence of higher levels of fecal matter results in oxygen depletion in the water in addition to the toxic effect of ammonia and other compounds during transport of fish. Hence pre-export starving of fish is beneficial for their survival during transport. Starving of fish even for much longer periods (eg. one week) will not have much impact on them provided they are properly fed after that period. (J Chandarasoma, 1998: comments on Draft Report)

Even before the fish are packed for export, improper catching, transport and holding methods take their toll on fish numbers causing heavy mortality. Therefore, in order to make up for these high mortalities, large quantities are collected from the wild, impacting wild stocks to an unnecessarily large extent.

The problem of information required for effective management of the fishery – because of secrecy about collection areas, species and quantities collected and marketed domestically and abroad, needs to be addressed. This cannot be overcome without introducting regulations concerning the use of standardised names on Customs and export declarations, and the registration and licensing of oranamental fish collectors, traders and exporters and the mandatory declaration ot all relevant information for the successful renewal of their licenses (Sivasubramaniam, 1998: comments on Draft Report). Detailed formats, for data to be declared by various categories of people involved in this industry, have already been prepared by Dr. K. Sivasubramaniam.

8.2 Activities extraneous to the export trade affecting species survival, habitat integrity and management

A diversity of factors external to the export trade such as deforestation, improper use of agrochemicals, habitat alteration and destruction, water diversion schemes, introduction of exotic species, infrastructure development in areas of significance to species survival, gemming, etc., affect species survival, Some of these are discussed by Pethiyagoda (1994). All these are a result of the non-existence of a coherent policy framework for sustained and integrated development. In such a vacuum, it is counter-productive to elaborate on the above factors.

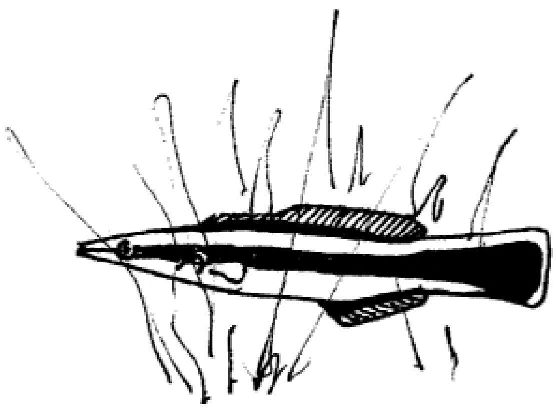
The development of an integrated policy is central to addressing these multi-disciplinary issues.

Various reef resources are extracted and utilised by coastal communities, without any practical limitations or management measures being imposed on their exploitation. Impacts resulting from land-based polluting practices further erode the resource base of the reef ecosystems, strengthening the forces that lead to reef degradation (Ekaratne, 1990b). There seems little prospect of this trend being stemmed; on the contrary, it is believed that the projected expansion of coastal communities in Sri Lanka over the next few decades (Olsen et al, 1992), and the increasing focus on locating industries along the coastal zone would further aggravate the impact on our coral reef resources. The need for sustainable management of Sn Lanka’s coral reef ecosystems and their resources is therefore urgent.

Among the foremost destructive practices that impact directly on the physical structure of the reef are the removal of coral for conversion into wall plastering material, the removal of reef organisms for the export aquarium industry, fishing practices that employ explosives and the indiscriminate use of fishing nets. Various pollutants – sediment arising from unsound land-use practices, agro-chemicals derived from agricultural overuse, and wastes draining into reefs from sewage and industry lead to reef degradation and loss of reef biodiversity (Herath, 1990; Ekaratne, 1990a, l990b; White and Ekaratne, 1995; Ohman *etal,* 1993; Costa, 1989; Dassanayake, 1994).

Reports say that the Crown-of-thorns starfish, *Acanthasterpianci*, has increased periodically to form large populations in reefs on the east and north-west coasts (De Bruin, 1972; Rajasuriya and Rathnapriya, 1994). Following in the wake of anthropogenic disturbances, organisms such as didemnids, corallivorous gastropods, sponges and algal species like Halimeda and Ulva (Ekaratne, 1997c) have invaded Sri Lankan coral reefs.

Physical removal of reef organisms, whether as a target species (such as in the aquarium trade) or as a non-target species (such as in the dynamite fishery or in set-nets laid on the reef to catch spiny lobsters) will also exert pressure directly on species of interest to the aquarium trade. Adults and semi-adults of various ornamental species, including *Heniochus acuminatus, Chaetodonfalcula, C. auriga, Acanthurus leucosternon,* and *Zanclus canescens* are said to be caught in traps and beach-seines. Some fisheries are said to account for many fish of little food value but of considerable importance for the live export trade, such as *Tetrasoma gibbosus, Lactoria cornuta* and *Diodon holocanthus.* These are generally thrown away, whether alive or dead (Wood, 1985, Jonklaas, 1985). Specific ornamental species, including Anthias spp and Dascyllus, are known to be fished deliberately as bait for the tuna and skipjack fishery (Jonklaas, 1985; Anderson, 1997). Other factors which may have led to the decline in numbers of ornamental fish include reef degradation and the food fishery (Wood, 1985).



SECTION 9

The Status of Relevant Information for Resource and Habitat Management

Marine habitats and their inhabitants have attracted far less research and study than terrestrial habitats or freshwaters. Therefore, much less information is available for management of marine aquarium fish resources than for freshwater fish resources.

The sustainability of all aquatic resources depends on the extraction pressure or rate of extraction. Where an aquatic resource such as a fish resource is renewable, its sustainability will depend on its regenerating capacity, linked to its reproduction and growth characteristics. For effective management of natural populations, therefore, it is necessary to get the relevant biological and ecological data in order to ensure that the resource is not over-exploited and that the habitat is not adversely impacted. This data is also required for information dissemination to interested personnel and stakeholders.

The other important data needed relates to extraction pressure – numbers of collectors, quantities collected and exported, etc. It is expected that the licensing scheme of the Ministry of Fisheries, which is under way, will generate this data.

9.1 Information required for sustainable management

The concept of sustainability has been around for a long time, although it has entered popular culture only relatively recently. Its recent interpretation views sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WECD, 1987). This concept interlinks the conservation and sustainable use aspects and leads us to the concept of sustainable management of our natural resources, including our rich heritage of biological diversity.

9.1.1 Status of information Available for Sustainable Management

The programme started recently by the Ministry of Fisheries to license fish collectors will yield information on fish collection. Together with customs data on exports, it should be possible to generate some information about extraction pressure on the natural resource base. Such an information base is not fully developed as yet.

Some qualitative data on the ecological/biological aspects of the freshwater aquarium fish resource is available, particularly through the work of Pethiyagoda (1991) and Senanayake (1980). This and other available data for freshwater fish are summarised above, in Section 6.

As regards the marine aquarium resource, extremely little information is available. Detailed quantitative data on reefs, reef processes and data on the diversity of the reef biota are lacking for Sri Lankan reefs (Ekaratne, 1997c). As for the species base of our reef ecosystems, species diversity and richness are known with some degree of comprehensiveness only for the scieractinian coral and fish fauna. Data on the status and condition of a few Sri Lanka reefs is available from a few reef surveys carried out so far by the National Aquatic Resources Agency (NARA). It is essential for NARA to expand its surveys to include other reef areas. NARA is well equipped to do such surveys and some of the reefs have been surveyed qualitatively for fish and scleractinian coral cover, but not for other organisms, while the extensive reef formations in the north and east have not been surveyed due to security reasons.

NARA's survey programme has revealed the existence of 183 species of stony corals in 68 genera, and over 300 species of fish in 62 families, including 35 species of Butterflyfish, as also the occurrence of spiny lobsters, dolphins, whale sharks and five species of sea turtles. Another three species of stony corals new to Sri Lanka and two species new to science were discovered early this year (Ekaratne *et al,* in prep.). The common reef-building corals belong to the families of Acroporidae, Agariciidae, Faviidae, Caryophyliidae, Merulinidae, Mussidae, Oculinidae, Pocilloporidae and Poritidae. Common octocorals include *Sarcophyton, Sinularia* and dendronephthids. (Mergner and Scheer, 1974; Rajasuriya,1994; Rajasuriya and de Silva 1988; Ekaratne, 1997c).

In relation to the smaller animals (mostly invertebrates) that contribute and maintain the complex inter-relationships of reef ecosystems, we know almost nothing or very little. To fill these gaps, a start has been made only now, as for example with the Biodiversity Skills Enhancement Project implemented by March for Conservation (MfC), Sri Lanka. This organisation provides taxonomic training, particularly with regard to reef invertebrates, and a data base is being compiled for these organisms (e.g., Ekaratne et al, 1997b).

Mergner and Scheer (1974) provide the only documentation on zonation of a reef habitat in Sri Lanka, indicating the paucity of knowledge on such important issues. Quantitative data on reefs are lacking, and studies on reef ecological processes have commenced only recently at Colombo University. It has been found that, at Hikkaduwa Sanctuary, coral recruitment extended almost throughout the year, and was maximum from May to August. In south-west reefs, the linear growth of *Acroporaformosa* ranged from *5.0* to 18.7mm month-1, with maximum growth in February/March and a lesser peak in September/October. *A. formosa* weight increments were high from March to July and peaked in June/July, in phase with pre-recruitment periods. Plankton studies of reef lagoons are likewise lacking and are limited to a study by Colombo University where annual cycles of plankton availability are being documented (Ekaratne, 1997c, Samaraweera and Ekaratne, 1996; Abeysirigunawardena. and Ekaratne, 1998).

Data on physico-chemical factors associated with reefs are also lacking and are limited to a few studies, including that of Colombo University. It is surprising that though sediment and particulate matter have been widely identified as one of the major impacting agents on reef ecosystems (e.g., Rajasunya and White, 1995; Ekaratne, 1990b, l997a), no related documentary data existed up to last year. A Colombo University study undertaken last year showed that south-west reefs experienced high loads of particulate matter, including sandy material, from May to November, with maximum loads of up to 3.2 kg day'm^2. Such studies are urgently needed for other reef locations over acceptable time scales.

The removal of coral ("coral mining") for conversion into wall plastering material is well documented by the Coast Conservation Department (CCD), while reef organism removal for the export aquarium industry was the focus of a study by Wood *(1985).* The status of marine aquarium fish is being studied under the leadership of Dr Elizabeth Wood (by the Marine Conservation Society jointly with NARA, on a Darwin Initiative funding programme). This would form a very good data base on completion. Colombo University is cataloguing the exports in the aquarium export trade. Together with the above-mentioned Darwin Initiative study, the results would form robust data base on this trade practice. The Crown-of-thorns starfish, *Acanthasterpianci,* merits further study. So do the effects of other organisms (such as didemnids, corallivorous gastropods, sponges and algal species like *Halimeda* and *Ulva)* on reef ecosystems bioerosion studies; some of which are being presently carried out by Colombo University.

Developing in situ methods suited for sustainable management is an accepted priority area in resource management. Some preliminary work carried out by the University of Colombo at Hikkaduwa Marine Sanctuary, using Acropora species, indicates the feasibility of re-establishment, restoration and rehabilitation of degraded reef areas. These methods require field testing on a broader scale and constitute another important area meriting future research focus, particularly in view of the coral bleaching and mortality that is being experienced over a wide geographic scale.

Reef-associated habitats which have a high biodiversity and nursery value also require identification for effective reef management and for planning the design of a Protected Area Network. Such habitats have been identified by Colombo University. These include *Halimeda* mats that harbour a rich diversity of organisms (polychaetes, amphipods, shrimps, crabs, molluscs, bryozoans, ascidians, foraminiferans, nemerteans, pycnogonids and platyhelminths). During periods of strong wave force, Halimeda clumps also served as a protective nursery habitat for a number of reef-associated organisms, including pipe fish, gobies, ophiuroids, holothuroids, echinoids, crabs, olives and other molluscs (Ekaratne, 1997c).

