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LIVE REEF FISH

The live reef fish export and aquarium trade

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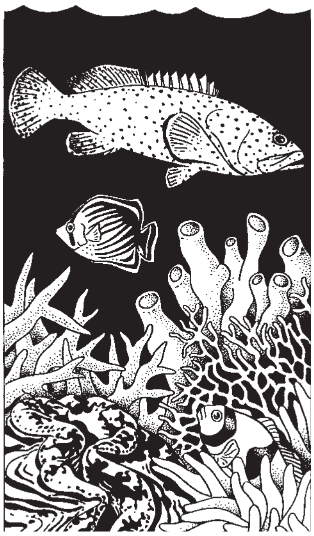

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Editor's mutterings

Baby sharks newest Live Reef Fish Trade target

As this edition went to press I received worrying reports from two regular Indonesia-based contributors to *the SPC Live Reef Fish Information Bulletin*—Mark Erdmann in Sulawesi and Jos Pet in Komodo. Mark says that during a recent trip around Sulawesi, 13 different villages claimed that within the last three months, large live fish transport boats were moored offshore. These vessels were accompanied by around 20 small fiberglass skiffs engaged in catching baby sharks (along with the usual groupers and humphead wrasse, which are growing extremely scarce in shallow water in the area).

Meanwhile, Jos reports that shark pups, especially reef blacktips, are being taken in very large quantities from Komodo and are being shipped by the 'boat loads'. Jos says that for the past year or so, 'baby shark' has been featured on tourist restaurant menus in Labuan Bajo. He surmises that these may be the fish that die during capture or storage. This sounds plausible, considering that many sharks (including reef blacktips) must swim continuously in order to get enough oxygen—and so will probably not tolerate life in small cages as well as groupers and wrasse.

Sharks are slow-growing, late-maturing fish that have only a handful of babies. Reef blacktips, for example, have only 1–3 pups. For these reasons, experts say that that most shark populations cannot withstand a fishing mortality even as low as 5% of the existing population each year. Given the current pressure on shark populations by shark finning operations in the region, this new fishery is clearly a cause for concern. I would be very interested in receiving reports (even if just a paragraph of two) from other areas on the targeting of shark pups for the live reef fish trade.

Inside this issue

Industry perspective

The perspective of the live reef food fish industry has been poorly represented in this publication. The problem has been finding appropriate people willing to write. Fortunately, Mr Patrick Chan, Chairman, Hong Kong Chamber of Seafood Merchants Ltd. has come to the rescue in this issue with two information-filled articles on the Hong Kong industry's perspectives and problems.

Aquaculture cost/benefit

Mike Rimmer makes the point in a recent article on Reef Fish Aquaculture (see *Noteworthy Publications* on page 39 of this issue), that the costs for aquaculture research and development (R&D) are very high, but the financial rewards to a country can be much larger. The cost of establishing the Atlantic salmon industry in Norway, for example, was estimated at about US$ 55 million over eight years, but the industry is now valued at ten times that amount per year. The US catfish industry cost about US$ 42 million for initial R&D, but is now worth more than six times that amount annually.

While selling the virtues of aquaculture to our politicians and others, however, we must discourage them from looking upon it as an alternative to improved fisheries management. By aquaculturing reef fish, we may take some of the pressure off wild stocks of some species, but aquaculture by itself is not enough. The need for improved fisheries management in much of the coastal tropics is urgent, and aquaculture, no matter how successful it might some day become, can never replace improved management of wild stocks (e.g. see Mous *et al.*, this issue, p. 20).

Moreover, if researchers don't come up with suitable, vegetable-based foods for carnivorous fish such as groupers, their expanding culture will ultimately place insupportable pressures on wild stocks of the species used as feed.

Eggs and stress

Various industry reports indicate that gravid female coral trout are subject to considerably higher mortality in holding facilities and in transit than males or non-gravid females. If this is the case, it is one more reason for not targeting spawning aggregations for the live reef food fish trade. Unfortunately there is no published research describing the relationship between female sexual maturity and stress tolerance of groupers or any other fish. Much research has been published on the effects of stress on fish reproduction but very little on the converse—the influence of reproductive status on stress tolerance. Here is a research opportunity begging for the attention of fish endocrinologists and physiologists.

More debate sought

Neither this editor nor the SPC or TNC, who support this publication, always agree with what goes into these pages. I believe that this is the way it should be. Some of the articles in this issue in particular, put forward controversial opinions. They offer good starting points for constructive debate. If you disagree with, or support, any of these opinions, let us know—in the form of letters to the editor, short or long articles, or opinion pieces.

Western tropical Atlantic countries leave us for dead

Once again a western Atlantic country demonstrates why this region is so far ahead of the Indo-Pacific in protecting reef fish spawning aggregations. The Bahamas government has recently approved the establishment of five no-take marine reserves. All of these sites contain known Nassau grouper spawning aggregations. Although stocks of Nassau grouper in the Bahamas appear to be healthy, these closures, coupled with other research activities, are being implemented to ensure that conservative management measures are taken as a precaution against the stock collapses that have occurred in other locations that once held stocks of Nassau grouper.

Cyanide doesn't kill fish???

Among the 328 people that attended the First International Conference on Marine Ornamental Species in Hawaii last November 'the position was taken that fish exposed to cyanide recover', according to Robert R. Stickney (*Marine Ornamentals 99. World Aquaculture* 31(1): p. 4). I suppose I ought to make some comment on this assertion, but it leaves me speechless.

Bob Johannes

The industry perspective: Wholesale and retail marketing aspects of the Hong Kong Live Reef Food Fish Trade[1]

by Patrick Chan[2]

Introduction

Eating live seafood (i.e. seafood kept alive until immediately before cooking) is a strong tradition among the people along the south-east coast of China. In recent years this culture has spread to the people of neighbouring countries with large Chinese populations, including Taiwan, Singapore, Malaysia and Thailand.

The Chinese word for 'fish' has the same pronunciation as the word for 'plentiful' and is an important symbol in traditional Chinese agricultural society. Fish are essential at all dinner receptions. In Hong Kong (HK) 95 per cent of all restaurants are Chinese, and most serve live seafood.

Each year about 30,000 to 35,000 metric tonnes of live reef fish are imported into HK with a total wholesale value of US$ 490 million. This does not include minor amounts of live reef fish caught by local fishermen from the reefs in the South China Sea. Although reef fish dominate the live seafood market, also imported live are lobsters, mantis shrimps, crabs, shrimps, abalone and certain clams. Small quantities of coconut crabs, scallops and giant freshwater eels are imported live as well.

Fifty-five to 60 per cent of the imported live reef fish is re-exported to the People's Republic of China (PRC). It was first exported to the Shenzhen Economic Zone close by HK, and subsequently to Beijing, Shanghai and other large cities in PRC.

Preferable types of live reef fish

Common reef food fish eaten in the region are shown in Table 1. Red coral trout, *Plectropomus areolatus*, is the most common medium-priced fish in both HK and PRC. Traditionally 'red' means 'good fortune' among the Chinese. Chinese hosts like to present a red coral trout at wedding, birthday or other celebration dinners. At present almost all red coral trout are caught wild. The wholesale price of these fish is about US$ 38/kg.

In HK, those who cannot afford coral trout, *Plectropomus* spp., often buy less expensive groupers (see Table 1), especially green groupers, *Epinephelus malabaricus* and *E. coioides*. These sell for about US$ 20/kg. They come mainly from aquaculture and the supply is therefore very steady. In PRC people may substitute certain freshwater fish if they cannot afford the more expensive reef fish.

After the economic crisis in Southeast Asia, high-priced reef fish became less popular. But hump-head wrasse, *Cheilinus undulatus* and high-finned grouper, *Cromileptes altivelis*, remain expensive because the supply is limited. They sell for about US$ 64/kg. In PRC it has become a tradition to serve these fish at business reception dinners in order to demonstrate the ability of the host to afford expensive food. Officials from state-owned organisations also like to order expensive seafood at their social gatherings because the bills go to their organisations, although recent reforms have curbed this practice. In HK the situation is different. As well as consuming live reef fish at social functions, people will order them after making some easy money, like winning at the racetrack or making a big profit on the stock market.

Countries of origin

About 50 per cent of live reef fish are imported from Indonesia, closely followed by the Philippines, Australia, Maldives, Vietnam, Malaysia and Thailand. Imports from Indonesia began in 1988. Most of the suppliers are Indonesian Chinese who normally set up floating cage stations and purchase their fish from fishermen. Fish are held in these cages until there are sufficient to notify HK

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1. Derived from two papers given at the Second International Conference and Exhibition on Marketing and Shipping Live Aquatic Products '99. Seattle.14-17 November 1999

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Table I. **Scientific, English and local names for common Live Reef Food Fish in Hong Kong.**

Scientific name	English name	Local name
High priced species		
Cheilinus undulatus	Humphead, maori or Napoleon wrasse	So Mei
Cromileptes altivelis	High-finned or mouse grouper, barramundi cod	Lo Shu Pan
Medium priced species		
Plectropomus leopardus	Spotted or leopard coral trout	Sai Sing
Plectropomus areolatus	Red or squaretail coral trout	Tung Sing
Lower priced species		
Epinephelus polyphekadion	Flowery grouper	Charm Pan
Epinephelus malabaricus	Green or malabar grouper	Ching Pan
Epinephelus coioides	Brown-spotted grouper	Ching Pan
Epinephelus bleekeri	Orange-spotted or green grouper	Chi Ma Pan
Epinephelus fuscoguttatus	Tiger or flowery grouper	Lo Fu Pan

buyers to send a live fish carrier to collect them. This is the way the operation will continue in most of Indonesia because there is no other practical means of transport. However, in big cites like Jakarta and Denpasar where international airports are available, suppliers operate their own live fish carriers and buy from fishermen from regions up to 4 to 5 days away by boat. These catches are sent to HK by air along with live lobsters.

