Pacific Island countries and the aquarium fish market

by Vincent Dufour [1]

Introduction

The marine aquarium-fish market is supplied through international trade in fish captured live in their natural environment, as very few ornamental sea fish breed in captivity. This difficulty is linked to their early life history when the fish are larvae a few millimetres in length, living in the open ocean. Larvae develop in this environment for two weeks to three months. The life cycle of coral reef fish therefore consists of two stages, i.e. a planktonic larval stage in the ocean, followed by juvenile and adult stages on the reef. As marine fish harvesting (100 t annually worldwide) is still based on collection in the natural environment, the impact of gathering ornamental fish appears low in comparison to fishing, although it does account for millions of specimens.

The marine aquarium fish market

Marine fish represent approximately 20 per cent of a total world ornamental fish market worth three billion dollars annually (Andrews, 1990). The unregulated economies of the exporting countries, which are often also developing countries, make it difficult to obtain quantitative data about the species exploited for the aquarium-fish trade. In addition, control in importing countries is often limited to packaging, which prevents monitoring of the exact number of fish. Estimates are made from the total weight, including water, of imported packages (Sieswerda & Marquardt, 1995).

The aquarium fish trade has probably doubled since the early 1980s and salt-water fish account for a growing proportion of this activity. There are three main reasons why the market has developed: 1) improvement in farming techniques and in aquarium equipment, 2) within the flourishing pet business, aquariums represent decorative and exotic ecosystems attractive to residents of temperate countries who spend long periods indoors, and 3) increase in air traffic (a major factor). Since 1980, increased tourism to tropical countries has led to more flights to and from exporting countries, making the supply of ornamental marine fish more diversified and less costly.

Importing countries

The largest importers of ornamental fish are the United States, the United Kingdom, Germany, France and Italy. In Asia, Japan is a major importer and China also has a tradition of keeping ornamental fish. The retail turnover of ornamental marine fish in the United Kingdom was worth £ 4.10 million in 1987, with an import value (CIF) of £ 1.10 million (Andrews 1990; Wood, 1992).

Exporting countries

We identified the destinations of three different exporting countries (Table 1). The USA was followed by some European countries: the United Kingdom, Germany, France, Italy. There was little variation in percentages between these destinations. The strong ties which exist between the United Kingdom and the three countries studied explains the high proportion of exports it accounted for.

International regulations

The international trade in wild animals, which is governed by the Washington Convention (CITES) has not yet endangered ornamental marine fish. However, some endemic ornamental fish species could be wiped out if large-scale harvesting were carried out in their restricted habitats. Sea-horses, whose large-scale harvesting was recently revealed, are probably responsible for a growing awareness of the risk of extinction facing some reef fish species (Vincent, 1996).

Marine aquarium fisheries in Island countries

The impact of aquarium fisheries on natural populations has been studied in detail only in the Maldive Islands, by Edwards and Shepherd (1992). Fish were harvested from an area of reef in a radius of 15 km from the capital, Malé. Almost 100,000 fish were being gathered annually in this zone (1 specimen/year/100 m^2), but this figure was very low for the Maldives as a whole. According to the abundances observed at fishing grounds and the number of specimens exported annually per species, 27 species seem to be threatened with overfishing and 12 of these species are being exploited at a rate equal to or higher than estimated yields, even if some are only collected in small quantities (Table 2). From the economic point of view, the study revealed both a turnover of 600,000 French francs (FOB value) and 25 full-time jobs. The price of fish varied by a factor of 100 depending on the species (average: US$ 2.43).

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Table 1: Destinations and trade percentages for marine fish exported from Sri Lanka (Wood, 1985), the Maldives (Edwards & Shepherd, 1992) and Singapore (Wood, 1992). The reference year is given in parentheses.

SRI LANKA (84)	800*	MALDIVES (86)	233**	SINGAPORE (89)	4 ,190**
United Kingdom	22%	Sri Lanka	69%	USA	31%
USA	20%	United Kingdom	14%	United Kingdom	18%
RFA	15%	RFA	6%	Germany	8%
Italy	9%	France	5%	Italy	8%
France	7%	Singapore	3%	France	7%
Belgium	7%	USA	1%	Switzerland	5%
Singapore	5%	Japan	1%	Japan	4%
Others	15%	Others	1%	Others	19%

* Value (£'000,000)
** Quantity (thousands of fish exported).