Identification of niche types that are associated with reef ecosystems have been carried out to a limited extent by Colombo University, where six niche types have been identified at the Hikkaduwa Marine Sanctuary (Abeysingunawardena. and Ekaratne, 1996). Studies on food and feeding of a few reef-dwelling fish species have been carried out at Colombo University (Janz , Ekaratne and Perera, 1996). Such studies would also assist in designing protected areas by identifying types and threshold levels of various interacting species that are required to maintain the desired fish species biodiversity and richness within a defined reef area.

9.1.2 Information & Training Required for Sustainable Management

Applying sound comprehensive scientific information to the development of a national fishery policy can reduce or eliminate much of the uncertainty that is impeding protection of freshwater and marine fisheries today. Implementation of science-based fishery management plans will help resolve the problems facing some fisheries, such as overfishing and the loss of spawning and nursery habitat, including fragile freshwater and coastal habitats. But improved management and correction of overfishing alone will not be enough to overcome the decline in fish stocks. Protection and restoration of aquatic ecosystems and proper care of watersheds and riparian habitats are critically important. New policies need to be initiated and existing ones continued and enhanced to eliminate, mitigate, and prevent activities that degrade habitats.

There is little reef expertise in the country, with not more than a handful of people engaged in established reef research programmes. This lack of suitably qualified and trained personnel is identified as the main impediment to the collection of research data enabling effective conservation and sustainable management of Sri Lankan reefs.

A basic requirement for sustainable management of a natural resource is to know our species base (species diversity and species richness) and get acquainted with the interacting ecological processes that sustain this species base, in turn requiring that the biological diversity be understood.

The sustainable utilisation of a natural resource, such as an exploitable fish species, requires that we have data with regard to the quantities that we can harvest without impairing its potential to maintain a population size with which the species can perpetuate itself in the long term. For estimating such quantities, we need to know the following;

- population sizes
- population-influencing processes, such as growth, reproduction, interactions, environmental impacts, etc.
- the influence that harvestable quantities would have on the population
- measures that could be adopted for stock regeneration whenever it becomes necessary to do so

The training of more researchers in reef ecology would be pivotal for understanding the ecological processes that need to be incorporated into appropriate reef management strategies in Sri Lanka. Personnel who have high quality university degrees, and thus the academic background to understand ecosystem processes, need to be trained with a view to developing a good ecological research perspective.

Conservation, by itself and for its own sake, would mean keeping the natural resource without subjecting it to anthropogenic change through its utilisation and would be possible only within legally protected areas, such as marine reserves.

Such conservation would require that we identify areas which would characterise representative reef ecosystems that, in our opinion, merit their being preserved outside the influence of human intervention. For this purpose of identifying areas for conservation, it is necessary for us to have a sufficiently robust data base that would yield information as to the variety, richness and spatial functions of the habitats within reef ecosystems. Research to collect the data for such an information base is therefore important if we are to delimit conservation areas or zones and accord them legally protected status.

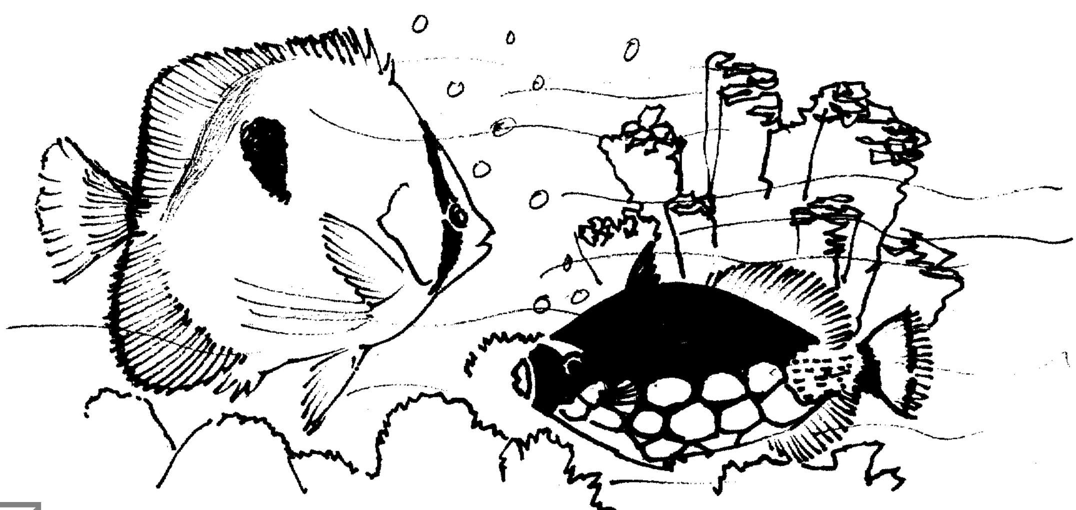
Conservation could also mean the conservation of a given species or a number of species. This however, would become meaningful for coral reef conservation only if such species conservation was carried out as part of a functioning ecosystem (as *in situ* conservation), rather than in isolation or away from its normal habitat (= *ex situ* conservation). The advantage of *in situ* conservation is that it would conserve not only the species in question, but other interacting species and, of course, the ecosystem as a functional entity.

As against conservation, sustainable management requires a far greater input of time, effort, personnel and other resources as well as a more detailed information data base that needs to be updated continuously and related to the management strategy that is being applied. Sustainable management also requires that the user community be educated about the advantages of using a resource sustainably as against using it as a "common property" natural resource where every user would exploit the resource maximally without being accountable for its long-term upkeep or sustainability.

Sustainable management depends on a cohesive holistic approach. Ecological data is only one of its necessary components. Data relating to socio-economics, education, community empowerment, policy and institutional reform and major land-use methods should be used both separately and in combination to establish an integrated practical strategy over a period of time.

9.2 A FInal Word

The multitude of exploitative and resource-degrading practices carried on at present in Sri Lanka together with the paucity of knowledge on reef and freshwater ecology, dictate that a precautionary approach be speedily adopted for sustainable management of Sri Lanka's aquatic ecosystems. This is essential so that these ecosystems can continue to sustain the capacity of the aquarium export trade to generate jobs and earn foreign exchange, as well as meet the requirements of future generations. It is their natural resources which we hold in trust.



<<

SECTION 10

Literature of relevance to management of aquarium fish and their habitats

Abeysirigunawardena, M.D. and S.U.K. Ekaratne. 1996. Niche diversity and fish species diversity for management of human activities in a marine sanctuary in Southern Sri Lanka. *Regional Workshop for Management of Coastal Resources.* Oct. 1996.

Abeysirigunawardena, M. D. and S.U.K. Ekaratne. 1998. Seasonal variation in reef-associated zooplankton. Ann. Scientific Sessions. Sri Lanka Association for Fisheries & Aquatic Resources. pp. 16.

Adam, S. 1997. The aquarium fishery of the Maldives. *In:* Workshop Proceedings on Integrated Reef Resources Management in the Maldives, BOBPfREP/76, pp. 93-1 16.

Alava, **V.R. and Gomes, L.A.O.** 1989. Breeding aquarium animals: the anemone fish. *NAGA,* 12(3), 12-13.

Allen, G.R., 1979. Butterfly and angelfishes of the World, vol.2. *Mergus Publishers,* West Germany. p. 149-352.

Allen, G.R., 1980. The anemonefishes of the world. *Aquarium Systems,* Mentor, Ohio. 104 pp.

Anderson, R.C. 1997. The Maldivian tuna livebait fishery. *In:* Workshop proceedings on Integrated Reef Resources Management in the Maldives, BOBP/REP/76, pp. 69-92.

Andrews, C. 1990. The ornamental fish trade and fish conservation. *Journal of Fish Biology.* 37 (Supplement A), pp. 53-59

Andrews, C. 1994. The aquarium trade and conservation. *Pet Age.* March 1994.

Anonymous. 1991. Tridacnid clam culture. SeaScape, **a** newsletter produced by Aquarium Systems. Volume 8.

Atkinson, MJ., B. Carison, and B.L. Crow. 1995. Coral growth in high-nutrient, low-pH seawater: **a** case study of corals cultured at the Waikiki Aquarium, Honolulu, Hawaii, Coral Reefs. 14: pp. 2 15-223

Axelrod, **H.R.** 1960. In passing *Ceylon.Tropical Fish Hobbyist.* May 1960. pp. 5-24.

Axelrod, **H.R.** 1967. Breeding aquarium fishes. *Book 1. TFH PubI.,* Neptune City, New Jersey. 480 pp.

Axelrod, H.R. 1980. Breeding aquarium fishes. Book 6. TFH Publ., Neptune City, New Jersey. 281 pp.

Axelrod, **H.R.,** & Burgess, W.E., 1979. Marine fish.. T.F.H. Publications, Inc. Ltd., New Jersey. 93 pp.

Banister, K.E. 1989. Shoals of fish. *Naturopa.* Number 62

Baquero, J. 1995. The stressful journey of ornamental marine fish. *Sea Wind* (a publication of Ocean Voice International) 9(1)

Bassleer, G. 1994. The international trade in ornamental fish, plus notes from a moderated discussion. Source of article unknown, date assumed.

Bassleer, G. 1995. The international trade in ornamental fish. Aquaculture Towards the 21st Century. Eds: KPP Nambiar and T Singh. *Infofish,* Malaysia. pp. 24 1-243.

Birkeland, C. (ed) 1997. Life and death of coral reefs, *Chapman and Hall,* New York, 1997, 536pp.

Bjork, M., Salim Mzee Mohammad, Marie Bjorkland, and Adelaida Semesi, 1995. "Coralline Algae, important coral reef builders threatened by pollution," *Ambio* 24, nos. 7-8 (December 1995), 502-4.

Bourne, G.C. 1905. Reports on solitary corals collected by Professor Herdman at Ceylon in 1902. Rep. Pearl Oyster Fisheries, Ceylon. (Suppl.) 29, 187-242.

Bronowski, J. 1977. The ascent of man. *Book Club Associates, London.* 448 pp.

Brown, B.E. 1997. Integrated Coastal Management: South Asia. *University of Newcastle,* UK.

Carlson, B.S. 1994. Meeting the Demand for Live Corals through Coral Farming and Networking with Aquarium Hobbyists. *AZA Annual Conference Proceedings,* September 1994

Cesar, H. 1996. Economic Analysis of Indonesian Coral Reefs. *World Bank,* Washington, D.C. 1996.

Chandrarathna, P. P. J., A. de Alwis and J. Jinadasa, 1998. Some aspects of reproductive biology and breeding of ornate Paradise fish *Malpulutta kretseri* (Deraniyagala 1937) under laboratory conditions. *Proc 54th Annual Sessions of the Sri Lanka Association for the Advancement of Science.*

Chandrasoma, J. 1996. Some aspects of reproductive biology and captive breeding of *Puntius nigrofasciatus* (Cyprinidae), an endemic and endangered species in Sri Lanka. *Sri Lanka J. Aquat. Sci.* 1, 103-111.

Chandrasoma, J. 1994. Reproductive biology and breeding of Cuming' s barb *(Puntius cumingii Gunther), J.* Appl. *Ichthyol.,* 10, 209-214.

Chandrasoma J.and de Silva, S.S. 1981. Reproductive biology of *Puntius sarana,* an indigenous species and *Tilapia rendelli(-melanopleura)* in an ancient man-made lake in Sri Lanka, *Fish.Manag.,* 12, 17-28.

Chaudhry, S.A. 1979. Imports play key role in tropical fish market. Review of international trade in tropical aquarium fish, conducted by Chaudhry for the International Trade Centre UNCTADD/GATT, Geneva. Source of article unknown.

Clout, M. 1995. Introduced species, the greatest threat to global biodiversity? *Species* – Newletter of the Species Survival Commission, *IUCN,* 24, pp. 35-36.