Today suppliers from Cairns in Australia, Manila in the Philippines, Sabah in Malaysia, Thailand and Vietnam rely heavily on air transportation; now more than 80 per cent of the catches from these countries are sent to HK by air.

Exports from Pacific Islands and other remote areas

As most of the Pacific Islands do not have direct flights to HK and the distance is very far, it is neither economically nor technically feasible to send live reef fish to HK by air. Export by ship is the only possible way. Large live-fish carriers are now able to take fish from some countries such as Fiji Islands, Kiribati and Seychelles in the Indian Ocean. However, the ships require 20 tonnes or more of fish or the transportation cost cannot be justified. Operators from Pacific Islands who wish to export live reef fish to HK are encouraged to establish contact with an importer in HK who will be able to arrange for a live reef fish carrier to take their fish. Normally the importer in HK is happy to provide technical backup and training to native fishermen. Hong Kong Chamber of Seafood Merchants Ltd. is able to assist.

Transportation by sea

Currently, live fish traders in HK are using two types of live fish transport vessels (LTVs). The first is the traditional HK fishing vessel. Its design was introduced from Scotland. It was based on that of metal hull trawlers operating in the North Sea, which were required to operate in rough seas. HK shipbuilders followed the design but built their ships from wood. Almost 99 per cent of HK fishermen use wooden vessels because this exempts them from being required to obtain proper navigation certification. The policy exists because the majority of HK fishermen are poorly educated and it is not possible for them to attend navigation training courses.

Some of these vessels are built with live wells for use in live reef fish transport. Initially such vessels were about 50–60 feet long with engine capacities of less than 300 HP. Now some LTVs are up to 120 feet long with engine capacities of up to 1500 HP. Such vessels can hold up to 20 tonnes of fish.

A few traders use metal-hulled LTVs. Second-hand LTVs were also bought from Japan, while others in the trade converted small cargo ships or tuna vessels. Generally the live-well capacity in metal-hulled vessels is larger than that of similar-sized, timber-hulled vessels, as the latter require more live-well partitions to support the hull.

Both types have water inlets and outlets in the hull, providing good water circulation during sailing. The water flow is up to ten times the holding capacity per hour. But all carriers must have strong pumping systems to maintain water flow when the vessels are stationary, as when loading or unloading.

The officer who supervises loading must be experienced and observant; the success of each shipment depends heavily on him. Special attention must be paid to the following during loading and unloading.

During low-tide periods, inshore waters typically have a lowered oxygen content and the water may be especially warm. It is thus risky to load or unload fish under these conditions.

Low atmospheric pressure causes fish to move to the surface where the temperature is higher and the oxygen concentration lower.

Fish are more active in warmer water; the oxygen consumption of fish may double or triple with a 10°C rise in temperature. This is of special concern when fish are placed under stress, as when being loaded or unloaded. Also, when the fish are disturbed they tend to huddle together, which may cause a drastic localised drop in oxygen level.

Good water circulation helps reduce these problems. Loading fish to different live wells in rotation can also help. When the live wells are loaded to 70 per cent of full capacity it is desirable to inject pure oxygen into the water through diffusers.

The holding capacity of live wells depends on the type of fish involved. Snapper are more active than grouper and thus require more space.

The size of the fish is also important, since small fish consume more oxygen per unit of weight than large fish. Average holding ratios are between 8 and 14 to 1, i.e. 8–14 tonnes of water per 1 tonne of fish.

HK buyers prefer to select and weigh fish immediately before loading. This is an effective way to avoid theft and mortality due to mishandling after weighing. It is not a good arrangement, however, as it is more stressful to fish.

Transportation by air

With more experience and improved skills and equipment, more and more live seafood is being transported by air, especially the higher-priced products. Generally speaking, fish are the most difficult live seafood item to transport by air. But with good practices their survival rate is very good if the total transportation time is within 24 hours.

Decline in water quality is the biggest problem—declining oxygen content, carbon-dioxide build-up, detrimental changes in pH, detrimental changes in temperature, and build-up of fish wastes. The loss of the protective layer of mucus on fish can also be a problem.

Every minute counts when packing live seafood for air transport. An experienced operator knows how much time his packing team needs to pack a box, and plans so that the team will start packing with just enough time for them to finish their task. Ideally the packing centre should be no more than a 30-minute drive from the airport. Running costs can be reduced if seawater can be directly pumped to the packing centre. This also cuts down the cost of water holding facilities, which are essential for any packing centre. An immediate water supply is needed for when the water in the holding tanks suddenly turns bad.

Fish should not be fed for at least 24 hours before they are packed—to avoid vomiting of undigested food which will pollute the water. Live reef fish can be given a freshwater bath for 2–3 minutes when they are first delivered to the centre. The freshwater tends to cause the fish to vomit undigested food and it also kills various external parasites.

The temperature of the holding water should be in the range of 21–23°C. Since reef fish typically live in water ranging in temperature from about 24 to 30°C, gradual reduction in temperature will render the fish less active and less stressed. The water in the holding pools should be well circulated and must go through a bio-filter to neutralise ammonia. Injecting air using an air compressor and diffuser can raise oxygen content.

The water temperature should be lowered another 2–3°C prior to packing. The chilling process should be slow and completed within four hours. Packing water should be the same temperature as that in the holding tank. Anaesthetic is used if the fish are packed in polyethylene bags.

In addition to cooling, it is a double measure to ensure that the fish will not become too active when the water temperature rises during transport. Anaesthetic use is not approved for food fish and other seafood in most markets, but it is commonly used in Southeast Asia. Even if anaesthetic were approved, the purge period would probably be greater than the usual pre-purchase holding time.

Australian live-fish exporters were the first to use plastic bins to transport live fish by air to HK. The bins are insulated and have a one-tonne water capacity. A battery-operated air pump is fitted at the upper compartment of the bin to inject air into the water through a diffuser. A simple skimmer device is also installed on the upper compartment. The capacity of a bin is about 240 kg of live fish. The survival rate is very good if the cargo is delivered to the buyer within 24 hours. As the water temperature can be well maintained in these bins no anaesthetic is used. However returning the bins is costly.

To pack live fish in polyethylene bags and expanded polystyrene boxes requires a skilful working team. The water is cooled as described above. Three to four kg of water are used per one kg of fish, depending on the type of fish and length of flight time. The box is passed on to a second worker who is responsible for the injection of pure oxygen into the bag; the bag is then secured with an elastic band. The box is then passed on to the final worker who checks the packing, adds coolant, and seals the polystyrene box with sealing tape. An experienced working team can process one box per minute.

The market chain

To people from elsewhere, the price of live reef fish in HK seems very high. This has created the impression among foreign suppliers that they have been deceived by HK buyers, and the prices they obtain from the latter are too low. In fact, imported live fish must go through several traders before they reach the restaurants, and each requires a profit. In addition the operations of importers and wholesalers require considerable capital. The annual business turnover of a major wholesaler in HK may reach US$ 25 million. One 15 t shipment of fish may involve US$ 250,000 and is unaffordable to retailers. The retailers buy the fish from wholesalers and in turn control the market distribution. Restaurants are the main end users.

Live reef fish importers operate one or more live-fish carriers. Foreign agents are responsible for the arrangement of adequate quantities of fish and clearance to bring the fish into the country. Larger importers may own floating cage stations in HK and will also act as wholesalers if they have a large holding capacity. Small importers will sell their fish to wholesalers and the latter will sell the fish to retailers after taking 8–14 per cent profit.

Retailers will hold their fish in their shops until they sell them. Marketing officers in these shops telephone the restaurants in their sales network each morning to take orders. The fish will be delivered to the restaurants the same afternoon. As there is risk of mortality during the hold period, retailers will normally take a profit of 24–35% and the restaurant will then mark the fish up by 100–150%.

As shipping skills have improved in recent years, overseas suppliers are increasingly sending live reef fish to HK by air. As the quantity in each air shipment is relatively small, a number of retailers have started importing live fish by air, avoiding the need to go through wholesalers. At the moment the situation is chaotic and the identities of wholesalers and retailers are hard to define, although wholesalers retain the leading role in the trade.

Payment and trading rules

Wholesalers normally settle their account with importers within one week of sale. If the fish cannot be sold immediately the wholesaler is required to buy the fish at a price agreeable to both parties and the risk will then be transferred to the wholesaler. The relationship between importers and wholesalers is close, and it is not uncommon to see wholesalers providing financial aid to importers, especially when the latter's transport vessel needs urgent repair or an additional deposit is needed for a future shipment.

Retailers are supposed to settle their bills within 10 days to 2 weeks. However, as the economy slumped during the past two years, unsettled accounts have sometimes dragged on for 4–6 weeks.

Retailers get higher profits from restaurants. However the normal restaurant payment term is 30–45 days. The payment from restaurants associated with big hotels is even slower. In addition, restaurant operators sometimes pressure retailers into subscribing to dinner coupons during special business promotions, which may cost several tens of thousands of HK dollars per year. Retailers also pay three per cent of the total annual sales as a commission for restaurant staff.

It might appear that the benefits are stacked in favour of the restaurateurs. However HK is one of the most expensive places to live in the world and restaurateurs are required to pay very high rents and salaries. Nevertheless, the restaurant business can be very profitable.

Re-export of Live Reef Fish to PRC

The import tax on seafood imported to PRC is 17 per cent. Other government departments also levy additional charges. The situation is confusing and varies from city to city. Organisations with strong connections may get quotas to import seafood at much lower cost.

For the past seven or eight years, much seafood has been imported through the small port of Yantien, located on the eastern border of the New Territories of HK. A designated fish-culture area is adjacent to Yantien and the fish farmers' cooperative there is able to sell its fish with an import tax of only three per cent. It is an open secret that live fish from elsewhere are often funnelled through this cooperative. Bribes are often given to import officials to facilitate the import clearance of such fish.