Table 2: List of fish species exported from the Maldives in quantities (specimens per year) greater than the theoretical yields in the fishing areas

Species	Quantities exported
Chaetodon auriga	1,840
Chaetodon lunula	230
Chaetodon unimaculatus	60
Chaetodon xanthocephalus	1,320
Apolemichthys trimaculatus	330
Pterois antennata	230
Pterois radiata	1,910
Balistoides conspicillum	80
Rhinecanthus aculeatus	1,570
Coris formosa	100
Macropharyngodon bipartitus	49,110
Novaculichthys taeniourus	1,860

Table 3: Number of specimens caught and value of the four main species of marine organisms concerned by the aquarium fish trade in the State of Hawaii in 1994

Species	Quantities caught	Value (US$)
Zebrazoma flavescens	199,359	318,262
Ctenochaetus strigosus	22,512	32,092
Acanthurus achilles	17,824	71,000
Zanclus cornutus	11,617	34,145
Total	**251,312** *	**455,499** **

* 59 % of total quantities exported
** 54% of total value of exports

The study pointed out that the average price of fish increased by a factor of seven between 1980 and 1989.

Hawaii

In 1994, 430,000 ornamental fish were collected in Hawaii. Of the 210 species captured, four accounted for 71 per cent of the total number of specimens (Table 3). Two-thirds of the fish were sold locally to exporters or retailers (Miyasaka, 1991; 1994). The fish caught were valued at US$ 850,000 (US$ 1.97 per fish). In 1994, 220 commercial licences were issued, but fishing and trading represented less than 100 full-time jobs.

Sri Lanka

A study carried out in 1984 (Wood, 1985) gave a list of the fish exported from Sri Lanka which included 29 species of Chaetodontidae, 13 of Labridae, 11 of Balistidae, 10 of Pomacentridae and 9 of Acanthuridae. The estimate given was 200,000 fish exported annually, equivalent to a turnover of US$ 600,000 to US$ 1,200,000 (FOB). The number of jobs was estimated at less than 500, many of which were probably only occasional.

Puerto Rico

Sadovy (1992) reports that 160,000 to 200,000 ornamental fish are harvested annually around the island and exported. Five fish species account for two thirds of the exports: *Gramma loreto*, *Opistognathus aurifrons*, *Holocanthus tricolor*, *Pomacanthus paru* and *Balistes vetula* . The author estimates that some species are already being over-fished. This activity has created about 70 jobs, including 40 full-time ones.

The Philippines and Indonesia

Few data are available on these two countries, although they are the two largest exporters of ornamental marine fish in the world. In the Philippines, this trade increased by a factor of 20 between 1970 and 1979 and continued to expand until 1990, with more than a million fish exported. It seems to have stagnated in the meantime due to the negative effects of cyanide fishing (Hingco & Rivera, 1991). More than 2,500 people were thought to participate in this activity. Indonesia exports ever-increasing numbers of ornamental marine fish. Damage to fishing grounds, by either increased cyanide fishing or overexploitation, is now posing severe problems in that country (Dayton, 1995).

Techniques used to harvest ornamental fish

Destructive fishing methods are currently the most serious problem for this sector. In the Philippines, fishing with sodium cyanide is prohibited, but is still used in 80 per cent of cases (Hingco & Rivera, 1991). This poison kills many fish during fishing or in the weeks that follow and is also dangerous for the fishermen themselves. Courses to train fishermen in other techniques are being tried. Amongst the other toxic substances used to harvest ornamental marine fish are organophosphorous insecticides, quinaldine, chlorine, diesel fuel and dynamite (Randall, 1987, Sadovy, 1992).

Quinaldine is thought to carry a risk for the divers' thyroid glands. Although some people do not see any disadvantage in using quinaldine, Australian scientists, for example, now use other alternative substances. But all the various chemical substances put in the water to harvest ornamental fish have been shown to be harmful, either to the environment or to the fish or the fishermen. We strongly urge that any use of synthetic chemical products or natural substances to collect ornamental fish be banned.

Of the other fishing techniques used, the barrier net is best. This is a 2 m high net, 10 to 15 m long, with a mesh size under 2.5 cm (Randall, 1987). Hand nets or dip nets are used for fishing with diving equipment, as they are selective. There is also a large variety of traps and scoop nets which can be used to catch ornamental marine fish. Care should be taken to ensure that live coral is not knocked over or broken by fishermen who want to capture the ornamental fish which hide there. Only nets with a mesh size under 2.5 cm should be used, as many small species are likely to be injured by bigger mesh. Stationary nets, dip nets, scoop nets and breathing apparatus may all be permitted.

Choice of species and quantities harvested

If harvests remain localised they do not endanger the natural stock, because it can be replenished through the movement of fish from adjacent areas or through colonisation by fish larvae from the ocean (Couchman & Beumer, 1992; Edwards & Shepherd, 1992; Randall, 1987; Wood, 1992). For that reason, it is preferable to have an 'after-the-fact' inspection of fish which have already been captured, to record the species, fishing ground location and harvesting conditions (dates, methods, etc).