Conroy, D.A. 1975. An evaluation of the present state of the world trade in ornamental fish. Food and Agriculture Organization of the United Nations. Rome. *FAQ Fisheries Technical Paper,* No. 146

Costa, H.H. and Fernando, E.C.M. 1967. The food and feeding relationships of the common meso and macro-fauna **of** the Maha Oya, **a** small mountainous stream at Peradeniya, Ceylon. *Cey. J. Sci.,* 7 (1 **& 2), pp. 54-90.**

Costa, H.H., 1989. Land-based sources of marine pollution in Sri Lanka. In: The Oceans: physical-chemical dynamics and human impact, (ed. Majumdar, **S.K.** et al), pp. 410-425.

Costanza, R. *et* al.,1997. "The value of the world's ecosystem services and natural capital," *Nature 387* (May 15, 1997), pp. 256.

Dassanayake, H. 1994. Shri Lanka. In: An environmental assessment of the Bay of Bengal region. SWEDMAR & *BOBP/REP/67* (ed.: Holmgren, 5), pp. 209-235.

Dawes, J. 1998. Captive breeding: a top priority in Sri Lanka. *Pets International.* 35.

De AIwis, A. and Rajasuriya, A. 1993. Management strategy for a relatively undisturbed coral reef system in Sri Lanka. In W. Erdelen, C. Preu, N. Ishwaran, C.M. Madduma Bandara (eds.) *Proc. International and Interdisciplinary Symposium Ecology and Landscape Management in Sri Lanka.* pp. 517-527

De Bruin, G.H.P. 1972. The 'Crown of Thorns' starfish *Acanthaster planci* (Linne) in Ceylon. *Bull. Fish. Res. Sri Lanka* (Ceylon), 23 (1 **and 2): pp.** 37-41.

De Silva, M.W.R.N. and Rajasuriya, A. 1985. Management plans for the proposed marine park at Hikkaduwa. Paper presented at the 41 St Annual session of the *Sri Lanka Association for the Advancement of Science,* 9-13 December 1985.

De Silva, M.W.R.N. 1985. Status of the coral reefs of Sri Lanka. *Proc. 5th mt. Coral Reef Congress, Tahiti,* Vol. 6, pp. 515-518.

De Silva, M.W.R.N., 1985. Research needs for the coral reef ecosystem of the Central Indian Ocean, pp. 153-165., In: *JOC/Unesco Workshop on regional co-operation in marine science in the Central Indian Ocean and adjacent seas and Gulf* Colombo, Sri Lanka, Unesco Worshop report No.37. 366p.

De Silva, M.W.R.N. 1987. Effects of the tourist industry on coral reefs at Hikkaduwa, Sri Lanka. Project report to the International Development Research Centre (IDRC). *National Aquatic Resources Agency,* Colombo, Sri Lanka.

De Silva, M.W.R.N. and Rajasuriya, A. 1989. Collection of marine invertebrates of Sri Lanka (Phase 1) Tangalle to Kalpitiya as part of the Zoological Survey of Sri Lanka. Report to Natural Resources Energy and Science Authority on NARESAISAREC. *Zoological Survey of Sri Lanka,* Project SARECII l/ZSSL-2.

De Silva, S.S. 1983. Reproductive strategies of some major fish species in Parakrama Samudra Reservoir and their possible impact on **the** eco-system, a theoretical consideration. *ln* Schiemer, F., Limnology of Parakrama Samudra, Sri Lanka. *W.Junk, The Hague.* l92pp.

De Silva, S.S. **and Kortmnlder, K.** 1977. Some aspects of the biology of three species of *Puntius (=Barbus)* (Pisces. **Cyprinidae).** *Neth. J. Zool.,* 27(2), **pp. 182-194.**

De Silva, S.S., Kortmulder, K. and Wijeratne, M.J.S. 1977. A comparative study of the food and feeding habits of *Puntius bimaculatus* and *P. titteya. Neth. J. Zool.,* 27(3), pp. 253-263.

De Silva, S.S., Schut, J. and Kortmulder, K. 1985. Reproductive biology of six Barbus species indigenous to Sri Lanka. *Env. Biol. Fish.,* 12(3), **pp.** 201-208.

De Silva, S. S., Cwnaranatunga P.R.T., de Silva C.D. 1980. Food and feeding and morphological features associated with feeding of four co-occurring Cyprinids (Pisces, Cyprinidae) *Neth J Zool* 30: **pp.** 57- 73.

De Silva, S.S., Cumaranatunga, P.R.T and Kortmulder, K. 1980. Some aspects of the biology of three species of *Puntius (Barbus)* (Pisces, Cyprinidae) endemic to Sri Lanka. *Neth.J.Zool.,* 27 **(2): pp.** 182-194.

Deraniyagala,P.E.P. 1929. Two new freshwater fishes. *Spolia Zeylanica,(2)* : pp. 73-77.

Deraniyagala, P.E.P. 1929. Some Anguilliform fishes of Ceylon. *Spolia Zeylanica.,* 15, pp. 1-29.

Deraniyagala, P.E.P. 1931. Further notes on the Anguilliform fishes of Ceylon. *Spolia Zeylanica.* 16 (2), **pp. 131-137.**

Deraniyagala,P.E.P. 1937 *Malpulutta kretseri* a new genus & species from Ceylon. *Spolia Zeylanica,* 20 (3): pp. 35 1-353.

Deraniyagala,P.E.P. (1943). A new Cyprinoid fish from Ceylon.J *RoyalAsiatic* Soc.(Ceylon), 35(96): pp. 158-159.

Deraniyagala, P.E.P. 1952. A coloured atlas of some vertebrates from Ceylon. (1): Fishes. National Mus. Ceylon, **Colombo. 149 pp.,** 34 pls.

Deranlyagala,P.E.P. 1960. A new subspecies **of the** fish *Chela laubuca* from Ceylon. *Spolia Zeylanica.* 29 (1): **pp. 17.**

Derr, M. 1992. Raiders of the Reef. *Audubon.* 48 (March/April 1992), pp. 48-56

<<

Divigalpitiya, W. M. C. I. and A. de Alwis, 1996. A preliminary investigation on the environmental impacts on the distribution of fish in two tributaries of Kelani river. *Proc. 52nd Annual Sessions of the Sri Lanka Association for the Advancement of Science,* Part 1, **pp.** 128-129.

Divigalpitiya, W. M. C. I., A. de Aiwis and J. Jinadasa, 1998. Resource partitioning among fish species of two streams in the South western Ichthyological province of Sri Lanka. *Proc. 54th Annual Sessions of the Sri Lanka Association for the Advancement of Science.*

Doherty, P.S., 1982. Some effects of density on the juveniles of two species of tropical, territorial damsellish. *J. Exp. Mar. Biol. Ecol., 65:* pp. 249-261.

Don McAllister, "Status of the world ocean and its biodiversity," *Sea Wind 9,* no. 4 *(1995),* pp. 14.

Edwards, **Aj. and A.D. Shepherd. 1992. Environmental implications of** aquarium-fish collection in the Maldives, with proposals for regulation. *Environmental Conservation.* 19(1)

Ekaratne, S.U.K. 1989a. Status of Sri Lankan Coral Reefs, Country report for workshop to establish funding priorities for management of biologically diverse ecosystems, Dept. of Zoology, *University of Colombo,* Sri Lanka.

Ekaratne, S.U.K. 1989b. Research priorities into effective management of coral reef resources of Sri Lanka: Country Report. In: United States National Science Foundation - *United States Agency for International Development Regional Workshop,* Bangkok, March 1989, pp. 160-170.

Ekaratne, S.U.K. 1990a. Development of alternatives for the effective management of coral reef resources of Sri Lanka. *International interdisciplinary symposium on ecology and landscape management in Sri Lanka,* p. 30.

Ekaratne, **S.U.K.** 1990b. Man-induceed degradation of coral reefs in Sri Lanka. Fifth MICE Symposium for Asia and the Pacific, *Nanjing University Press,* China, pp.22-27.

Ekaratne, S.U.K. 1996. The current status of the export of freshwater fish from Sri Lanka, particularly in relation to endemic species. *Ministry of Environment,* Sri Lanka. 55pp.

Ekaratne, S.U.K. 1997a. Final Report on coral reef ecology at Hikkaduwa marine sanctuary. lO2pp.

Ekaratne, *et al.* l997b. Taxonomic guides for identification of benthic organisms. Series produced for Marine Taxonomic Workshops. *March for Conservation,* Colombo, Sri Lanka.

Ekaratne, S U K. l997c. Research and Training for Conservation and Sustainable Management of Coral Reef Ecosystems in Sri Lanka: Present Status and Future Directions. Review Paper for "Year of the Reef" Regional Workshop on the Conservation & Sustainable Management of Coral Reefs, December 15th to 17th, 1997. *MS Swaminathan Research Foundation,* Chennai, India. pp. 1-13.

Ekaratne, S U K and Jinendradasa, S S. 1997. Aquatic resources extraction: issues involved in sustainability and long-term ecological implications. *Economic Review:* Special issue on aquatic resources: potential for development. 8-12, 29-31.

Ekaratne, S U K. and Jinendradasa, S S. 1998. Effects of elevated sea surface temperatures on reef corals in Sri Lanka. Ann. *Scientific Sessions Sri Lanka Ass. for Fisheries & Aquatic Resources.* p. 29.

Evans, D. 1981. Threatened freshwater fish of Sri Lanka. *IUCN Conservation Monitoring Centre,* 58 pp.

Fernando, C.H. 1956. The fish fauna of paddy fields and small irrigation ditches in the western lowland of Ceylon and a bibliography of reference to fish in paddy fields. *Bull. Fish.Res.Stn Sri Lanka.* 7, pp. 223-227.

<<

Fernando, C.H. 1956. On the food of four common freshwater fish of Ceylon. *Ceylon J. Sc.,* 7(2), pp. 201-2 17.

Fernando, C.H. 1963. A guide to the freshwater fauna of Ceylon. Supplement 1. *Bull. Fish.Res.Stn.,* 16(1): pp. 29-38.

Fernando, C.H. 1965. A preliminary survey of 21 Ceylon lakes - three parasites and predators, food of fish and marginal fauna. *Bull. Fish. Res. Stn,* Ceylon, 18 (1), pp. 17-28.

Fernando, C. H. and Indrasena, H.H.A. 1969. The freshwater fishes of Ceylon. *Bull. Fish. Res. Stn* Ceylon, 20 (2): pp. 101-134.

Fernando Y. D. N. and Piyasiri, S. 1993. Preliminary investigations on food habits of fish in Kotmale reservoir. Proc. *49th Annual sessions of the Sri Lanka Association for the Advancement of Science,* Part I, 168.

Frakes, T. 1993. Red Sea Reef "Mesocosms" in Monaco. SeaScope. *Newsletter by Aquarium Systems.* Vol 10. Fall 1993

Gash, A. 1994. U.S. & world ornamental fish trade overview. Unpublished report *TRAFFIC USA Newsletter.*

Geisler, R. 1967. Limnologisch-ichthyologische Beobachtungen in Sudwest-Ceylon. tnt. Revue Ges. Hydrobiol., *52(4),* pp. 559-572.

Geswell, R.L. and D. Vaughan. 1994. Progress of the International Working Group for the Propagation of Ornamental Marine Fish and Invertebrates. AZ4 *annual conference proceedings,* September 1994

Goldstein, R.J. 1996. Sea hunt: Recommending marine invertebrates for beginners. *Pet Age.* February 1996

Gomez, E.D. and H.T. Yap. 1985. Coral Reef in the Pacific – their potential and their limitations in environment and resources in the Pacific. AL. DahI and J. Carew-Reid, eds. *UNEP Regional Seas Response and Studies, No. 69*

Gunasekera, S. 1995. Impacts of live fish export trade on the indigenous freshwater fishes of Sri Lanka – considering five endemic species. Dissertation for partial fulfillment for diploma in wildlife management, *Open University of Sri Lanka,* unpublished.

Hale, L.i. and Kumin, E., 1992. Implementing a coastal resources management policy, the case of prohibiting coral mining in Sri Lanka. *Coastal Resources Centre of the University of Rhode Island,* USA. 30p.