Recently the central PRC government has taken drastic action to eliminate smuggling, and this import channel has thus become increasingly difficult. Several shipments of seafood have been held and heavy fines imposed, but the import of live reef fish has not stopped.

In the past, operators in big cities like Beijing and Shanghai relied on retailers to supply them with seafood from Yantien. Problems often occurred because of retailers absconding with cargoes after securing a credit line from traders in Yantien. The chance of catching them was slim because they operated with just a truck and a hand phone. Many HK seafood operators who had set up shops in Yantien a few years ago suffered huge losses from such unreliable clients. Now operators in Yantien, most of them local people, are very cautious concerning who they sell their product to. They are also able to change the RMB (PRC currency) into HK dollars in the black market, which helps them survive financially.

Following the opening of HK's new airport, a new and important live-seafood entry point was established in Shekou, which is an industrial zone adjacent to the western border of HK. A few HK transportation companies are now cooperating with state-owned organisations that have seafood-import quotas. Several fishing vessels now travel between Shekou and Tung Chung, which is a port only five minutes by truck from the HK airport.

This channel can save a lot of time and the service charge is significantly less that the normal import duty. Shekou is also convenient for those wishing to send seafood to other big Chinese cities like Shanghai and Beijing. The Shenzhen airport is just a 25-minute drive from Shekou. Some HK operators have set up holding centres in Shekou and provide holding and re-packing services for the live-seafood traders in PRC.

Import formalities

Hong Kong is a free port and does not levy any customs tariffs or duties on imports. It maintains no anti-dumping laws, countervailing duty laws, import quotas and tariffs. There are no value-added or general service taxes. However, cargo-handling charges are about HK$ 1.4 (US$ 1 = HK$ 8 in February 2000) per kg.

Normally the consignee will appoint a transportation company to take the cargo from the airport. The appointed truck driver can collect the cargo on production of the airway bills and letter of authorisation from the consignee or the company seal.

Truck rental normally costs between HK$ 500–900, depending on its capacity. If fish are shipped in polystyrene boxes, there will be additional labour charges.

The airway bill must be prepared by the shipper's cargo-handling agent. The original copies go with the cargo and a photocopy is faxed to consignees. A certificate of origin is usually not required, although it may be required under certain circumstances.

An import and export declaration must be made by the consignee within 14 days after the import or export of any article other than cargo for transhipment, transit, or for exhibition purposes and with a value of less than HK$ 1,000. The declaration is used mainly by the Census and Statistic Department to enforce the regulations relating to import and export.

Goods at the airport are physically inspected on a selective basis after inspection of the airway bill. The custom hours for general cargo are Monday through Friday, 8 am to 3 pm, but live products can get clearance outside these hours.

Live marine fish do not require a health certificate (although dead fish and all shellfish, crayfish, etc. do).

The HK International Airport is about 50 km from the city and transport vehicles take 35 to 40 minutes to reach urban areas via a good highway network. However, a total of 2–3 hours will be needed for the transportation workers to clear the cargo and deliver to the consignee. The air temperature could reach 35°C between mid-May and late September and sufficient coolant must be used to maintain packing temperature.

Current status of the live reef fish trade based in Hong Kong

Patrick S.W. Chan[1]

At the end of 1999, the live reef food fish trade based in Hong Kong was experiencing several difficulties. They involved two issues:

1. Supply of wild-caught, market-sized fish (mainly groupers but also including some other families of reef fishes such as the wrasses), and
2. Prospects for increased mariculture to supply the industry and meet consumer demand.

Wild-caught fish supply

Following the Asian economic downturn starting in late 1997, both wholesale and retail prices declined by about 50 per cent compared to the peak prices of earlier years. The industry has been experiencing a number of difficulties as a result and is now operating on a much finer profit margin (less than 10% gross) than before.

These problems have been worsened by other factors, both inside and outside Hong Kong. Within Hong Kong, wholesalers have been affected because restaurants, also affected by the economy, increasingly delay their payments. In addition, reduced demand means that when large quantities of fish are brought into Hong Kong by ship, they cannot be sold quickly.

This is particularly difficult during the northern winter, when the sea temperature in Hong Kong is lower than 18°C, as reef fish cannot survive at such low temperatures and therefore cannot easily be stored while awaiting sale. Shipments of smaller quantities of fish, which would be more appropriate for the current market demand, are not viable economically because of high transport costs. The market price in Hong Kong is now so low, that to date, more than 20 per cent of live reef fish operators have ceased to operate.

Prices of fish decreased by a further 15–20 per cent for about three months following several incidences of sea imports of large numbers of ciguatoxic fishes. Both the government and the industry have done their best to prevent toxic fishes from being imported into Hong Kong. The Health and Agriculture, Fisheries and Conservation Departments have carried out regular random checks on imported reef fish. Traders have stopped buying fish from Kiribati, Papua New Guinea, and Sri Lanka, from where the toxic fish were reportedly imported. Traders also agreed to stop selling high-risk fish, such as moray eels and red snapper, *Lutjanus bohar*.

There has also been a marked change in the transport mode of imported fishes; the current ratio of imported fishes by ship and air is 45/55 compared to a ratio of about 65/35 in the past. Sea imports have dropped markedly. Local traders use live-fish carriers to collect the catches from the fishermen. But the fish will then be delivered to packing centres, normally located in cities with an international airport, for export by air. This kind of trading continues to grow because it requires lower running capital and the risk is smaller than if fish are stored until enough have been accumulated for a large export shipment.

Since the transport of large quantities of fish by ship is not economically viable, there has been an increased demand for more small shipments of fish by air. Air cargo space has become more limited, however, as more fish are being sent by air. Moreover, fish sent by air may suffer from lack of sufficient oxygen during transport. There is no way to tell quickly if a fish is sick and likely to die within a short time after arrival.

Other factors, external to Hong Kong, have also affected the supply of fish to Hong Kong businesses. In Maluku and Sumatra in Indonesia, there has been serious social unrest. Given that major fish supplies come from Indonesia, especially Maluku, this has affected the amount of fish being exported by sea.

The situation in most big cities within Maluku is out of control and Chinese have become a target of attacks. As most of the agents and operators are Indonesian Chinese they have been forced to leave Maluku. Most of the fishing has now stopped because there are no longer any buyers and it is too

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dangerous for Hong Kong people to be there. Many people were killed in the confrontations and the situation has been much worse than was apparent from news reports aired in Hong Kong.

Organised cyanide fishing in Indonesia has almost ceased completely because, using this method, divers can only operate in shallow water (no deeper than 30 m) and target fishes are no longer readily found in shallow waters. In 1994, there were more than ten local companies who ran big fishing vessels with teams of divers catching fish using cyanide. In those days, a vessel could catch 800–1000 kg of fish per day; catches in 1998 declined to 50–70 kg / day.

All these companies had powerful connections but they are still required to pay substantial operation fees to the authorities concerned. Hong Kong traders are also required to pay a very heavy export fee to navy, army, police, customs, immigration, judicial staff and even to journalists. These extra costs have become unaffordable because of the poor market in Hong Kong. Many Hong Kong traders therefore gave up trading in live fish in Indonesia. The last company that ran two fishing vessels with divers closed in the first half of 1999.

Before 1995, 75 per cent of the reef fish, mostly humphead wrasse, from east Indonesia was caught by cyanide, but now the situation has greatly improved since divers are no longer able to see the fish in shallow areas and it is very difficult for them to catch fish at depths beyond 30 metres. It has become more appropriate and easier to use hook and line for the remaining fish in deeper waters.

At present, there are local fishermen still catching fish with chemicals (commonly cyanide but also Derris root) but the authorities rarely stop them. These fishermen are too poor to pay the fine and if they are jailed, their family members will go hungry. These fishermen have been using chemicals to catch fish since long before Hong Kong traders came to Indonesia. In the past their catches were salted and dried and sold to local traders once every one or two months.

Fish from mariculture

One alternative and safe (i.e. ciguatera-free) source of fish for the live reef fish trade is mariculture. Hong Kong currently has a small mariculture sector which has regularly been producing about 3,000 metric tonnes (t) of fish annually through the grow-out, in net cages, of wild-caught (imported) juveniles (last year, however, because of red tides, production was just over 1,000 t). Given that the areas suitable for culture in Hong Kong are limited and water quality is deteriorating—severe problems with red tides have recently resulted in high fish mortality—there appears to be little opportunity for cage culture to expand in inshore waters.

In order to increase the supply of high-quality fish, such as groupers, for the live reef fish trade, the mariculture industry, therefore, needs assistance and diversification. Current problems that need to be addressed include:

- High Hong Kong wages for workers and problems in hiring foreign workers;
- Difficulties in obtaining good-quality trash fish at reasonable prices;
- Limited provision of medicines to treat fish because of the tight import controls on medicine;
- Lack of technical expertise or back-up from government;
- Lack of local supply of fish fry / fingerling—all must be imported, and
- Lower production costs in People's Republic of China, Thailand, and elsewhere, making Hong Kong prices for cultured fishes not competitive.

Since last year imported *Epinephelus bleekeri* fry caught in Thailand have been sick, the black grouper fry supply from Sri Lanka has dropped substantially and fry supply from Thailand and Vietnam this season appears to be low. These factors, combined with the 50 per cent drop in the price of fish in Hong Kong in the past three years, provide serious challenges for a viable mariculture industry in Hong Kong.

One possible approach to these problems would be for Hong Kong to develop its own hatchery to produce vaccine-treated fry / fingerlings and to consider moving the grow-out operation to land. Good quality, cheap, pellet fish feed also need to be developed in order to improve growth, reduce the risk of disease and reduce the need to catch wild fish for fish-feed purposes.

With the exception of the humphead wrasse, hatcheries in Taiwan, Japan, Australia and Malaysia are able to hatch fingerlings for most of the reef fishes preferred by the markets in Hong Kong and People's Republic of China. If the mariculture sector in Hong Kong were to be given some help to overcome the problem of high mortality, local products would still be able to compete with the fish from other countries because we could save on freight costs, which are very high. In the long run, mariculture is the solution to the problem of over-fishing but for this idea to be supported a lot remains to be done by the authorities and other relevant units.