Study of natural stocks of ornamental fish should only be considered if fishing activity increases significantly. However, in order to avoid any possible risk of overfishing, the *precautionary approach* (Garcia, 1994) should be taken, so as to define temporary fishing quotas for ornamental fish with high commercial value and low abundance on the reef.

These quotas should be applied on a species-by-species basis (e.g., annual harvest of 100, 1000 or 10,000). The quotas could be increased after verification that the natural stocks of the various species are not threatened if they are exceeded. In a similar manner, a quota could be set for endemic species, when they are sufficiently abundant.

Limits to the management of fish stocks

A pre-requisite of stock management is an estimate of the population from which harvesting will occur, followed by a count of the number of fish harvested. However, fish abundances sometimes contradict harvest forecasts based on estimated stocks, even with commercial fishing. One of the principal factors in the natural fluctuation of ornamental marine fish stocks is the number of larvae colonising the reef, which represent true natural fish production. As fishing for the aquarium trade is based on the number of specimens and not on biomass, the colonisation rate could yield a theoretical maximum harvest.

However, for many species, the number of larvae colonising any given island in any one year depends on how well the larvae survive in the ocean and cannot be used to predict figures on another island or even for the following year. On a smaller scale of time and space, the colonisation rate is more easily predictable by species (Dufour & Galzin, 1993).

Also, the mortality rate for young reef fish, which is very high on the reef during this period, decreases rapidly. The number of very young fish colonising the reef is therefore much higher than the number of adults already settled in the reef (Dufour et al., 1996).

In contrast to the normal fishery management methods, which optimise biomass and not the number of specimens harvested, it would be preferable in this case to collect the fish as young as possible, since about 90 per cent of them will disappear before adulthood. This practice would conserve the stock of adult fish, which are the natural producers of these larvae. But little is yet known about very young fish, which are difficult to catch alive.

Table of regulatory methods used in the main ornamental fish exporting countries

Country	Regulatory body	Number of fisherfolk	Authorisation	Fishing method	Restrictions	Follow-up / comments
USA (Florida)	Marine Fisheries Commission	100–125 full-time	Fishing licences and state legislation	Drop net, seine, dip net, quinaldine	Size limits and daily quotas for certain species; limited net-mesh size	No initial assessment of populations
USA (Hawaii)	Marine Fisheries Services	220 fishing licences, 60 full-time jobs	Fishing licence (commercial or non-commercial), project operator's licence	Net, scoop net	Special permit to collect live rocks (restrictions on madrepores)	Monthly monitoring of fish by species and island; monitoring of exports (quantity and value)
Sri Lanka	None	500 or less	No permit	Dip net	No	No
Philippines	Department of Agriculture	1500 to 3000	Licensed operators and divers, licensed and inspected breeding sites	All types of nets, scoop net, spear guns (cyanide)	Cyanide is illegal; restrictions on fishing in certain areas	No previous studies, collection monitored in certain areas.
Maldives	Marine Research Section, Ministry of Fisheries and Agriculture	About 25 full-time jobs	No permits	Dip net, net	Uncontrolled collection on about 10% of the reef. Overall quotas of 100,000 fish; more detailed quotas for 22 species	Quotas based on estimates of the yields in the authorised zone (studied by Edwards & Shepherd, 1992).
Kenya	Department of Fisheries	8 part-time	Annual fishing licences (but very lax legislation)	Dip net	Chemicals prohibited; fishing prohibited in reserves; export approval for adult fish	No monitoring
Fiji	Fisheries Division	10 full-time, 20 part-time	Licensed fishermen	Dip net	Poison and destruction of coral prohibited; fishing zones; export quotas by company: 50 to 100,000 fish annually	List of species required with each shipment exported
Australia (Great Barrier Reef)	Department of Primary Industry	20 full-time; 80 part-time	Licensed fishermen	Net, dip net	Fishing allowed outside protected areas; chemicals prohibited; destruction of habitat prohibited	No monitoring before collection, quantities taken quarterly requested
Palau *	Ministry of Resources and Development	?	Fishing licence and inspection of operators	Authorised nets, poison prohibited	Hard corals prohibited; limit of 20 fishing permits per year	No follow-up or quotas
Puerto Rico	None	40 full-time; 30 part-time	No permits	All types of nets, quinaldine	Export of hard corals prohibited	Proposed Regulations (Sadovy, 1992)

* From: Graham, T. (1996). Managing Palau's aquarium fishery. SPC Live Reef Fish Information Bulletin #1: 13–18

Small Island countries' participation in this trade

Collection of ornamental fish and lagoon fisheries

Aquarium-trade fish species are not those normally harvested for food, which enables diversification of the species targeted (Couchman & Beumer, 1991; Edwards & Shepherd, 1992). Collection of ornamental fish can also help diversify fisheries, without any particular effect on the resources which are already being exploited. Conflicts of interest are, however, possible with some users of the reef, particularly tourists, who visit the lagoon.