Harvey, D. 1996. "Ornamental Fish Exports and Imports Higher" *In* "Aquaculture Outlook," March 7, 1996. Published by the *Economic Research Service, U.S. Department of Agriculture.*

Herath, H. M. B. K, **J. Jinadasa and A Dc** Aiwis, 1998. Species diversity, population density and commercial exploitable yield of ornamental fish in Upper Walawe Basin. Proc. 54th Annual Sessions of the *Sri Lanka Association for the Advancement of Science.*

Herath, J.W. 1990. The coral and shell industry of Sri Lanka. Sri Lanka German Technical Cooperation and Coast Conservation Department, Colombo, 43 pp.

Heslinga, **G.A.** 1995. Sustainable aquaculture in the marine aquarium industry. Paper prepared for Sustainable Aquaculture '95, *Pacific Congress on Marine Science and Technology '95,* held in Honolulu, Hawaii, June 11-14, 1995

Hettiarachehi, M., T. M. S. Tennakoon and H.H. Costa, 1993. Experimental study on the culture of the catadromous ornamental fish *Monodactvlus argentus* in net pens. *Proc. 49th annual sessions of the Sri Lanka Association for the Advancement of Science,* Part I, 168-169.

<<

Hettiarachchi, M. and T. M. S. Tennakoon, 1993. Preliminary study **on food of** *Monodactylus argentus* in Negombo Estuary. *Proc. 49th Annual Sessions of the Sri Lanka Association for the Advancement of Science, Part 1, 171.*

Hinrichsen, D. 1997. "Requiem for Reefs?" *International Wildljfe* (March/April 1997), pp. 8.

HofTmann, T.W. 1990. Wildlife conservation in Sri Lanka: A brief review of the present status. Proc. Seminar of the Bombay Natural History Society, 1983. *Oxford University Press,* Bombay, 656 pp.

International Development Research Centre (IDRC). 1995. Reef Relief. Article printed on the World Wide Web by ***IDRC***

IUCN. 1994. IUCN red list of threatened animals. *IUCN,* **Gland, Switzerland and Cambridge, 286 pp.**

IUCN. 1996. IUCN red list of threatened animals. *IUCN,* **Gland,** Switzerland and Cambridge (ed.: J. Baillie and B. Grrombridge)

Jameson, S.C., J.W. McManw and M.D. Spalding. 1995. State of the reefs: regional and global perspectives. *International Coral ReefInitiative Executive Secretariat.* Background Paper. May 1995

Jameson, **SJ., John W. McManus and Mark D. Spalding,** 1995. State of the Reefs: Regional and Global Perspectives Washington, D.C. **ICRI.,** *U.S. Department of State,* 1995, pp. 24.

Janz , M.R.G., S.U.K. Ekaratne and R.S. Perera. 1996. Food and feeding studies of coral reef fish for sustainable reef management. *Regional Workshop for Management of Coastal Resources.* Oct. 1996.

Jenings, S. and Lock, J.M. 1996. Population and ecosystem effects of reef fishing. *In:* Reef Fisheries (ed Polunin, N **V C &** Roberts **CM).** *Chapman & Hall, London.* Ch. 8. pp. 193-218.

Jinadasa,J. **and Kotalawala, A.B.** 1991. Interrelationships among the species of the Genus Putius *(Teleostei cyprinidae)* as indicated by the Caudal Skeletons. *Vidyodaya J., Science* 3 (1) pp. 99-107.

Johannes, R.E., and M. Riepen, 1995. Environmental, economic and social implications of the live fish trade in Asia and the Western Pacific (Bonnet Hill, Tasmania, Australia; RE Johannes Pty **Ltd** and Wellington, New Zealand: Fisheries Development Associates, 1995). Distributed by *The Nature Conservancy,* **Honolulu,** Hawaii

Jones, S. 1938. On the breeding habits and development of a Cyprinid Danio *(Darnio) malabaricus* (Jorden). *Bull.Fish.Res.Stn Ceylon.* 16: pp. 79-90.

Jonklaas, **R.L.,** 1985. Population fluctuations in some ornamental fishes and invertebrates off Sri Lanka. Paper No. 47: *Symposium on endangered marine animals and marine parks,* Cochin, India. 12-16 January, 1985.

Kaufman, L and Paul Dayton, 1997. "Impacts of Marine Resources Extraction on Ecosystem Services and Sustainability," in Nature's Services: Societal Dependence on Natural Ecosystems, ed. Gretchen Daily *(Washington, D.C.: Island Press, 1997),* **pp.** 275.

Kelleher, G. and Kenchington, R. 1992. Guidelines for establishing marine protected areas. *IUCN,* 79pp.

Kerstitch, A. 1995. Farms of the sea: The blue revolution. *Freshwater and Marine Aquarium.* February **1995.**

Kipper, H. 1995. The optimum marine aquarium. Pan 11. *Freshwater and Marine Aquarium,* January 1995.

Klostermann, **A.F.** 1993. Coral growth in captivity. *Freshwater and Marine Aquarium.* May 1993.

Kortmulder, K, Feldrugge, E.3.& S.S.de Silva. 1978. A combined field study of *Barbus (Puntius) nigrofasciatus* Gunther, (pisces,Cyprinidae) and water chemistry of its habitat in Sri Lanka, *Neth. J.Zool.,* 28(1), pp. 111-131.

<<

Kotalawala,A.B. 1994. The impact of the weirs across Wak Oya, a main tributary of the Kelani river, on the stream **fauna. Vidyodaya J.,** *Science.*

Kotalawala, A.B and J. Jinadasa. 1992. Interrelationships among the species of the Genus Putius *(Teleostei Cyprinidae)* as indicated by the meristic and morphological characters.Vidyodaya J., *Science,* 4, pp. 39-57.

Kottelat, M and **Pethiyagoda, R. 1990.** *Danio pathirana,* a new species of cyprinid fish endemic to southern Sri *Lanka. Ichthyol. Explor. Freshwaters, 1, pp. 247-252.*

Kvalvag, K. 1982. Ornamental fish trade, the view from Indonesia. *Infofish Marketing Digest,* 5, pp. 36-38.

Kvalvag, K. 1984. Markets for marine ornamental fish. *Infofish Marketing Digest,* 6, pp. 17-20.

Lubbock, H.fl., & Polunin, N.y.C., 1975. Conservation and the tropical marine aquarium trade. *Environmental Conservation,* 2(3): pp. 229-232.

Madhu, S.R. 1996. Ornamental fish divers of Sri Lanka. *Bay of Bengal News,* December 1996, Vol. II, No. 4, pp. 12-14.

Madhu, S.R. 1996. Export of ornamental fish. “This business runs on trust”. *Bay of Bengal News,* December 1996, Vol II, No. 4, pp. 15-17.

Mahaulpatha, W.A.D. A. De Aiwis and J. Jinadasa, 1992. Growth assessment of some ornamental fish species fed with low cost feeds. *Vidyodaya J.* of *Sci.,* **4 (1), pp.** 219-232.

Malakoff, D. 1997. “Extinction on the High Seas,” *Science* 277 (July 25, 1997), pp. 487-88.

Mapatuna, P.M. and De Aiwis, A 1993. Species composition and population dynamics of freshwater fish fauna in Heen Ela (Western Province). *Proc. 49th annual session of the Sri Lanka Association for the Advancement of Science,* Part **I, pp. 166** -167.

Maragos, J.E., M. P. Crosby, and John W. McManus, 1996. Coral reefs and biodiversity: a critical and threatened relationship. *Oceanography* 9, no. 1 (1996), pp. 87.

Marcelline, S. 1997. Row over rare reef fauna. *The Sunday Observer,* June 29, 1997. pp. 17.

McAllister, D.E. and J. Baquero. 1994. Ornamental fish industry’s environmental program. *Sea Wind* (a publication of Ocean Voice International) 8(3)

McClanahan, **T.R.** 1994. Kenyan coral reef lagoon fish: effects of fishing, substrate complexity, and sea urchins. *Coral Reefs.* (13)

Mendis, A.S. and Fernando, C.R. 1982. A guide to the freshwater fauna of Ceylon. *Fish.Res.Stn., Ceylon.* l60pp.

Merguer, H. and Scheer, G. 1974. The physiographic zonation and ecological conditions of some South Indian and Ceylon coral reefs. *Proceedings of the 2nd International Coral Reef Symposium,* Brisbane, Australia, (2): **pp. 3-30.**

Mee, J. 1993. An overview of the ornamental aquatic sector in Sri **Lanka.** *Report prepared for USAID AgEnt Project.* **51pp.**

Moe, MA., 1982. The Marine Aquarium Handbook. *The Norns Publishing Company,* Marathon, Florida. 170 pp.

Moyle, P.B. and Senanayake, F.R. 1984. Resource partitioning among the fishes of rainforest streams in Sri Lanka. *J. Zool.* Lond., 202, pp. 195-223.

Munro, **I.S.R.** 1955. The marine and freshwater fishes of Ceylon. Dept. of External Affairs, Canberra, Australia.

NARA. 1987. Preliminary hydrographic and ecological survey of the marine sanctuary at Hikkaduwa, Galle, Sri Lanka, National Aquatic Resources Agency, 33pp.

NARA. 1998. Submission titled "Comments and observations from NARA on the statements made by Professor Ekaratne in his report titled 'Status and trends related to exported ornamental fish resources and their habitats in Sri Lanka". Submitted to BOBP by Professor P W Epasinghe, Chairman, *National Aquatic Resources Research & Development Agency.*

Nakatani, K., Rajasuriya, A., Premaratne, A. **and A.T.** White (eds.) 1994. The coastal environmental profile of Hikkaduwa, Sri Lanka. *Coastal Resources Management Project,* Colombo, Sri Lanka 70 pp.

Nalinda,M.A.K. 1987.The loaches of Sri Lanka.Loris.,17 *(5):* pp. 203-206.

Niemeier, **P.A.** 1989. The Coral Fishery and Trade of Japan. *Marine Fisheries Review.* 5 1(4)

Norse, E.A. Global marinebiological diversity: A strategy for building conservation into decision-making. Washington, **D.C.:** *Island Press,* 1993, 14.

Norse, **E.A.** 1993. Global marine biological diversity. *Island Press.* Washington, D.C.

Ogden, J.C., 1985. Observations and in-situ experiments on the community structure of coral reef fishes. Paper presented at the *Underwater Association Symposium, British Museum (Natural History),* 23rd March, 1985.

Ohman, M.C., A. Rajasuriya and O. Linden. 1993. Human Disturbances on Coral Reefs in Sri Lanka: A Case Study. *Ambio.* 22(7), 474-480.

Olsen, S., Sadacharan, D., Samarakoon, J.I., White, A.T., Wickremeratne, H.J.M., and M.S. Wijeratne 1992. Coastal 2000: A resource management strategy for Sri Lanka's coastal region, Volumes 1 and 2. *Coastal Resources Management Project and CCD, Sri Lanka,* pp. 81 and 21.

Pennisi, E. 1997. Brighter Prospects for the World's Coral Reefs? *Science* 277, July 25, 1997), pp. 492.

Pernetta, **J.C.** 1993. Marine protected area needs in the South Asian seas Region Volume 5: Sri Lanka, *IUCN,* Switzerland, 67 pp.

Pethiyagoda, R. 1991. Freshwater fishes of Sri Lanka. *Wildlife Heritage Trust of Sri Lanka,* Colombo 8, 362 pp.

Pethiyagoda, R. 1994. Threats to the indigenous freshwater fishes of Sri Lanka and remarks on their conservation. *Hydrobiol.,* 285, pp. 189-201.

Piet, G.J. and Guruge, A.H.P. 1997. Diel variation in feeding and vertical distribution of 10 co-occurring fish species: consequences for resource partitioning. *Env. Biol. Fish.,* 50, pp. 293-307.

Polunin N.V.C. and Roberts, C.M. 1996. Reef Fisheries. *Chapman & Hall,* London. 477pp.