The Second International Conference and Exhibition on the Marketing and Shipping of Live Aquatic Products '99

by Yvonne Sadovy[1]

The above conference was held from 14–17 November 1999, in Seattle, Washington and covered the marketing and shipping of finfish, shellfish, 'ornamentals' (aquarium fish) and plants. A wide range of subjects was addressed with an interesting mix of business, science, advocacy, capture and culture, presented by government officers, biologists, businessmen, engineers, conservationists, fishers and mariculturists, to name but a few. Topics ranged from physiology to social, ethical and humanitarian considerations, wildlife and health, regulations and the problem of introducing exotic species, to live-holding-system engineering, live shipment issues, resource management and marketing. This range reflects the many areas involved in the business of maintaining and marketing live aquatic organisms. There was much interest in the high-value Hong Kong / mainland China live seafood market and the possible acceptability of species, including cold-water species, currently not included in the Hong Kong-based trade; New Zealand, Australian, and North American companies were among those exploring trading possibilities in fishes and invertebrates.

A brief summary is given of just a few of the 40 or so interesting talks representing some of the range of subjects presented. The selections inevitably reflect my own interests or addressed areas that were new to me. Moreover, this summary is by no means exhaustive; the Proceedings will be out soon and I did sneak off briefly to take a look at downtown Seattle! Based in Hong Kong, I am aware of the trade in live animals that come from coral reefs. However, there has been a live fish fishery off California for the local Asian market since at least 1988 (see Tegner & Dayton, *SPC Live Reef Fish Information Bulletin* 2: 25–26) which includes various rockfishes (scorpaenids), kelp greenling, ling cod and sheepshead wrasse. Data have been collected since 1993 and there are over 1,000 fishers involved, active from the intertidal zone to a depth of 20 fathoms. There is concern about overfishing. For ornamental (marine aquarium) fisheries, talks covered concerns regarding 'hit-and-run' types of collecting and the advantages and disadvantages of the Florida-based fishery; the marine aquarium fishery is managed but not based on biological information, simply based on some compromise acceptable to both government authorities and fishers. Humanitarian concerns were also expressed in the treatment and sale of live organisms in general; the need for a practical code of ethics was identified. Concerns were also expressed regarding the overfishing of blue crab in some areas.

Interesting presentations were given on physiological differences among species that make them more or less able to withstand the stress involved in capture and shipment. Even closely related species (the example given involved crabs) may differ in this respect; a difference that could make a species more or less suited to live trade. An understanding of the stress response is also clearly important for reducing mortality and maintaining quality (and, dare I say it, for reducing cruel and unusual punishment!). One speaker suggested that data on mortality would be useful in addressing such problems and for working towards practical solutions. It is clear that such issues cannot be ignored; there has been at least one lawsuit filed to ban trade in live marine organisms in the United States. Public interest and concern over the treatment of live organisms, in the West at least, has been growing in the last 30 years.

We learned about the intricacies of the HACCP (Hazard Analysis Critical Control Point) methodology. About 30 per cent of seafood is traded internationally. There are several problems with current international trade that involve food safety concerns, such as paralytic shellfish poisoning and ciguatera fish poisoning. A major problem in applying the HACCP guidelines is determining when a hazard is significant and poses an unacceptable risk to the consumer; does this mean that someone has to die first before the guidelines are rigorously applied? Also an issue is the possibility of introducing internationally, water-shipped organisms, such as dinoflagellates, that could cause problems in the future if successfully transferred.

Overall, the prognosis among industry members for the live food trade as a high-value, quality market, was very good. Issues of overexploitation, animal welfare, suitable-species selection, reduced mortality and exotic introductions, however, need to be addressed and were just a few of those discussed—plenty of food for thought!

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Ciguatera management

by Richard J. Lewis[1]

Ciguatera is a global disease caused by the consumption of warm-water fish contaminated with ciguatoxins—a family of heat-stable, lipid-soluble, highly oxygenated, cyclic polyether molecules. They have their origin in *Gymnodinium toxicus*, a benthic dinoflagellate (a type of single-celled algae) at the base of tropical nearshore marine food chains (Lewis & Holmes, 1993). Outbreaks of this algae, and thus of ciguatera, have complex environmental origins beyond the scope of this article.

Many species and many families of reef fish can be involved in ciguatera poisoning. Families include the muraenids (moray eels) and lutjanids (e.g. red snappers) which are notorious in the Pacific, serranids (groupers, coral trout, coral cod), lethrinids (emperors), scombrids (tuna-like fishes), carangids (jacks or trevallies) and sphyraenids (barracudas).

Ciguatera causes diverse and often long-lasting human health effects. While it is estimated to affect more than 25,000 persons annually (allowing for under reporting), fatalities are rare (~ 0.1% of cases). One exception is ciguatera in the Indian Ocean, which is more often fatal. Some fatalities may be avoided with the introduction of better clinical management practices, including the use of a mannitol therapy, discussed later.

While ciguatera is a global problem, it is mostly confined to discrete regions of the Pacific and western Indian Oceans, and the Caribbean Sea. In the Pacific, ciguatera has long been recognised as a widely distributed phenomenon affecting many of the island nations (Banner & Helfrich, 1964). Despite this wide distribution, there are many areas relatively free of ciguatera that are adjacent to areas of high risk. An explanation for such patchiness in the occurrence of ciguatera remains elusive. Current difficulties in predicting, detecting and treating ciguatera mean that this form of fish poisoning will continue to have large socio-economic impacts, particularly in third world countries. Nowhere are these impacts greater than in regions where fish is the principle source of protein, such as the atoll island communities of the Pacific (Lewis, 1992).

Symptoms and treatment

The symptoms of ciguatera (up to 30 or more) are well described in all regions where ciguatera is a significant problem. Bagnis *et al.* (1979) described over 3,000 cases of ciguatera in French Polynesia. A similar syndrome is observed in the western and central Pacific (Gillespie *et al.*, 1986). In the Pacific, the onset of the first symptoms can be as short as 30 minutes for severe intoxications, while in milder cases may be delayed for up to 24 or occasionally 48 hours from time of consumption of fish. The first symptoms are often neurological in nature (e.g. tingling of the lips). Some neurological symptoms can take several days to develop, including the reversal of temperature perception (see below), which is highly characteristic for ciguatera. Ciguatera typically lasts for several weeks, but sometimes lasts for months. In a small percentage of cases (estimated <5%) certain symptoms may persist, or may be induced, over a period extending into years. The severity, number and duration of symptoms reflect the combined influence of dose, toxin profile, and individual factors.

Gastrointestinal symptoms, such as vomiting, diarrhoea, nausea and abdominal pain, typically occur early in the course of the disease (> ~ 50% of cases), and often, but not always, accompany the neurological disturbances. Neurological disturbances that invariably occur in ciguatera include tingling of the lips, hands and feet, temperature perception disturbances where cold objects give a dry-ice sensation, and an intense itch that moves unpredictably across different patches of skin (> ~ 70% of cases). These symptoms can occur throughout the illness.

Generalised disturbances often include a profound feeling of fatigue (90% of cases) that can last throughout ciguatera. Aches of muscles (> 80%), joints (> 70%) and teeth (> 30%) occur to varying extents, and mood disorders including depression and anxiety (50%) occur less frequently. Severe cases of ciguatera can involve hypotension (abnormally low blood pressure) with bradycardia (reduced heartbeat), breathing difficulties and

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paralysis. Some sufferers of ciguatera experience adverse reactions to certain foods, and some victims experience a relapse of the symptoms initially experienced, while intoxicated with alcohol.

Differences in symptomatology of ciguatera between the Pacific Ocean, where neurological symptoms predominate, and the Caribbean Sea, where gastrointestinal symptoms predominate, have been shown to arise from different classes of ciguatoxins (Murata *et al.*, 1990; Lewis *et al.*, 1998). The similarity of ciguatera symptoms across the western, central and eastern Pacific, suggests that a class of similar ciguatoxins are involved. A third class of ciguatoxins (yet to be chemically defined) is likely to explain the different symptomology observed in the Indian Ocean (Lewis & Hurbungs, unpubl.). Here fish can accumulate lethal levels of toxin (Habermehl *et al.*, 1994), and produce symptoms reminiscent of hallucinatory poisoning, including lack of coordination, loss of equilibrium, hallucinations, mental depression and nightmares (Quod & Turquet, 1996).

Effective treatment of ciguatera requires accurate diagnosis of the syndrome. Presently, ciguatera is a clinically determined disease, diagnosed based on an illness clustered around the recent consumption of a risk fish species. Intravenous mannitol was first introduced as a treatment for ciguatera in the late 1980s (Palafox *et al.*, 1988; Pearn *et al.*, 1989). Diagnosed cases of ciguatera where the patient is not dehydrated are treated with an intravenous infusion of mannitol, given at 1 g/kg over ~ 30 min. In instances where symptoms recur within the first 24 hours after treatment, a second infusion is usually effective. Mannitol is not consistently beneficial, but appears best when used in the acute phase of more severe intoxications. Reasons for a poor response are not known. Symptomatic and supportive therapies still have a role in managing more severe cases, especially for the control of fluid and electrolyte balance. Local anaesthetics and antidepressants may also be useful in some instances. During the recovery phase it is recommended that victims avoid fish and alcohol for 3–6 months, and long-term sufferers should consider whether avoidable foods are contributing to recurrences of symptoms.