Assessment of economic impact

Although ecological considerations must be applied in a way that ensures the natural environment is better protected, economic criteria remain decisive in this type of activity. Regulatory requirements for the collection of fish must not hamper the economic viability of the activity, or fishing will go on either illegally or without providing any economic benefits. For example, it would be pointless to authorise collection of fish only on remote islands, because the cost of local transport would then make these fish more expensive than those produced in other exporting countries. For these reasons, absolute ecological requirements must take the form of regulatory constraints which do not threaten the economic viability of this activity. They should allow for sustainable development of the activity while preserving the natural environment.

An assessment of this activity in Island countries

By comparing this market in exporting countries, it can be determined that the export of 100,000 fish represents an annual turnover of approximately US$ 200,000 and 10 to 20 full-time jobs. Except for a few countries which have very limited reefs, it seems reasonable to assume that the ichthyological fauna and the extent of the reef structures in most of the island countries in the Indo-Pacific zone permit a level of production comparable to that of the Maldives or Fiji. It is also important to know whether the cost of harvesting and exporting the fish will be competitive in comparison with competing countries.

Air freight represents 50 per cent of the price and its cost cannot be locally controlled. However, as the FOB value of ornamental fish includes the cost of fishing, storing, packaging and local transport, it must also be very competitive. Fishing costs (boats, fuel, gear etc.) can be quite high, as can labour costs, and this is significant, as the fish are caught by hand. Labour costs will therefore be a determining factor in the economic viability of this fishery, since some exporting countries have very low-priced labour. This type of fishing is also often a secondary professional activity. In order to encourage it, local regulations must lessen the salary-related costs and grant customs-duty reductions on the gear needed for this activity.

Recommendations and conclusions

The harvest of ornamental marine fish is of economic interest for Island countries. If the costs of transport and salaries can be controlled, the development of this activity could quickly yield, for an annual harvest of 100,000 fish, a turnover of US$ 200,000 and 10 to 20 permanent jobs. In order to conserve resources, the first thing to be done is to ensure that are no transgressions of authorised fishing methods. Arrangements must be made to ensure that inspections are carried out during fishing or later if necessary and dissuasive penalties must be applied.

We propose that catches of the most vulnerable species be regulated according to the *precautionary approach*, by setting quotas. Monitoring of the quantities exported, together with visits to the fishing grounds, should make it possible to adjust the quotas. If the activity increases significantly (say more than 250,000 fish annually), monitoring of the densities of exploited populations would be needed at the fishing grounds in order to ensure sustainable development of this activity. Tax incentives should also be devised.

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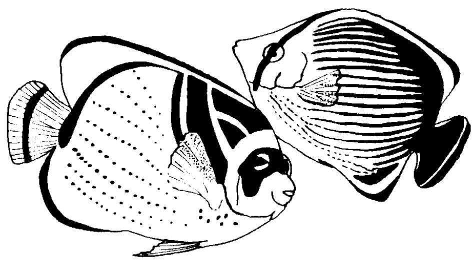

Wild-caught juvenile reef-fish for farm growout: more research needed on biology and fisheries

by R.E. Johannes

The Sabah workshop on reef-fish aquaculture, discussed on page 37 in this issue, has highlighted the need for accelerated research on the biology of the late larval and early post-settlement fish of species important in the live reef-fish trade, and of fisheries for the latter. Published information on how, when, where and what species of wild juveniles can be caught to supply reef-fish farmers in the region is sparse.

A quick and relatively inexpensive way to get vital portions of this information would be to interview fishers who specialise in catching reef-fish juveniles for growout. They possess much valuable knowledge concerning seasonality, habitat preferences, and year-to-year trends in abundance of the targeted fish in their waters—information often largely unknown to researchers.

Some may dismiss such information as 'anecdotal', but the fishers who possess it depend upon it for their livelihoods. Information obtained from small-scale tropical fishers can be highly informative, reliable, and invaluable to researchers and industry (e.g. Johannes, 1981). Often, moreover, such knowledge cannot be obtained by conventional biological research without the expenditure of a great deal of time, money and effort.

For example, large numbers of juvenile specimens of the panther or mouse grouper, *Cromileptis altivelis*, one of the most highly valued species in the live reef-food-fish trade, are captured for growout by fishermen in Indonesia (H. Sanger, pers. comm.). Yet the scientific literature yields no information concerning the kind of habitat preferred by the juveniles of this species.

We should be asking appropriate fishers and middlemen throughout the region what species can be supplied as juveniles in large quantities from the wild, as well as where and when are they most accessible and what local catch trends have been in recent years. A