Prem Kumar, K., Vijayakumar, B., Padmanabhan, K.G. and Kortmulder, K. 1987. Food and feeding of two cyprinid forage fishes *Puntius* (= *Barbus) filamentosus* and *P. Amphibius* from South Kerala, India. *Neth. J.* Zool. 36, pp. 449-461.

Rajasuriya, A. 1991. Location and condition of reefs along Sri Lanka's Coast. pp.203-210, Proc. Seminar on Causes of Coastal Erosion in Sri Lanka. *Coast Conservation Department,* Colombo, Sri Lanka, 366p (by NARA)

Rajasuriya, A. 1994. Report on the present status of the coral reefs in the Hikkaduwa Marine Sanctuary. *NARA and the Coastal Resources Management Project,* Colombo, Sri Lanka.

Rajasuriya, A. 1994. Three genera and twelve species of stony corals new to Sri Lanka (abs.). Paper presented at the *2nd annual scientific sessions ofNARA, Colombo.*

Rajasuriya, A. and de Silva, M.W.R.N. 1988. Stony corals of fringing reefs of the western, south-western and southern coasts of Sri Lanka. Proceedings of the *International CoralReefSymposium,* Australia, Vol. 3, p. 287-296.

Rajasuriya, A. and A.T. White 1995. Coral reefs of Sri Lanka: review of their extent, condition and management status, *Coastal Management,* 22, 77-90.

Rajasuriya, A. and K. Rathnapriya 1994. The abundance of the crown-of-thorns starfish *Acanthasterplanci* (Linne, *1758)* in the Bar Reef and Kandakuliya areas and implications for management (abs.). Paper presented at the *2nd annual scientific sessions of the National Aquatic Resources Agency* (NARA), Colombo.

Rajasuriya, A., **De** Silva, **M.W.R.N. and Ohman, M.C.** *1995.* Coral reefs of Sri Lanka: human disturbance and management issues. *Ambio* Vol.24 No.7-8, Dec 1995.

Rajasuriya, A. and White, AT. 1995. Coral Reefs of Sri Lanka: review of their extent, condition and management status. *Coastal Management.* Vol.23: **pp.** 77-90.

Rajasuriya, **A. and Wood, E.M.** 1997. Coral reefs in Sri Lanka: Conservation Matters. *Marine Conservation Society* and *National Aquatic Resources Agency,* l4pp.

Ranasinghe, P.N. and D. V. N. Samarasinghe. 1997 Categorization of endemic freshwater fishes of Sri Lanka using the new IUCN criteria of 1996: A reassessment. *Sri Lanka Naturalist,* 1(3, 4), pp. 3 1-33.

Randall, J.E. 1987. Collecting Reef Fishes for Aquaria. Chapter 2 *In* Human impacts on coral reefs: facts and recommendations. B. Salvat, ed., *AntenDe Museum E.P.H.E.,* French Polynesia

Richards A. 1993. Live reef fish exports to Southeast Asia from the South Pacific. *SouthPaafic Commission Newsletter,* No. 67: pp. 34-36.

Richards, A. 1993. Live reef fish export fisheries in Papua New Guinea: current status and future prospects. *Forum Fisheries Agency* Report No. 93/10.

Ridley, S **0.** 1883. The coral faunas of Ceylon with descriptions of new species. *Ann. Mag. Natural History.* 11(6), pp. 250-262.

Roberts, C.M. 1993. Coral reefs: health, hazards and history. *Trends in ecology and evolution.* 8(12). December

Roberts, C.M. 1995. Effects of Fishing on the Ecosystem Structure of Coral Reefs. *Conservation Biology.* 9(5). October 1995.

Roberts, C.M. 1997. Marine Reserves: A brief guide for decision makers and users. *Caribbean Conservation Ass.,* Barbados.

Russell, B.C., Anderson, G.R.V., & Talbot, F.M., 1977. Seasonality and recruitment of coral reef fishes. *Aust. J.Mar. Freshwater Res.,* 28: pp. 521-528.

Sadovy, **Y.J. 1996. Reproduction** of reef fishery species. In: *Reef Fisheries* (ed Polunin, N V C & Roberts C M). *Chapman & Hall,* London. Ch. 2., pp. 15-60.

Sale, P.F. and Dybdahl, R., 1975. Determinants of community structure for coral reef fishes in **an** experimental habitat. *Ecology, 56:* pp. 1343-1355.

Sale, P.F., 1977. Maintenance of high diversity in coral reef fish communities. *Am. Nat.* 111: pp. 337-359.

Sale, P.F., 1980. Assemblages of fish **on patch** reefs – predictable or unpredictable? *Env. Biol. Fish.,* 3(3): **pp.** 243-249.

Sale, P.F. and Ferret, D.J. 1988. Early survivorship of juvenile coral reef fishes. *Coral Reefs,* 7, pp. 117-124.

Sale, P.F., Douglas, W.A. and Doherty, P.A. 1984. Choice of microhabitats by coral reef fishes at settlement. Coral Reefs, 3, pp. 91-99.

Saim, R. 1996. "The status of coral reefs in the Western Indian Ocean with notes on related ecosystems," working paper prepared for the *International Coral Reef Initiative Workshop,* Seychelles, March 1996.

Salm, R.V.S., & Proud, K.R.S., 1981. Guidelines needed for the commercial exploitation of coral reef fishes. *V-Conservation Indonesia, 5(1):* pp. 5-6.

Salm, R.V.S., 1975. Critical marine habitats of the northern Indian Ocean, including Sri Lanka, India and Pakistan. Unpublished report.

SaIm, R.V.S., 1979. Sunken Treasures. *Animal Kingdom,* 82: pp. 13-18.

Samaraweera, E.K.V. and S.U.K. Ekaratne. 1996. Diversity and dynamics of zooplankton at Hikkaduwa Marine Sanctuary, Sri Lanka. *Regional Workshop for Management of Coastal Resources.* Oct. 1996.

Schiemer, F. and Hofer, R. 1983. A contribution to the ecology of the fish fauna of Parakrama Samudra, in: Scheimer, **F.** (Ed.), Limnobogy of Parakrama Samudra, Sri Lanka. W. Junk, The Hague. l92pp.

Senanayake, F. R., 1980. The ornamental fishery in Sri Lanka. *Marga Institute.* Sri Lanka Centre for Development Studies. 15pp.

Senanayake, F. R. 1980. The biogeography and ecology of inland fishes of Sri Lanka. Ph.D dissertation. *Univ. Cali., Davis*

Senanayake, F.R. 1985. *Barbus srilankensis,* a new species of Cyprinid fish from Sri Lanka. *Ceylon. J. Sci., Biol.,* 15 (l&2), pp. 396-402.

Senanayake, F.R. 1987. A checklist of the freshwater fishes of Sri Lanka, *Loris* 17 (5): pp. 396-402.

Senanayake, F.R. and Moyle, P.B. 1981. Conservation of freshwater fishes in Sri Lanka. *Biological Conservation,* 22, **pp. 181-195.**

Senanayake, F.R., **Soule, M. and Senner, J.W.** 1977. Habitat values and endemicity in the vanishing rain forests of Sri Lanka. *Nature,* 265: pp. 181-195.

Shoup, C.O. 1996. Coral Commerce Concerns Conservationists. *Traffic USA Newsletter.* 15 (1). January 1996.

Shoup, **C.0. and A.L. Gash.** 1995. Trade in CITES-Listed Hard Corals, 1989-1993. A Preliminary Report *Traffic USA Newsletter.* Washington, D.C.

Shulinan, M.A., 1984. Resource limitations and recruitment patterns in a coral reef fish assemblage. *J. Exp. Mar. Biol. Ecol.,* 74: pp. 85-109.

Sloboekin, **L.B., & Fishelson, L.,** 1974. The effect of the cleaner wrasse *Labroides dimidiatus* on the point diversity of fishes on the reef front at Ellat. *Am. Nat.,* 108: pp. 369-376.

<<

Smith, C.L., and Tyler, J.C., 1972. Space resource sharing in a coral reef fish community. In Collette, S.D., & Searle, S.A.,(eds), Results of the Tektite program: ecology of coral reef fishes. Nat. Hist. Mus. *LosAngeles CountySci-Bull.,* 14:pp. 125-170.

Smith, M and JifTry, F. 1986. The reproductive strategy of *Laheo dussumieni* and implications of hydro-electric and irrigation projects on the Mahaweli Ganga, Sri Lanka. *Proc. Asian Fish. Soc.,* pp. 693-696.

Spalding, M. **and** A. M. **Grenfell,** 1997. "New Estimates of Global and Regional Coral Reef Areas," *Coral Reefs* (1997) 16: pp. 225-230.

Steene, **R.C.,** 1978. Butterflyfish and Angelfishes of the World. Vol 1. *John Wile and Sons,* New York. 144 pp.

Stratton, R.F. 1995. Mini-Reef Aquariums. *YearBOOKS, JDC,* T.F.H. Publications, IDC. Neptune, N.J.

Talbot, **F.H.,** Russell, S.C., & Anderson, **G.R.V.,** 1979. Coral reef fish communities: unstable high-diversity systems? *Ecol. Monogr.,* 49: pp. 425-440.

UNEP/LUCN, Coral Reefs of the World. Volume 2: *Indian Ocean, Red Sea and Gulf* (Gland, Switzerland: *IUCN,* 1988), xxi.

United Nations Environment Programme (UNEP) and World Conservation Union (IUCN), 1988. Coral Reefs of **the World. (Gland, Switzerland:** *IUCN*, 1988), xvi.

Vasal, S. and Sudara Raj, B.I. 1978. Thermal tolerance and preference of the Indian catfish, *Heteropneustesfossilis. Env. Biol. Fish,* 3(3), pp. 309-3 15.

Walsh, W.J. 1978. Aquarium reef fish collecting: promise or problem? In Papers and Comments on Tropical Reef Fish. *University of Hawaii Sea Grant College Program,* Working Paper No. 34.

Watson, C. A. 1995. Investing in the future: captive breeding of marine tropicals. *Freshwater and Marine Aquarium.* 18(3). March 1995.

WECD, 1987. Our common future (The Bruntland Report): *World Commission on Environment and Development.* New York: Oxford University Press.

Wells, S.M., (ed.). 1988. Coral Reefs of the World. Vol.2: Indian Ocean, Red Sea and Gulf. *UNEP/IUCN,* Gland, Switzerland, 389 pp.

Wells, **S.M.** 1995. Science and management of coral reefs: problems and prospects. *Coral Reefs.* 14,

Wells, S.M. and A.C. Alcala. 1987. Collecting of Corals and Sheds. Chapter 1 in *Human impacts on coral reefs: facts and recommendations.*

White, A. T. and Ekaratne, S.U.K. 1995 Coastal tourism in Sri Lanka: guidelines for environmental protection. *In: Eco-tourisin: Concept, design and strategy* Eds, S Hiranburana, V Stithyudhakarn and P Dhambutra Srinakharinwirot University Press, Bangkok. pp. 115-134.

White, A.T., V. Barker, and G. Tantrigama, "Using integrated coastal management and economics to conserve coastal tourism resources in Sri Lanka," *Ambio* 26, no. 6 (1997), pp. 335-44.

Wickramanayake, **E.D.** 1990. Conservation of endemic rainforest fishes of Sri Lanka: Results of a translocation experiment. *Conserv. Riol.* 4(1), pp. 32-37.

Wilkinson, W. and Buddemeier, R. 1994. Global Climate Change and Coral Reefs: Implications for People and Reefs. Gland, Switzerland: *IUCN,* 1994.

<<

Wilkinson, R. 1993. Coral reefs are facing widespread devastation: can we prevent this through sustainable management practices? In Proceedings of the 7th International Coral Reef Symposium 1. *Guam,* 1993, pp. 11-21.