Avoiding ciguateric fish

Presently there is no validated screen for ciguateric fish (Lewis, 1994 and 1995). Antibody assays and sodium channel assays are currently being developed that may provide a much-needed, cost-effective screen for ciguateric fish. Unfortunately, detection of ciguateric fish is made difficult by a number of factors, including the low levels of ciguatoxins present in ciguateric fish (< 0.05 parts per billion for one common type of ciguatera molecule), the multiple structural forms that are present even within a single fish, the absence of any useful chromophore (a part of a molecule that is either coloured or absorbs light in the ulraviolet range making detection easier), the meagre quantities of ciguatera compounds available for research, and the difficulties of synthesising even fragments of these molecules.

Analytical methods with the required sensitivity have been developed, but are unlikely to be cost-effective for routine screening and require the streamlining of sample preparation (Lewis *et al.*, 1999). Tests that detect the presence of ciguatoxin in patients would overcome the present limitations of differential diagnosis.

Difficulties in detecting ciguatera are exacerbated when different classes of ciguatoxins are encountered as in Hong Kong where both Pacific and Indian Ocean ciguatoxins occur. In such instances sodium channel assays have some advantages because they reflect the potency of the toxins present without specific structural requirements. Alternative approaches to monitoring that can reduce the health risk associated with ciguateric fish include:

- Bans on the capture or trade of certain species;
- Bans on the capture or trade of fish from certain (high-risk) locations;
- Recommendations to consume small (<50 g) portions of any one fish;
- Bans on fish over a certain size (effectiveness not well documented).

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Grouper/Wrasse Species Survival Group formed

I am pleased to announce the formation of a new Specialist Group under the Species Survival Commission (SSC) of the International Union for the Conservation of Nature (IUCN) which specialises in groupers (Serranidae) and wrasses (Labridae). The IUCN SSC is a science-based network of experts located around the world whose mission it is 'to conserve biological diversity by developing and executing programmes to study, save, restore and manage wisely species and their habitats'.

Specialist groups carry out the main work of the SSC and are organised by species or group of species, by region, and / or by conservation theme or discipline across a wide range of plants and terrestrial and aquatic animals; their members are experts in their respective fields. They are invited and have, as part of their responsibility, to assess the conservation status of their particular species or group of animals. Assessments are carried out according to internationally accepted categories and criteria established by IUCN. For those species determined to be under some level of threat, possible restorative action is identified with a view to maintaining biodiversity and healthy populations.

The grouper / wrasse group was formed in 1999 because of growing concerns over the status of several larger groupers and wrasses, which appear to be particularly vulnerable to overharvesting. Two species currently in the live reef fish trade are listed as 'Vulnerable' under IUCN criteria: these are the Humphead (Napoleon or Maori) wrasse, *Cheilinus undulatus*, and the Giant grouper, *Epinephelus lanceolatus*. About 16 other grouper species in commercial fisheries worldwide were also included in the 1996 IUCN Red List of Threatened Animals. For further information on this group, please contact me at: yjsadovy@hkusua.hku.hk

Yvonne Sadovy, *Specialist Group Chair*

Review of grouper hatchery technology

by Mike Rimmer[1]

The following article is a slightly condensed version of an article published in the Grouper Aquaculture Electronic Newsletter, 27 January 2000. (http://naca.fisheries.go.th)

Larval rearing of groupers

Successful larviculture of groupers has been constrained by generally poor and irregular survival. The principal constraints to successful larviculture (Kohno *et al.*, 1990 and 1997; Tamaru *et al.*, 1995; Leong, 1998; Rimmer *et al.*, in press) are:

1. the small gape of the larvae and hence their requirement for small prey at first feed; and
2. the occurrence of high mortality at various stages through the larval rearing phase.

This document briefly reviews grouper larviculture technology, and summarises the current status of this technology.

Taxonomic note

Because of the sometimes-confused taxonomic status of groupers, particularly the genus *Epinephelus*, the literature pertaining to grouper aquaculture commonly misidentifies the species concerned. There is a voluminous literature on *E. tauvina*, but most of this in fact refers to the estuary cod (or greasy grouper) *E. coioides*. To add to the confusion, the synonym *E. suillus* is also sometimes used to refer to *E. coioides*. The black-spotted cod *E. malabaricus* is sometimes referred to by its synonym *E. salmoides*. However, much of the Thai literature on *E. malabaricus* apparently refers to *E. coioides* (R. Yashiro, pers. comm.). In the following literature review, references to *E. tauvina* and *E. suillus* are assumed to refer to *E. coioides*, and references to *E. salmoides* to *E. malabaricus*. Instances of possible misidentification of *E. coioides* as *E. malabaricus* are noted.

Status of grouper hatchery technology

Eggs of *E. coioides*, *E. fuscoguttatus*, *Cromileptes altivelis* and *Plectropomus leopardus* take 15–19 hours to hatch, while the European white grouper, *E. aeneus* take around 25 hours to hatch (Rimmer *et al.*, in press). Grouper eggs and newly hatched larvae are very sensitive to stress and handling (Predalumpaburt & Tanvilai, 1988; Caberoy & Quinitio, 1998). Handling mortality is minimised by handling only neurula-stage eggs (after the formation of the optic vesicles) and by stocking eggs into the culture tanks 2 hours before hatching so that the larvae need not be handled (Lim, 1993; Tamaru *et al.*, 1995; Caberoy & Quinitio, 1998). Grouper larvae are stocked at relatively high density: 20–30 per litre (Ruangpanit, 1993; Duray *et al.*, 1996) up to 50 per litre (Lim *et al.*, 1986; Aslianti, 1996). The larvae are sensitive to light during the early stages of their development and are generally kept in darkened conditions.

Rearing tanks are generally rectangular and range in size from 5 to 30 m^3 (Rimmer *et al.*, in press). Tank size, shape and colour may affect the survival of grouper larvae cultured intensively. *E. coioides* larvae cultured in 3 m^3 tanks demonstrated a better survival rate (19.8%) at Day (D) 24 compared with only 7.4% for those in 0.5 m^3 tanks at D21 (Duray *et al.*, 1997). Growth and survival of *E. fuscoguttatus* larvae was improved using cylindrical rather than rectangular larval rearing tanks (Waspada *et al.*, 1991b). *Cromileptes altivelis* larvae exhibited higher survival in green or blue coloured tanks than in red or yellow coloured tanks, but growth rate was not affected by tank colour (Aslianti *et al.*, 1998). Grouper larval rearing tanks are usually supplied with microalgae (generally *Nannochloropsis oculata*, formerly known as marine *Chlorella*), or *Tetraselmis* sp. at 500 x 10^3 to 100–500 x 10^6 cells per ml ('green water' system) (Ruangpanit, 1993; Tamaru *et al.*, 1995; Watanabe *et al.*, 1996; Leong, 1998; Rimmer, 1998; Rimmer *et al.*, 1998). The microalgae provides a shading effect, provides food for the live prey organisms added to the tanks, and may also be ingested by the larvae (although whether the larvae gain any nutritive value from ingested microalgal cells is unknown). More recently, the use of *Isochrysis* for 'green-water' rearing has been shown to improve larval growth and survival (Su *et al.*, 1998).

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The mouth of larval groupers generally opens 2–3 days after hatching (D2–3), and the larvae begin feeding soon thereafter (Kitajima *et al.*, 1991; Kungvankij *et al.*, 1986; Ruangpanit, 1993; Ruangpanit *et al.*, 1993; Duray 1994; Doi *et al.*, 1997). Kohno *et al.* (1997) described the development of the feeding apparatus in *E. coioides* in detail and suggested that the major difficulties in larval rearing of groupers were attributable to the small size of the bony elements forming the oral cavity, small mouth and body size, poor reserves of endogenous nutrition and lower initial feeding rates.

Grouper larvae are initially fed on rotifers, often in combination with oyster trochophores, mussel larvae, sea urchin eggs or barnacle nauplii (Hussain & Higuchi, 1980; Lim, 1993; Ruangpanit, 1993; Tamaru *et al.*, 1995; Watanabe *et al.*, 1996; Rimmer *et al.*, 1998). Oyster trochophores, mussel larvae, sea urchin eggs and barnacle nauplii are around 70 µm in size and are thus small enough to be readily consumed by the larvae (Kungvankij *et al.*, 1986; Tamaru *et al.*, 1995). Small-strain (S-type) rotifers (*Brachionus rotundiformis*) are too large for newly hatched grouper larvae to ingest. Super-small-strain (SS-type) rotifers (*Brachionus* sp.), or S-type rotifers screened to <90 µm, are suitable for grouper larvae at first feed (Lim, 1993; Tamaru *et al.*, 1995; Watanabe *et al.*, 1996; Duray *et al.*, 1997; Su *et al.*, 1997). Optimal prey density during the early larval stages is 10–20 organisms / ml (Ruangpanit, 1993; Ruangpanit *et al.*, 1993; Tamaru *et al.*, 1995; Wardoyo *et al.*, 1997).

The use of copepod nauplii as prey during the early larval rearing of groupers has shown considerable promise in improving larval growth and survival (Hussain & Higuchi, 1980; Doi *et al.*, 1997). Provision of nauplii of calanoid copepods (mainly *Pseudodiaptomus annandalei* and *Acartia tsuensis*) and rotifers in rearing tanks, resulted in higher survival and faster growth in *E. coioides* compared with the use of rotifers alone (Doi *et al.*, 1997; Toledo *et al.*, 1999). *E. coioides* larvae actively select copepod nauplii in preference to rotifers (Toledo *et al.*, 1997).