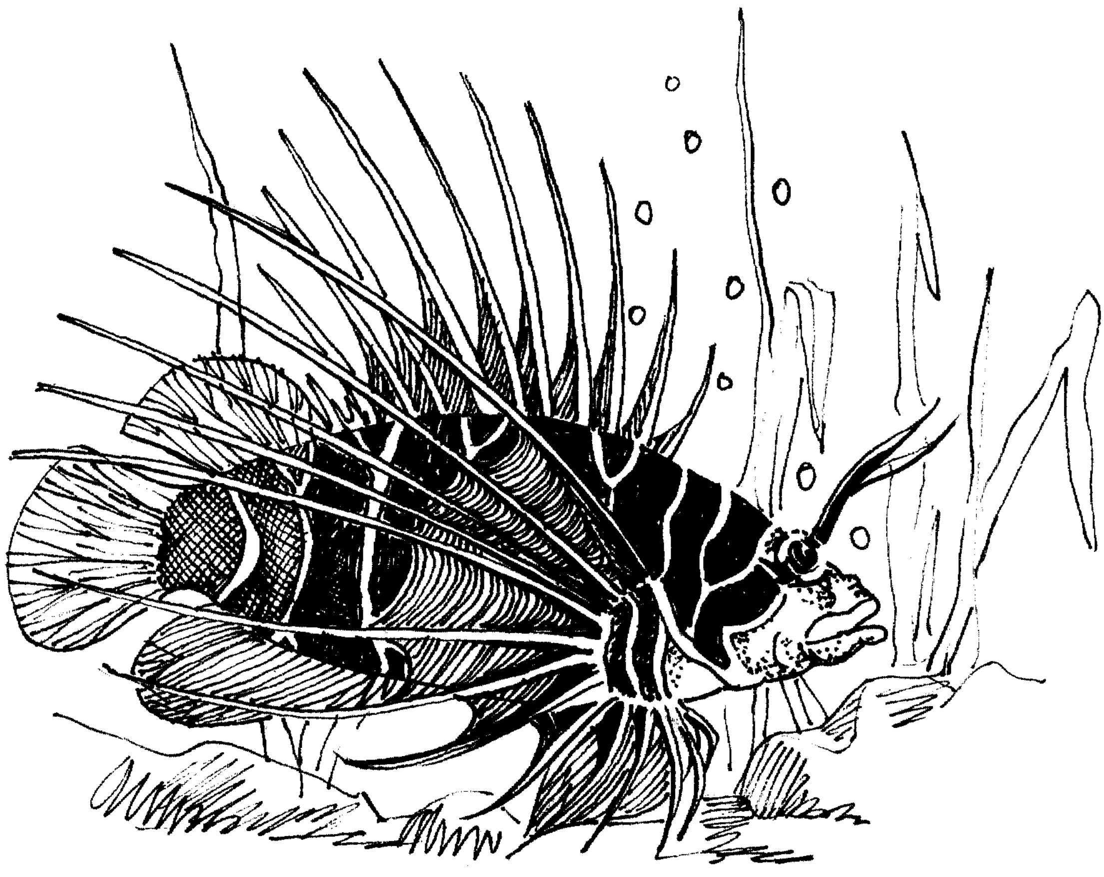
Williams, D., Mc B., 1983. Daily, monthly and yearly variability in recruitment of a guild of coral reef fishes. *Mar. Ecol. Prog. Ser.,* 10: pp. 23 1-237.

Wood, E. 1986. Exploitation of coral reef fishes for the aquarium trade. *Rep. Marine Conservation Soc.,* U K. ll8pp.

Wood, E. 1992. Trade in tropical marine fish and invertebrates for aquaria: Proposed guidelines and labelling scheme. A report for the Marine Conservation Society, Herefordshire, U.K.

Wood, E. **and Rajasuriya, A.** 1996. Handbook of marine protected species in Sri Lanka, 26pp. Marine Conservation Society, Herefordshire, U.K.

Young, F.A. 1996. The state of tropical marine aquarium animal cultivation. Freshwater and Marine Aquarium. 19(5).



SECTION 11

Annexes

Annex 1. Commonly used vernacular names of exported freshwater aquarium fish

Zoological name	*English name*	*Sinhala name*
1. *Anguilla bicolor*	Level-finned eel	*Kalu aandha*
2. *Chela laubuca*	Blue laubuca	*Tatu dandiya*
3. *Danio malabaricus*	Giant danio	*Ruth kailaya*
4. *Daniopathirana*	Barred danio	
5. *Esomus thermoicos*	Flying barb	*Ravul dandiva*
6. *Garra ceylonensis*	Stone sucker	*Gal pandi*
7. *Puntius amphibius*	Scarlet-banded barb	*Mada ipila*
8. *Puntius asoka*	Asoka barb	*Asoka pethiya*
9. *Puntius bimaculatus*	Redside barb	*ipili kadaya*
10. *Puntius chola*	Swamp barb	*Kota ipilla*
11. *Puntius cumingii*	Cuming's barb	*Pothaya*
12. *Puntius dorsalis*	Long-snouted barb	*Katu kureya*
13. *Puntiusfi/ainentosus*	Filamented barb	*Pethiva*
14. *Puntius nigrofasciatus*	Black ruby barb	*Bulath hapaya*
15 *Puntius pleurotaenia*	Black-lined barb	*Hitha messa*
16. *Puntius ticto*	Tic-tac-toe barb	*Thith pethiya*
17. *Puntius titteya*	Cherry barb	*Lay thiththeya*
18. *Puntius vittatus*	Silver barb	*Podi pethiya*
19. *Rasbora daniconius*	Striped rasbora	*Dandiya*
20. *Rasbora vaterifloris*	Golden rasbora	*Hal mal dandiya*
21. *Lepidocephalichthvs thermalis*	Common spiny loach	*Ehirava*
22. *Acanthobitis urophthalmus*	Tiger loach	*Vairan ehirava*
23. *Schistura notostigma*	Banded mountain loach	*Kandu ehirava*
24. *Mystus gulio*	Long-whiskered catfish	*Anguluwa*
25. *Mvstus keletius*	Yellow catfish	*Path ankutta*
26. *Mystus vittatus*	Striped dwarf catfish	*lri ankutta*
27. *Ompok bimaculatus*	Butter catfish	*Walapoth tha*
28. *Heteropneustes fossilis*	Stinging catfish	*Hunga*

Contd...

29. *Oryzias melastigma*	Blue eye	*Hande titteya*
30. *Aplocheilus dayi*	Day's killifish	*Uda handeya*
31 *Aplocheilus parvus*	Dwarf panchax	*Udda*
32. *Aplocheilus werneri*	Werner's killifish	*fri handeya*
33. *Microphis brachyurus*	Short-tailed pipefish	
34. *Monodactylus argenteus*	Mono	*Kapuwa*
35. Toxotes chararеus	Archer fish	*Dhimitta*
36. *Scatophagus argus*	Scat	*Ilatthiya*
37. *Etroplus maculatus*	Orange chromide	*Kaha koraliya*
38. *Etroplus suratensis*	Pearl spot	*Koraliya*
39. *Butis butis*	Upside down sleeper	*Vaneya*
40. *Eleotrisfusca*	Brown gudgeon	*Puwak badilla*
41. *Glossogobius giuris*	Bar eyed goby	*Weligowwa*
42. *Redigobius bairearops*	Rhino-horn goby	
43. *Schismatogobius deraniyagalai*	Red-neck goby	
44. Sicyopterus grisseus	Gara	
45. Sicyopus jonklaasi	Lipstick goby	
46. Anabas testudineus	Climbing perch	*Kavaiya*
47. Belontia signata	Combtail	*Thalkossa*
48. *Malpulurra kretseri*	Ornate paradisefish	*Malpulutta*
49. *Pseudosphromenus cupanus*	Spike-tailed paradisefish	*Pulutta*
50. Channa orienralis	Smooth-breasted snakehead	*Kola kanaya*
51. *Channa striata*	Murrel	*Loolla*
52. Macrognathus aral	Lesser spiny eel	*Bata kola theliya*
53. Mastacembelus armatus	Marbled spiny eel	*Gan theliya*
54. *Tetraodon fluviatilis*	Common puffer	*Paeththaya*

<<

Annex 2. Names under which marine fish are exported from / through Sri Lanka as recorded in Customs returns from exporters (note that a single fish species is sometimes referred to by multiple names)

Group	*Family*	*Scientific name*
Surgeon fish (15 spp.)	Acanthuridae (23 + spp.)	*Acanthurus bariene*
		Acanthurus blochii
		Acanthurus ibelie
		Acanthurus leucosternon
		Acanthurus lineatus
		Acanthurus nigricans
		Acanthurus pyroferus
		Acanthurus sohal
		Acanthurus tennenti
		Acanthurus trioglosus/triostegus
		Acanthurus xanthopterus
		Acanthurus nigroris
		Ctenochaetus marginatus
		Ctenochaetus striatus
		Ctenochaetus strigosus
		Paracanthurus hepatus
Unicorn fish (3+spp.)	Acanthuridae	*Naso brevirostris*
		Naso lituratus
		Naso viamingi
		Naso sp.
Tangs (5+ spp.)	Acanthuridae	*Zebrasoma desjardini*
		Zebrasoma scopas
		Zebraasoma veliferum
		Naso lituratus
		Zebrosoma xanthurus
		Zebrosoma sp.
Glass fish (1 sp)	Ambassidae (1 sp)	*Ambassis sp.*
Frog Fish (2+ spp.)	Antennariidae (2+ spp.)	*Antennarius hispidus*
		Antennarius biocellatus

Contd

<<

		Antennarius sp.
		Histrio histrio
Cardinal fish (2+ spp.)	Apogonidae (2+ spp.)	*Apogon angustatus*
		Apogonsp.(A. cyanosoma, A. Endeketaenia)
		Sphaeramia nematoptera
Trigger fish (16+spp.)	Balistidae (16+spp.)	*aculeatus = Rhinecanthus aculeatus*
		Balistoides conspicillum
		Balistapus undulatus
		Balistoides viridescence
		Monocanthus parda/is
		Melichthys indicus
		Odonus niger
		Oxymonocanthus Iongiristris
		Pseudobalistes fuscus
		Pseudobalistes flavimarginatus
		Rhinecanthus assasi
		Rhinecanthus acu/eatus
		Rhinecanthus rectangulus
		Rhinecanthus verrucosus
		Sufflamen bursa
		Sufflamen chrysopterus
		Balistes rectangulus
Needle fishes (1 spp.)	Belonidae (1 spp.)	*Balistes aculiatus*
Blennies (10+spp.)	Blennidae (10+spp.)	*Blennies*
		Strongylura ancisa
		Ecsenius pulcher
		Escenius bicolor
		Escenius lineatus
		Escenius midas
		Escenius naucrates
		Escenius frontalis
		Escenius species
		Me/acanthus smithii
		Malacanthus brevirostris

Contd

		Plagiotremus sp.
		Scorpion blenny
Flounders (5 spp.)	Bothidae (5 spp.)	*Bothus mancus??*
		Bothus ocellatus
		Pseudorhombus jenvnsii
		Pseudorhombus sp.
		Scopthalmus aquosus
Dragonets (1+ sp.)	Callionymidae (1+ sp.)	*Synchiropus marmotatus*
		Synchiropus sp.
		Xceinus sp.
Trevallies (2 spp.)	Carangidae (2 spp.)	*Caranx sem*
		Gnathanodon speciosus
Sharks (1+ sp.)	Carcharhinidae (1+ sp)	*Carcharhinus melanopterus*
Bamboo sharks (1 sp.)		*Cheiloscyllium taeniourus*
Butterfly fishes (34+ spp.)	Chaetodontidae (34+spp.)	*Chaetodon auriga*
		Chaetodon chrysurus/xanthurus
		Chaetodon citrinellus
		Chaetodon co//are
		Chaetodon decussatus Ipictus
		Chaetodon falcula
		Chaetodon guttatissimus
		Chaetodon klenii
		Chaetodon larvatus
		Chaetodon lineolatus
		Chaetodon lunula
		Chaetodon madagascariensis
		Chaetodon megaprorodon
		Chaetodon melannotus
		Chaetodon meyeri
		Chaetodon mesoleucos
		Chaetodon mitratus
		Chaetodon oxyfasciatus
		Chaetodon plebeius
		Chaetodon rafflesi

Contd...