S-type rotifers are fed from about D7 (Tamaru *et al.*, 1995; Su *et al.*, 1997), and brine shrimp (*Artemia franciscana*) are introduced from about D10. Brine shrimp are initially fed at 1–3 / ml, increasing gradually to 7–10 / ml at D25–35 (Ruangpanit, 1993). Higher prey densities (2–3 / ml) enhance growth and survival (Duray *et al.* 1997), as does frequent feeding of brine shrimp (4–5 times per day) (Ruangpanit, 1993; Duray *et al.*, 1997). Grouper larvae fed rotifers and brine shrimp enriched with *n*–3 HUFAs demonstrate better growth, survival and greater stress endurance than those fed with normal live feeds (Pechmanee *et al.*, 1988; 1993; Pechmanee & Assavaaree, 1993; Chao & Lim, 1991; Dhert *et al.*, 1991; Lim, 1993; Quinitio, 1996). Most laboratories supplement live prey for grouper larvae with microalgae (e.g. *Tetraselmis*, *Chaetoceros*), home-made lipid emulsions (egg yolk blended with cod liver oil), or commercially available lipid emulsions or microencapsulated supplements (Ruangpanit 1993; Rimmer *et al.*, in press). Minced fish or shrimp may be introduced from about D35 to wean the larvae (or juveniles) from live to inert feeds (Hussain & Higuchi, 1980; Ruangpanit, 1993; Tamaru *et al.*, 1995).

Survival of groupers to metamorphosis is generally low: usually <10% and commonly <1%. Recent reports of survival in experimental conditions are: 1–10% (average 4%) for *E. coioides* (J. Toledo, pers. comm.) and 1–5% for *C. altivelis* (K. Sugama, pers. comm.). In addition to low average larval survival, survival is highly variable, and a (relatively) successful larval rearing 'run' can be followed by several runs which have negligible or zero survival. It is this both these aspects, low and irregular survival, that have constrained the application of the existing fingerling production technology to commercial hatchery production.

The major causes of mortality in grouper larviculture are:

1. High mortality associated with the commencement of exogenous feeding. This mortality may be associated with the provision of live prey organisms of unsuitable size and nutritional composition, but even when 'suitable' prey types are used, there is generally high mortality at this stage (Ordonio-Aguilar *et al.*, 1995; Duray *et al.*, 1997).
2. Several mortality syndromes have been described for grouper larvae. A commonly reported mortality syndrome is the 'shock syndrome' that occurs in late stage larvae from about D25 (Lim, 1993; Duray *et al.*, 1997). This problem may be related to nutritional deficiencies in the live prey organisms used to feed the larvae, since shock syndrome is symptomatic of low levels of HUFAs in the diet (Cowey & Sargent, 1972).
3. Cannibalism is a major cause of mortality during the later stages of larval rearing, i.e. from D30–35 (Lim, 1993; Tamaru *et al.*, 1995; Rimmer *et al.*, in press). Although cannibalism can be controlled by grading larvae and juveniles into similar size classes, grading is often associated with high mortality because handling commonly induces the shock syndrome seen in late stage larvae (Rimmer *et al.*, in press). Provision of shelter is reported to reduce cannibalism in juvenile *E. malabaricus* (*E. coioides*?) (Rimmer *et al.*, in press).

Nutritional requirements of larval groupers

The few studies that have been carried out on the nutritional requirements of larval groupers suggest that supplementation of the larval diet with HUFAs improves growth and survival. Waspada *et al.* (1991c) found higher growth rates of *E. fuscoguttatus* larvae when they were fed rotifers supplemented with bakers yeast with sardine oil or bakers yeast with cod oil. These treatments had high levels of EPA (8.8–8.9% respectively) but highly variable levels of DHA (0.1–5.5% respectively) (Waspada *et al.*, 1991a). Su *et al.* (1997) found that growth and survival of larval *E. coioides* were associated with the fatty acid composition of the larvae. Larvae with high levels of total fatty acids grew faster than those with lower levels, and larvae with high DHA or EPA content (>2 mg / g DW) exhibited better survival (>10%) than those with lower HUFA content.

Ruangpanit *et al.* (1993) reported improved survival of *E. malabaricus* (*E. coioides*?) larvae when brine shrimp used for larval rearing were enriched with a cod liver oil / egg yolk emulsion (*n*–3 HUFA = 450 mg / g) or were supplemented with copepods or the freshwater cladoceran *Moina*. Dhert *et al.* (1991) found that supplementation of brine shrimp with an emulsion containing high levels of DHA had little effect on growth or survival of *E. coioides* larvae, and concluded that application of DHA could be delayed until D25 before mortality due to nutritional deficiency affected *E. coioides* larvae.

Thyroid hormone treatment

Lam (1994) and Lam *et al.* (1994) reported that the levels of the thyroid hormone are higher in buoyant than in non-buoyant *E. coioides* eggs. The buoyant eggs are more viable than non-buoyant eggs, suggesting a relationship between levels of thyroid hormone and viability. Application of 0.01–1.0 ppm triiodothyronine (T3) or thyroxine (T4) is effective in increasing larval survival and hastening the resorption of the dorsal and anal fins in 2–6 days in contrast to 2–3 weeks in fish not so treated (Tay *et al.*, 1994; de Jesus, 1996; de Jesus *et al.*, 1998). Thyroid hormones can be applied by immersing eggs or larvae in a bath, or by bioencapsulation using rotifers or brine shrimp. De Jesus *et al.* (1998) concluded that a dose rate of 0.01 ppm T4 is appropriate for accelerated metamorphosis and improved survival in 3- to 4-week old grouper larvae.

Commercial grouper larviculture in Taiwan

The only commercial hatchery production of grouper fingerlings that has been identified is from Taiwan. Larviculture of groupers (as well as other marine finfish species) in Taiwan is undertaken using either the 'indoor method' or 'outdoor method', i.e. in concrete tanks indoors or in outside ponds (Rimmer, 1998).

Indoor method

The indoor method utilises large fibreglass or concrete tanks up to about 100 m^3. The rearing tanks are circular or rectangular in shape, flat-bottomed and with a white or light-coloured interior. Larviculture is undertaken using either greenwater or clearwater techniques. The algal density used for greenwater culture ranges from 50,000 to 500,000 cells / ml. Variables such as algal density are only measured in research hatcheries—commercial hatcheries just add algal cells until the desired shade of green is reached (Rimmer, 1998).

Generally, eggs are added directly to the larval rearing tanks. Grouper larvae are fed oyster trochophores from first feed (usually D4) for 2 days. Rotifers are also added to the rearing tanks, generally commencing from first feed. Recent research at Taiwan Fisheries Research Institute's Tungkang Marine Laboratory (TML) indicates that a combination of oyster trochophores and small rotifers (either SS-strain, sieved S-strain, or neonates) is the best initial feed (Su *et al.*, 1997). Rotifer densities are maintained at about 2–3 / ml until the grouper larvae are large enough to eat brine shrimp or adult copepods, which is when the dorsal and pectoral spines reach the end of the caudal fin. Generally, grouper larvae are able to feed on adult copepods from D16 (water temperature >26°C) or D22 (<26°C) (Rimmer, 1998).

Outdoor method

The outdoor method of larval rearing is undertaken in concrete or earthen ponds ranging in size from 200 m^2 to 0.5 ha, and, less commonly, to 1 ha. The ponds are filled only 1–2 days before they are stocked with eggs. The inlet is screened with a fine mesh 'sock' filter to exclude potential predators and nuisance species. Stocking density for grouper ranges from about 1 kg of eggs (i.e. *c.* 1.5 million eggs) in 0.1 ha to 2 kg (*c.* 3 million eggs) in 0.2–0.5 ha larval rearing ponds (Rimmer, 1998).

One or two enclosures formed by a tarpaulin set around a floating support structure are set up in the pond, usually with shadecloth overhead to reduce light intensity, and mild aeration to ensure adequate dissolved oxygen and mixing of the water within the enclosure. The enclosures range in size from 5 m^3 in small concrete ponds, to 8–10 m^3 in earthen ponds 0.2–0.5 ha in area. The enclosures are pumped full of pond water, and fertilised grouper eggs are added to the enclosures. Oyster trochophores are added to the enclosures from first feed (usually D4) for 2 days, then the larvae are released into the pond. The enclosures allow smaller quantities of oyster trochophores to be fed while retaining relatively high prey densities. They also allow the farmer to visually estimate larval survival after the first few days of culture, which is the period when most mortality occurs. If survival is very low, the farmer may choose to restock the enclosure with another batch of larvae, rather than release the survivors into the pond (Rimmer, 1998).

Rotifers (and, incidentally, other zooplankters) are cultured in small concrete or earthen ponds, usually about 0.05–0.1 ha. The rotifers are cultured using trash fish placed in fertiliser bags and left to decompose in a corner of the pond, or by the addition of organic wastes. A paddle-wheel aerator is placed in the pond to assist with aeration and to generate a current in the pond. Zooplankton is harvested using a fine (*c.* 85 µm) mesh net that is set downstream from the paddle-wheel aerator for 1–2 hours. The collected zooplankton is added to the larval rearing pond. Farmers attempt to maintain rotifer density at about 3–4/ml, but, as is the case with other aspects of pond management, rotifer density is not measured, but is maintained 'by eye'. Later in the larval rearing cycle, adult copepods are harvested from the zooplankton production ponds using the same technique, although with a larger mesh (*c.* 210 µm) mesh net. Some farms pump water from the rotifer production ponds into the larval rearing pond, and may also pump zooplankton-rich water from grow-out ponds into the larval rearing ponds (Rimmer, 1998).

The larvae are reared in the ponds until they reach 2.5–3 cm total length (TL), when they are harvested. In the case of grouper, this takes about 4 weeks. Pond temperatures need to be above 20°C to ensure any larval survival for grouper; if pond temperatures drop below 18°C, the grouper larvae will die. For this reason, some farms will not purchase grouper larvae until April, even though eggs are available from early March. In addition, farmers feel that the quality of eggs produced early in the season is inferior to that of eggs produced later in the season. Survival of groupers using both indoor and outdoor larval rearing methods is highly erratic, but generally low: 7 per cent survival is regarded as good. Researchers at TML report that a major constraint to grouper aquaculture is the irregular nature of larval survival. The major problem, according to TML researchers, is high mortality at first feed, although there is often low-level mortality throughout the larval rearing process (Rimmer, 1998). Because of the generally low survival of groupers in larviculture, prices for grouper fingerlings are relatively high: US$ 2–3 per fingerling (Tamaru *et al.*, 1995).