<<

		Chuetodon semilarvatus
		Chaetodon tennetti
		Chaetodon trafacialis
		Chaetodon train gulum
		Chaetodon trifaciatus
		Chaetodon unimaculatus
		Chaetodon vagabundus
		Chaetodon xanthocephalus
		Forcipiger longirostris
		Hemitaurichthys zoster
		Heniochus permutatus
		Heniochus sp.
		Heniochus pleurotaenia
		Heniochus acuminatus
		Heniochus singnlarias
Hawkfishes (5 spp.)	Cirrhitidae (5 spp.)	*Cirrhithichthys oxycephelus*
		Cirrhithichthys aureus
		Cirrhithichthys griseum
		Oxycirrhites zypus
		Paracirrhites forsteri
(1 sp.)	Clinidae	*Cristiceps aurantiacus*
(1 sp.)	Dactyloptidae	*Dactyloptera orientalis*
Rays (1 sp.)	Dasyatidae	*Taeniura lymma*
Porcupine fishes (3 spp.)	Diodontidae	*Diodon sp.*
		Diodon histrix
		Diodon liturosus
Bat / Spade fishes (2 spp.)	Ephippidae/Platicidae	*Platax orbicuraris*
		Platax teira
Cornet fishes (1 sp.)	Fistularidae	*Fistularia commersonii*
Mojarras (1 sp.)	Gerridae	*Gerres argyreus*
Gobies (28 +spp.)	Gobidae	*Amblvgobius albimacula*
		Amblyeleotris guttata
		Amblyeliotris steinitzi
		Amblyeleotris callopareia

Contd

		Amblyeleotris sp.
		Cryptocentrus cinctus
		Fusigobius sp.
		Gobiodon citrinus
		Gobiodon sp.
		Istigobius sp.
		Istigobius rigillius
		Priolepis cincta
		Priolepis cinctus
		Ptereleotris evides
		Prereleotris zebra
		Valencianea puellaris
		Anthlygobius species
		Gobionellus stigmaticus
		Amblyliotris diagonalis
		Amblyliotris maculata
		valenciennea helsdingenii
		Valencinnea sexguttata
		Valencianna strigata
		Valenciennea Iongipinnis
		Valenciennea wardi
		Vajenciennea sp.
		Ptereleotris heteropterus
		Ptereleotris microlepis
		Nemateleotris decora
		Nemateleotris magnifica
		Gobius viamosa
		Amblygobious niger
		Gobious niger
		Goby species
Soap Fish (1 sp.)	Grammistidae	*Grammistes sexlineatus*
Sweetlips (8 spp.)	Haemulidae	*Gaterin diagrammus*
		Gaterin lineatus
		Gaterin orientalis

Contd...

		Gaterin pictus
		Gaterin sp.
		Plectorhinchus albovitatus
		Plectorhinchus diagrammus
		Plectorhinchus lineatus
		Plectorhynchus orientalis
(1 sp.)	Haloclavidae	*Haloc/avidae sp.*
Halfbeaks (1 sp.)	Hemiramphidae	*Hemiramphus sp.*
Sea Horses (2 spp.)	Hippocampidae	*Hippocampus kuda*
		Hippocampus hippocampus
Squirrel/soldier fishes (9 spp.)	Holocentridae	*Myripristis berndti*
		Myripristis murdjan
		Neoniphon sammara
		Sargocentron caudimaculatum
		Sargocentron diadema
		Sargocentron spiniferum
		Holocentrus sp.
		Holocentrus diadema
		Holocentrus rubrum
		Holocentrus sargocentron diadema
Flagtails (1 sp.)	Kuhliidae	*Kuhlia nwrginata*
Wrasses(/Diesel) (42+ spp.)	Labridae	*Anampses lineatus*
		Anampses melanurus
		Bodianus axillaris
		Bodianus diana
		Bodianus bilunulatus
		Bodianus bicolor
		Cheilinus chiorurus
		Consformosa
		Fissilabrus labroides
		Cons sp.
		Gomphosus greeniG. caeruleus
		Ginogisus varius
		Gomphosus varius

Contd

<<

Halichoenes argus

Halichoenes centriquadrus

Halichoeres marginatus

Halichoeres scapularis

Halichoeres trispilus

Halichoenes zeylonicus

Halichoeres nebulosus

Halichoeres sp.

Hemigymnus fasciarus

Hemigymnus melapterus

Labroides bicolor

Labroides dimidiatus

Labnoides phthirophagus

Macropharyngodon bipartitus

Macropharyngodon geoffroyi

Macropharyngodon ornatus

Novaculichthys taeniorus

Pseudocheilinus hexataenia

Red rare wrasse

Thallasoma hardwicki

Thallasoma lunare

Thallasoma quinqaivirrata

Cons gaimard

Cons gaimard africana

Larabicus quadnilineatus

Gomphosus caeruleus

Cinhilahinis sp.

Cirrhylabrus/Cinhilahiris rubriventralis

Halichoeres leucoxanthus

Stethojulis trilineata

Halichoenes hortulanus

Cirrhilabrus sp.

Anampses meleagrides

Paracheilinus filamentosus

Contd...

<<

		Halichoeres flavescens
		Wrasses
		Thalassoma lutescens
Emperor fish (2 spp.)	Lethnnidae	*Lethrinus harak*
		Lerhrinus ornatus
Snappers (4 spp.)	Lutjanidae	*Lutianus sebae*
		Lutjanus decussatus
		Lutjanus fulviflamma
		Lutjanus kasmira
(1 sp.)	Microdesmidae	*Macolar niger*
File fishes (3 spp.)	Monocanthidae	*Alutera scripta*
		Amanses scopas
		Pervagor melanocephalus
Mullets (1 sp.)	Mugilidae	*Mugil sp.*
Goat fishes (5 spp.)	Mullidae	*Parupeneus barberinus*
		Panupeneus bifasciatus
		Parupeneus cyclostomus
		Parupeneus fiavolineatus
		Parupeneus indicus
		Parupeneus sp.
Moray Eels (11+ spp.)	Muraenidae	*Echidna zebra*
		Echidna nebulosa
		Eel nebulosa
		Gymnorhorax javanicus
		Gymnothonax favagieneus
		Gymnothorax pnasinus
		Gymnothorax funebris
		Gymnothorax tessalata
		Gymnothorwc sp.
		Rhinomuraena quaesita
		Siderea grisea
		Gymnomuraena zebra
		Muraehana zebra
		Muraehana brown

Contd...

<<

		Gymnothorax mordax
		Gymnothorax nub i/is
		Muraena tessellata
Sandperches (3 spp.)	Mugiloididae / Pinguipedidae	*Mirolabrichthys dispar*
		Parapercis clathrata
		Parapercis schuinslands
		Parapercis sp.
Snake Eels (2 spp.)	Ophichthidae/Muraenidae	*Myrichthys maculosus*
		Myrichthys colubrinus
Cat sharks (1 sp.)	Orectolobidae	*Chiloscyllium plagiosum*
		Chiloscyllium confusum
Cowfish (1 sp.)		*Lactoria cornuta*
Boxfish (3 spp.)		*Ostracion cubicus*
		Ostracion melegris
		Tetrasomus gibbosus
Cat fish (3 spp.)	Plotosidae	*Thysanophrys sp.*
		Plotosus angularis
		Angels
		Plotosus lineatus
Angel fish (20+ spp.)	Pomacanthidae	*Apolemichthys trimaculatus*
		Apolemichthys xanthurus
		Apolemichthys armira gei
		Centropyge argi
		Centropyge argus
		Centropyge eibli
		Centropyge multispinis
		Centropyge bluefin
		Centropyge sp.
		Neopomacanthus nemurus
		Pornacanthus annularis
		Pomacanthus asfur
		Pomacanthus imperator
		Pomacanthus semicirculatus
		Pomacanthus sp.

Contd

	Pygoplites diacanthus
	Centropyge flavopectoralis
	Centropyge acanthops
	Pomacanthus maculosus
	Holocanthus xanthurus
	Holocanthus sp.
	Abudefduf saxatilis
Damsels, anemone fish (37 spp.) Pomacentridae	*Damsels*
	Abudefduf septemfasciatus
	Abudefduf sordidus
	Abudefduf vaigiensis
	Amphiprion sp.
	Amphiprion sebae
	Amphiprion nigripes
	Ampriprion melanopus
	Ampriprion xanthurus
	Amphiprion callopareta
	Blue damsel
	Chromis dimidiata
	Chromis ternatensis
	Chromis viridis
	Chrysiptera biocellata
	Chrysiptera glauca
	Chrysiptera leucopoma
	Chrysiptera unimaculata
	Chrysurus chrysurus
	Dascyllus aruanus
	Dascyllus trimaculatus
	Green damsel
	Neopomacentrus azysron
	Neopomacentrus bonang
	Neopomacentrus filamentosus
	Neopomacentrus nemurus
	Plectroglyphidodon dickii

Contd

<<

		Plectroglyphidodon lacrymatus
		Plectroglyphidodon leucozona
		Pomacentrus amboinensis
		Pomacentrus caeruleus
		Pomacentrus chrysurus
		Pomacentrus species
		Pomacentrus filamentosus
		Pomacentrus melanochir
		Stegastes sp.
		Multispined Damsel
		Paraglyphidodon polycanthus
		Pomacentrus philippinus
		Amblyglyphidodon flavilatus
		Stegaastes nigricans
		Stegastes lividus
		Chromis multilineata
		Chromis sp.
		Dascyllus carneus
		Pomocentrus leucostictus
Dottyback fishes (4 spp.)	Pseudochromidae	*Pseudochromis wilsoni*
		Pseudochromis cupanus
		Pseudochromis flavivertex
		Pseudochromis fridmani
Sting Rays (1 sp.)	Rajidae	*Urolophus lobatus*
Parrot fishes (6 spp.)	Scaridae	*Cetoscarus bicolor*
		Scarus dimidiatus
		Scarus fraenatus
		Scarus gibbus
		Scarus rubroviolaceus
		Scarus sordidus
Scats (5 spp.)	Scatophagidae	*Scatophagus argus*
		Scatophagus bifrons
		Scatophagus rubrifrons
		Scatophagus tetracan thus

Contd

		Scatophagus greeni
Scorpion/lion fish (8 spp.)	Scorpaenidae	*Dendrochirus zebra*
		Dendrochirus biocellatus
		Dendrochirus brachypterus
		Inimicus filamentosus
		Pterois antennata
		Pterois miles / melas
		Pterois radiata
		Groupers
		Pterois volitans
Groupers,Basslets (22+ spp.)	Serranidae	*Cephalopholis argus*
		Cephalopholis boenack
		Cephalopholis leopardus / leoardus
		Epinephelus flavocoeruleus
		Epinephelus hexagonatus
		Epinsphelus lanciolatus
		Epinephelus merra
		Mirolabrichthys evansi
		Nemanthias carberryi
		Variola louti
		Cephalopholis miniata
		Pogonoperca punctata
		Cephalopholis polleri
		Anthias squamipinis
		Anthias kashiva
		Anthias evansi
		Anthias fuicherumus
		Anthias binwculatus
		Anthias despar
		Anthias parverastria
		Anthias squamipinnis
		Anthias species
		Anthias luzonensis
Sharks (1 sp.)	Sharks	*Carcharinus melanopterus*