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Cyanide fishing on Indonesian coral reefs for the live food fish market – What is the problem?

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Abstract

According to three precautionary estimations, the reef-degrading capacity of the cyanide fishery for food fish on Indonesia's coral reefs amounts to a loss of live coral cover of 0.047, 0.052 and 0.060 m^2 per 100 m^2 of reef per year. These estimates for the rate of coral cover loss are low compared to published rates of natural coral recovery. Differences in growth rate between species of hard coral will cause coral reefs to take longer to recover from the effects of cyanide fishing than a direct comparison of the rate of coral cover loss with published rates of natural coral recovery would suggest. Still, the cyanide fishery for food fish may not be as threatening to Indonesia's coral reefs as is sometimes assumed, especially not as compared to other threats such as blast fishing (responsible for a loss of live coral cover amounting to 3.75 m^2 per 100 m^2 of reef per year, (Pet-Soede, Cesar & Pet, 1999)), or coral bleaching caused by global climate change (cf. Hoegh–Guldberg, 1999). Setting the input variables for the estimates at extreme values did not change these conclusions substantively. The depletion of grouper stocks by the trade in live reef food fish, however, is worrying from both fisheries and conservation perspectives. Strategies to abate the depletion of these grouper stocks should not only consider cyanide fishing, but also other fishing methods.

1. Introduction

The Live Reef Food Fish Trade (LRFFT) has rapidly expanded throughout Southeast Asia and beyond during the 1990s, and the demand for live fish is projected to grow even more in the future (Dragon Search, 1996). The trade concentrates on the catch of groupers (Serranidae, especially *Cromileptes altivelis* and species of *Plectropomus* and *Epinephelus*) and Napoleon wrasse (*Cheilinus undulatus*), catering to 'high-end' customers who are willing to pay up to hundreds of dollars (US$) per serving (Johannes & Riepen, 1995). These fish are top predators, sedentary in character and strongly territorial; they are typically long-lived and slow growing; many assemble in large numbers to spawn. These characteristics contribute to the rampant overexploitation engendered by the LRFFT, which has already led to calls to include many of the target species in Appendix II or III of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Lau & Parry-Jones, 1999). Two of the target species (*Cheilinus undulatus* and the giant grouper *Epinephelus lanceolatus*) are currently listed as 'vulnerable' on the International Union for the Conservation of Nature (IUCN) Red List (Baillie & Groombridge, 1996).

Besides the problem of overexploitation of target species, there is a concern that one of the most widely used capture methods, the application of cyanide solution to stun the fish, is causing severe reef degradation (Johannes & Riepen, 1995). The perceived problem of reef degradation, together with the intriguing nature of the trade has attracted public attention, put pressure on policy makers to abate cyanide fishing, and created a greater willingness among environmental organisations to get involved in the LRFFT issue (Johannes & Riepen, 1995; Pratt, 1995; Barber & Pratt, 1997a; 1997b). However, there is still considerable uncertainty about the extent of the coral reef degradation by cyanide fishing for live food fish. Laboratory experiments showed that exposure of zooxanthellate hard coral to a range of cyanide doses likely to occur during cyanide fishing results in coral bleaching or death of the polyps (Jones & Steven,

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1997). Bleaching of corals is caused by cyanide affecting the photosynthesis of the symbiotic zooxanthellae (Jones & Hoegh-Guldberg, 1999; Jones, Kildea & Hoegh-Guldberg, 1999). However, the toxicity of cyanide to corals under experimental conditions is, in itself, no proof for degradation on the scale of a reef. This is because the rate of coral loss due to cyanide fishing may be lower than the rate of natural coral growth, or it may be that under natural conditions cyanide is dissipated too rapidly by water currents to affect exposed corals (cf. Jones & Steven, 1997).

It is also unclear how reef degradation from the cyanide fishery for live food fish compares to the problem of overexploitation of target fish and to the problem of reef degradation caused by other destructive fishing techniques. Erdmann & Pet-Soede (1996, 1999) and others have previously suggested that the reef degradation from cyanide fishing may be wrongly emphasised, and that the more important issue requiring attention in the LRFFT is the potential for overexploitation of the target species (irrespective of capture technique). McManus, Reyes & Nanola (1997) have concurred that reef degradation from cyanide fishing in the LRFFT certainly is minimal compared to that wrought by blast fishing. Unfortunately, quantitative figures are generally lacking to help clarify this debate. One exception is the model of the effects of destructive fishing methods on coral cover in Bolinao (Philippines), which gives an estimate of a decrease of only 0.4% live coral cover per year due to destruction by cyanide fishing for ornamental fishes (McManus, Reyes & Nanola, 1997).

In an attempt to further clarify this debate and thereby better focus attention on the LRFFT issues most worthy of action, we have quantitatively estimated the reef degradation potential of cyanide fishing in the LRFFT in Indonesia by three independent methods, using both data from published reports and the authors' collated experience with cyanide fishing. We hope that this opinion paper will stimulate additional information inputs that are needed to make decisions on how reef conservation dollars may best be directed.

2. Calculation of the effects of cyanide fishing on coral reefs

One way to assess the degradation afflicted by the LRFFT is to estimate what amount of reef is being destroyed per fish caught with cyanide, and multiply this by an estimate of the number of fish caught by the cyanide fishery. Even though this method requires the input of imprecise variables, this method should provide a crude approximation of the order of magnitude of reef degradation caused by cyanide fishing in the LRFFT.

In the Spermonde Archipelago (Central Indonesia), on average one bottle (0.5–1 L) of cyanide solution is used to catch one fish (Pet & Pet-Soede, 1999). We assumed this fully destroys live coral cover in an area of one square metre, both by poisoning the coral polyps and by the fisher breaking away coral to extract the stunned fish.

Based on personal observations, this figure of one square metre is probably an over-estimation for reefs with a relatively high cover of massive coral structures, as retrieving stunned fish that hide in the cavities under these massive structures will not require nearly as much breakage as retrieving fish that hide between branching corals. Additionally, squirted fish often flee their shelters, thus the damage to coral by the diver retrieving the fish is minimised (pers. observ.). Even the chemical damage per fish caught may be limited to an area smaller than one square metre (pers. observ.; Erdmann & Pet-Soede, 1996). Finally, this figure may result in an over-estimation of the reef-degrading capacity of the LRFFT because we assumed that the 'killing area' was fully covered with live coral.

However, we decided to use the one-square-metre figure because we felt that the consequences for management of under-estimating the reef-degrading capacity of the LRFFT, i.e. allowing the cyanide fishery to continue, would be more severe than consequences of over-estimation, i.e. directing too many resources to the abatement of the cyanide fishery (precautionary approach).

The estimate of reef area destroyed per fish caught, using Indonesia as an example, was multiplied by the number of fish caught per km^2 per year, which was derived from:

1. the potential production and yield of grouper on pristine coral reefs where exploitation has only just begun, usually by large-scale operations (Pet & Pet-Soede, 1999);

2. the mean observed effort of cyanide fishers times the estimated catch per unit of effort (CPUE) in situations where reefs have already been exploited for some time, and where the most fish are caught by medium-scale operations (Pet & Pet-Soede, 1999);

3. the volume of the LRFFT in Hong Kong, a significant proportion of which comes from Indonesia. In Indonesia live food fish is also caught by other methods, mainly hook-and-line and bamboo traps (pers. observ.; Erdmann & Pet-Soede 1999), but we adopted a precautionary approach by assuming that all fish were caught with cyanide.

2.1 Method I: Estimation based on the potential production and yield of groupers

Estimates for the Maximum Sustainable Yield (MSY) of groupers in other coral reefs average 1000 kg per km^2 coral reef per year (Russ 1991; Jennings & Polunin 1995). If a pristine reef were to be exploited at a rate higher than this MSY, this would eventually lead to lower catch rates. We assumed an exploitation rate for the first year of twice the MSY, i.e. 2000 kg per km^2 per year, because the LRFFT tends to over-exploit its fishing grounds (Bentley, 1999). The average individual size of fish caught by large-scale cyanide fishing operations in relatively pristine areas has been estimated at 3.33 kg (Pet & Pet-Soede, 1999), about 2 kg heavier than the overall average size of fish encountered in the LRFFT (Johannes & Riepen, 1995). Hence, the total catch amounts to 600 fish per km^2 reef area, resulting in an estimated loss in coral cover of 0.060 m^2 per 100 m^2 of reef per year.

2.2 Method II: Estimation based on fishing effort and CPUE

In Komodo National Park, a creel survey was conducted in 1997 to describe patterns in resource use. During this survey, which covered the full surface area of the Park and which was repeated 18 times during the 12-month period, the number of fishing operations using hookah compressors was recorded. Most, if not all, of the hookah compressor operations in the Komodo area use cyanide to catch live fish (pers. observ.). The crew, usually consisting of *c.* five persons of whom two were hookah divers, operated from a motorised boat making trips of three days each. At that time, the ban on cyanide fishing was not enforced, mainly because it was usually impossible to obtain legal proof that cyanide was actually used. The number of cyanide operations in the Park seemed high compared to areas outside Park boundaries, probably because fishing opportunities within Park boundaries were still good. Within the boundaries of the Park, on average 3.2 medium-scale cyanide operations per day were encountered (Pet, 1999). The coral reef area in the Park, estimated as a 50-m wide strip following the perimeter of all islands including their shallow reef areas, was *c.* 17 km^2. Therefore, the daily effort per km^2 of coral reef averaged 0.19 operations.

Estimates for the catch per trip in Komodo were not available. Therefore a catch estimate was used from the Spermonde Archipelago, an area approximately 400 km from Komodo. In Spermonde, an operation of similar size uses about 7.5 bottles of cyanide to catch an equal number of fish during each of the two days that fishing actually takes place (Pet & Pet-Soede, 1999). Therefore, the total area potentially destroyed was 7.5 fish times 0.19 operations times 365 days times one m^2, i.e. 520 m^2 per km^2 reef area. Assuming that the targeted reef patches were fully covered with live coral, it follows that the rate of live-coral-cover loss amounts to 0.052 m^2 per 100 m^2 of reef per year.