Contd

<<

Rabbit fishes (3 spp.)	Siganidae	*Siganus canaliculatus*
		Siganus javus
		Siganus lineatus
Barracudas (2 spp.)	Sphyraenidae	*Sphynaena jello*
		Corythoichthys paxtoni
Pipe fish (3 spp.)	Syngnathidae/Solenostomidae	*Solenostomus sp.*
		Stenopodidae sp.
		Syngnathus sp./corea
Grunters (1 sp.)	Teraponidae	*Terapon jabua*
Puffers (8+ spp.)	Puffers	*Arothnon hispidus*
		Arothron melagris
		Arothnon nigropunctatus
		Arothnon sp.
		Canthigasten reticularis
		Canthigaster margaritara
		Canthigaster jactator
		Canthigaster solandri
		Canthigaster valentini
Electric Rays (1 sp.)	Tropedinidae	*Narcine brunneus*
Moorish Idol/Tobies (2 spp.)	Zanclidae	*Zanclus canescens*
		Zanclus cornutus

<<

Annex 3, Fish species that have been afforded legal protection by the Fauna and Flora Protection (Amendment) Act, No 49 of 1993

Marine Fish (seven species)

Centnopyge bispinosus	Two spined angelfish
Pygoplires diacanthus	Regal angelfish
Cons aygula	Clown coris
Labroides bicolour	Bicolor wrasse
Pierois radiata	Lionfish
Platax pinnarus	Batfish
Chaetodon semeion	Golden buttedlytish

Freshwater **Fish** (12 species)

Labeo fisheri	Green labeo
Labeo porcellus	Orange-fin labeo
Puntius asoka	Asoka barb
Puntius martenstyni	Martenstyn's barb
Puntjus srilankensis	Blotched filamented barb
Puntius bandula	Bandula barb
Rasbora wilpira	Wilpita Rasbora
Schismatogobius deraniyagalai	Red-neck Goby
Sicyopterus halei	Red-tailed Goby
Sicvopus jonklaasi	Lipstick goby
Channa onientalis	Smooth-breasted snakehead
Lepidocephalichthys jonklaasi	Jonklaa's Loach

Annex 4. Marine fish species that have been afforded legal protection by the Fisheries and Aquatic Resources Act, No 2 of 1996

(published on 16.7.1998)

Species **prohibited from** export in live **form** (as the first schedule)

(12 species)

Chaetodon semeion	Golden / Dotted butterflyfish (Chaetodontidae)
Centropyge bispinosus	Two-spined angelfish (Pomacanthidae)
Pygoplites diacanthus	Regal angelfish (Pomacanthidae)
Coris aygula	Clown coris (Labridae)
Labroides bicolor	Bicolor wrasse(Labridae)
Pterois radiata	Lionflsh (Scorpaenidae)
Platax pinnarus	Batfish (Ephippidae)
Epinephalus lanceolatus	Giant grouper (Serranidae)
Epinephalus flavocaeruleus	Blue and yellow grouper (Serranidae)
Plectorhynchus obscurum	(Haemulidae)
Plectoryhynchus albovittatus	Giant sweetlips (Haemulidae)
Chrysiptera kuiteri	Pomacentridae

Species restricted from export - exportable under a permit (as the second schedule)

(17 species)

Chaetodon octofasciarus	butterflyfish (Chaetodontidae)
Chaetodon ornatissimus	Ornate butterIlyfish (Chaetodontidae)
Chaetodon falcula	Saddleback butterflyfish (Chaetodontidae)
Chaetodon xanthocephalus	Yellowhead butterflyfish (Chaetodontidae)
Chaetodon ephippium	Saddled butterflyfish (Chaetodontidae)
Chaetodon unimaculatus	Teardrop butterflyfish (Chaetodontidae)
Chaetodon madagascariensis	butterflyfish (Chaetodontidae)
Chaetodon bennetti 's	butterflyfish (Chaetodontidae)
Chaetodon meyeri	Meyers butterflyfish (Chaetodontidae)

<<

Chaetodon trianguluin	Triangular butterflyfish (Chaetodontidae)
Henjochus monoceros	Masked bannerfish (Chaetodontidae)
Heniochus pleuroraenia	Phantom bannerfish (Chaetodontidae)
Centropyge flavipectoralis	Yellowfin anglefish (Pomacanthidae)
Balistoides conspicillum	Clown triggerfish (Balistidae)
Pseudoba/istes fuscus	Blue/rippled triggerfish (Balistidae)
Variola louti	Lyretail grouper (Serranidae)
Variola aihimarginata	Whitemargin Lyretail grouper (Serranidae)

Annex 5. Freshwater fish species that have been afforded legal protection by the Fisheries and Aquatic Resources Act, No.2 of 1996

(Published on 16.7.1998)

Species **prohibited from export in live** form (as the first schedule)

(12 species)

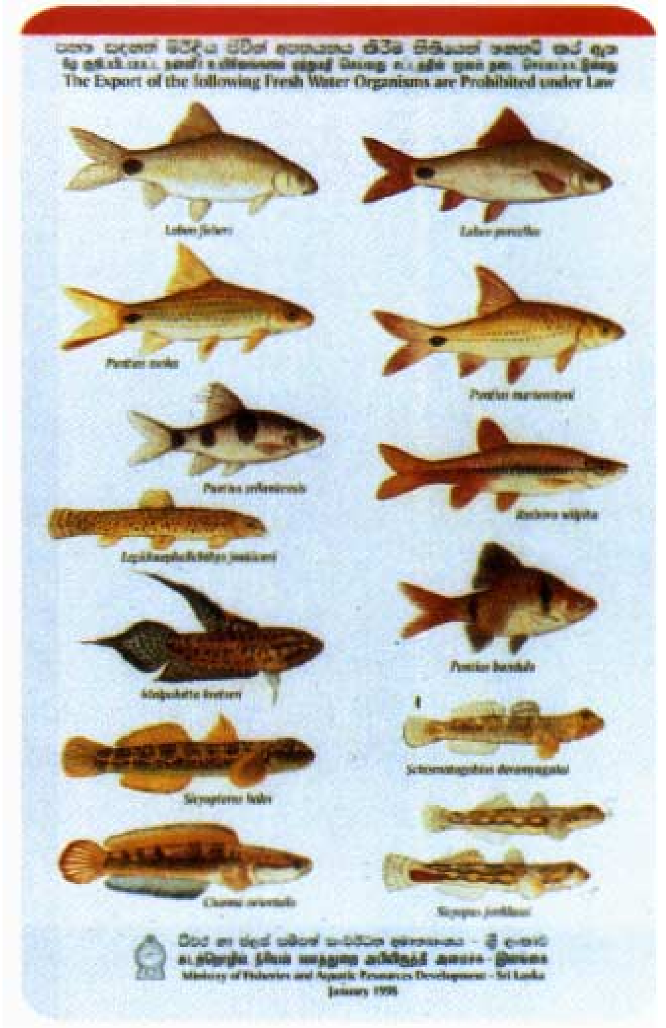
Labeofisheri	Green labeo (Cyprinidae)
Labeo porcellus	Orange-fin labeo (Cyprinidae)
Puntius asoka	Asoka barb (Cyprinidae)
Puntius martenstni	Martenstyn's barb (Cyprinidae)
Puntius srilankensis	Blotched filamented barb (Cyprinidae)
Rasbora wilpita	Wilpita Rasbora (Cyprinidae)
Malpulutta knetseri	Ornate Paradisefish (Belontidae)
Schismatogobius deraniyaga/i	Red-neck Goby (Gobidae)
Sicyopterus halei	Red-tailed Goby (Gobidae)
Sicvopus jonklaasi	Lipstick goby (Gobidae)
Channa onientalis	Smooth-breasted snakehead (Channidae)
Lepidocephalicthys jonklaasi	Jonklaas's Loach (Cobitidae)

Species restricted **from export - exportable under a permit** (as the second schedule)

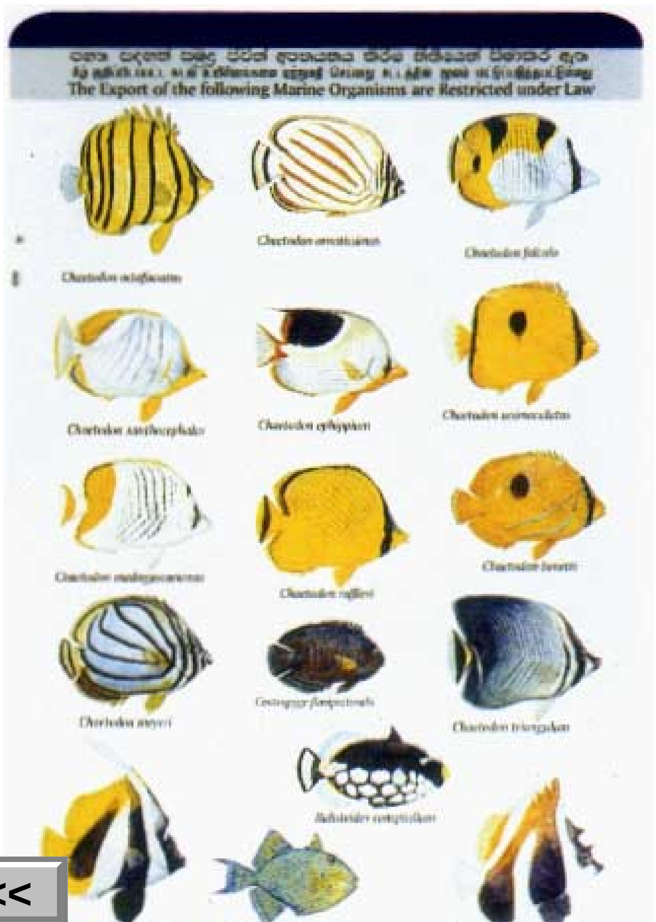
(8 species)

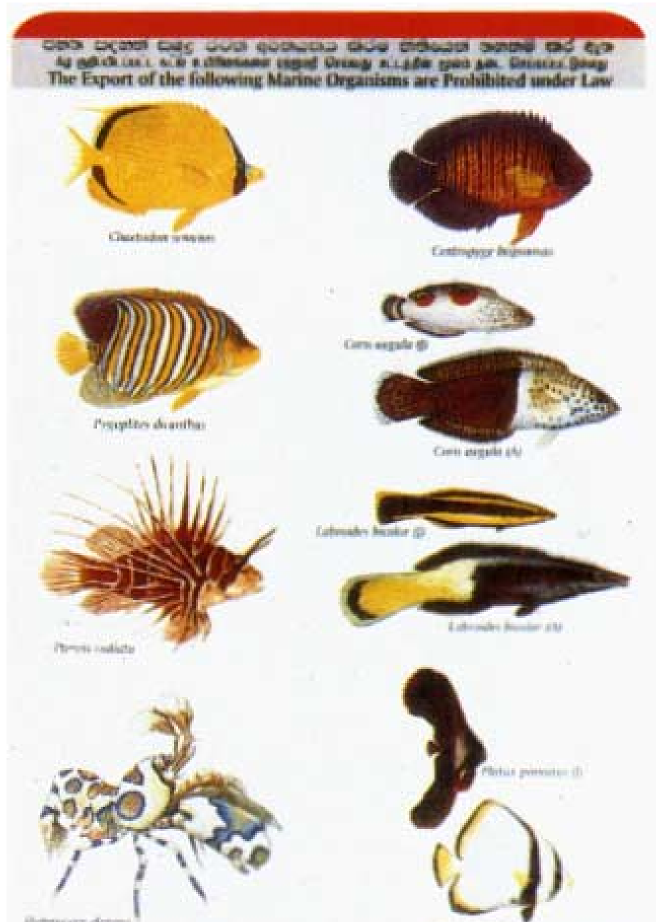
Danio pathirana	Barred danio (Cyprinidae)
Puntius cumingii	Cuming's barb (Cyprinidae)
Puntius nignofasciatus	Black ruby barb ((Cyprinidae)
Puntius titteya	Cherry barb (Cyprinidae)
Rasbora vaterifloris	Golden rasbora (Cyprinidae)
Claritas brachysorna	Walking cafish (Claridae)
Belonia signata	Combtail (Belontidae)
Macrognathus aral	Lesser spiny eel (Mastacembelidae)

<<



Identification** cards **for** ornamental fish **in** Sri **Lanka printed by BOBP





<<