2.3 Method III: Estimation based on the volume of the trade in live reef food fish

The annual imports of live reef fish into Hong Kong amounted to *c.* 32,000 tonnes in 1997. It is believed that Hong Kong accounts for *c.* 60 per cent of the total LRFFT volume, and that 50 per cent of all live reef fish originates from Indonesia (Johannes & Riepen, 1995; Lau & Parry-Jones, 1999). Hence, the total amount of fish from Indonesia that reached their destination must have amounted to 27,000 tonnes. This estimate is high (see appendix), but we used it purposefully to ensure we did not underestimate the capacity of the live reef fish trade to damage the reef. Assuming that 50 per cent of all fish caught dies shortly after catching or during transport (Johannes & Riepen, 1995; Indrawan, 1999), the annual catch from Indonesia's coral reefs (85,707 km^2, Tomascik *et al.*, 1997) amounts to 54,000 tonnes, or 630 kg per km^2 per year. Assuming that most fish caught originated from medium-scale operations, the average body weight of the fish in the landings was 1.33 kg (Pet & Pet-Soede, 1999). It follows that the associated rate of live-coral-cover loss would be 0.047 m^2 per 100 m^2 of reef per year.

2.4 Sensitivity analysis

To assess to what extent the methods presented above may be under- or over-estimating the actual reef degradation by the cyanide fishery, we did the same calculations with each of the variables set at what we considered extreme values (Table 1). It should be noted that the minimum and maximum estimates relate to averages over a year, for all over Indonesia, which is why our lower and higher extreme values, which we named 'conservative' and 'worst' (Table 1), may appear not so extreme to some readers. For example, there are reports of whole shipments of live fish dying, but it would not be correct to use this record as a lower estimate for post-harvest mortality in our calculations, because there will also be shipments with little mortality. Also, the resulting lower and maximal estimates for reef degradation are extremes in a sense that we think it is unlikely that all variables are either on the 'conservative' side, or on the 'worst-case' side. However, the extreme estimates can be interpreted as a means to assess the risk of drawing the wrong management conclusions.

The conservative estimates for loss of coral cover caused by the LRFFT ranged between 0.004 and 0.005 m^2 per 100 m^2 of reef per year, whereas the worst-case estimates ranged between 0.5 and 0.7 m^2 per 100 m^2 of reef per year.

3. Conclusions & discussion

The estimates for loss in live coral cover caused by the cyanide fishery for food fish in Indonesia ranged between 0.05 and 0.06 m^2 per 100 m^2 of reef per year. Though the values for the various variables used in each of the three methods are only approximate, all methods arrived at a level of reef degradation that was of the same order of magnitude.

These estimates for reef degradation are low, both considered by themselves and as compared to reported values for reef recovery. The conservative estimate suggests a negligible amount of reef degradation caused by the LRFFT: after a century of cyanide fishing at its present level of effort, only 0.4 m^2 per 100 m^2 of live coral cover would be lost. Even according to the worst-case estimates, it would still take the LRFFT about 40 years to decrease live coral cover by 25 m^2 per 100 m^2 of

Table 1. **Results of the sensitivity analysis for the estimation of reef degradation, expressed as the yearly loss of live coral cover in m^2 per 100 m^2 of reef, caused by the Live Reef Food Fish Trade (LRFFT). For each input variable, a range of likely values was estimated by the authors. 'Best': Best precautionary estimate (equals the arithmetic or geometric mean of the extremes of the range). 'Conservative': Extreme of the range that leads to more conservative estimates for reef degradation. 'Worst case': Extreme of the range that leads to higher estimates for reef degradation.**

Method / variable	Best	Extremes	
		Conservative	Worst case
Area of live coral cover lost per cyanide bottle used or per fish caught(m^2)	1.0	0.3	3.0
Method I: Potential production and yield of groupers in pristine areas exploited by large-scale operations			
MSY ($kg . km^{-2}$ coral reef . yr^{-1})	1,000	500	2,000
Body weight per fish (kg) *	3.33	6.66	1.67
Reef degradation **	**0.060**	**0.005**	**0.719**
Method II: Fishing effort and CPUE of medium-scale operations			
Effort (trips $day^{-1} . km^{-2}$ reef)	0.190	0.095	0.380
Fish caught per unit of effort	7.50	3.75	15.00
Reef degradation **	**0.052**	**0.004**	**0.624**
Method III: Volume of LRF, mostly caught by medium-scale operations			
Hong Kong imports (tonnes)	32,000	25,600	38,400
Through Hong Kong (%)	60	80	40
From Indonesia (%)	50	70	30
Post-harvest mortality (%)	50	30	70
Body weight of fish (kg) *	1.33	2.66	0.67
Reef degradation **	**0.047**	**0.004**	**0.502**

* The average body weight for fish caught was set at a higher value in Method I than in Method III, because large-scale operations operating in pristine areas tend to catch larger fish than medium-scale operations that tend to work in areas that have already been fished for some time (Pet & Pet-Soede, 1999).

** Loss of live coral cover, in m^2 per 100 m^2 of reef per year.

reef. As the LRFFT in Indonesia may have been active for 10 years or so (Johannes & Riepen, 1995), it would be exaggerated to state that the LRFFT in Indonesia has already caused widespread damage to the coral reefs. Our best estimate for reef degradation caused by the LRFFT is 40 times lower than the rate of coral cover increase as observed in Komodo National Park (Central Indonesia), where live-coral cover increased by 2 m^2 per 100 m^2 of reef per year after enforcement of the ban of blast fishing (Pet & Mous, 1999). However, this comparison has to be regarded with caution, because increase in live-coral cover does not equal recovery to the state of a pristine coral reef, with its complex structures and its relatively high abundance of the longer-lived hard corals, such as some species of *Porites*. On the other hand, some reefs seem to be able to re-establish their complexity quickly after near-complete annihilation; after a volcanic eruption and destruction by the lava flow, the reefs around Banda (Eastern Indonesia) recovered completely after a period of five years, featuring 124 species and table coral colonies with a diameter of over 90 cm (Tomascik, van Woesik & Mah, 1996).

The damage done by the cyanide fishery for the much smaller sized, ornamental fish is probably much greater than that for food fish, as the number of target fish per unit of reef area is much higher. Also, mechanical reef destruction in the fishery for ornamental fishes may be more extensive, as branching corals are broken apart over large areas, in order to retrieve the small fish (pers. observ.). A relatively high estimate of reef loss inflicted by the fishery for ornamental fish (0.4% reef loss per year) was also suggested by McManus, Reyes & Nanola (1997).

The quantification of effects of cyanide squirts on biota other than the target fish and hard corals is hampered by the lack of field data. The risk of adverse long-term effects from cyanide fishing on the environment is probably low, as there are no reports of cyanide bio-magnification or cycling in living organisms (Eisler, 1991). Cyanide seldom persists in surface waters owing to complexation or sedimentation, microbial metabolism, and loss from volatilisation (Eisler, 1991). Our impression was that *around* the areas where we observed coral bleaching caused by cyanide fishing, there was no evidence for mortality in other benthic organisms. Hence, the estimates for reef degradation presented in Table 1 are likely to pertain to the amount of live-cover loss, including cover of benthic organisms other than hard corals, rather than to the loss of hard-coral coverage exclusively. Mortality in non-target fishes caused by cyanide fishing is even more difficult to quantify. Because of their higher metabolic rate per unit of body weight, smaller fish that were in the direct vicinity of the target fish at the moment of capture most probably die. The mortality probably depends on the rate of dilution of the squirted cyanide, and on the amount of fish that were in the direct vicinity of the target fish. This unknown collateral damage is one of the reasons why we think that cyanide fishing should not be tolerated.

In the absence of scientific evidence that shows that the amount of reef degradation is higher than our observation of one square metre per cyanide-caught fish, we must conclude that the reef-degrading capacity of the cyanide-based LRFFT is not as obvious as is sometimes assumed. Therefore, there is a need to get the priorities right when deciding how to allocate reef conservation dollars. There are numerous threats to coral reefs that are beyond doubt (cf. Bryant *et al.*, 1998). Some of these threats, such as global warming (Hoegh-Guldberg, 1999), need to be addressed on a global scale, but others, notably blast fishing (Pet-Soede, Cesar & Pet, 1999) can be addressed cost-efficiently at a local level (Pet, 1997; Pet & Mous, 1999). We are of the opinion that, within the category 'destructive fishing practices for food fish', blast fishing deserves a higher amount of conservation effort than cyanide fishing. Blast fishing accounts for a loss in live coral cover of 3.75 m^2 per 100 m^2 of reef yearly (Pet-Soede, Cesar & Pet, 1999), which is about 75 times more than our best estimate, and still about 5–6 times more than our 'worst-case' estimate for the loss of coral cover due to cyanide fishing for food fish.

The second effect of the LRFFT, the depletion of grouper stocks in their fishing grounds (cf. Bentley, 1999) is more worrying from both conservation and fisheries perspectives. The specific nature of the market for live food fish, where rarity increases the price up to a level where it is economically sound to catch the very last specimen, puts the fish stocks that are targeted by the LRFFT at a high risk (Sadovy & Vincent, 2000). The grouper spawning-aggregation sites are easily located by the fishers, and the life-history characteristics of groupers (longevity and size-dependent sex change) make these stocks even more vulnerable to overexploitation (Sadovy, 1997; 1994a). Hence, the size-selective fishing methods practised in the LRFFT affect reproductive success of the exploited stocks in two ways: by extracting the more fecund larger individuals, and by affecting the sex ratio (Johannes *et al.*, 1999). As the target fish are mostly top predators, the LRFFT may also indirectly affect the reef fish community at the lower trophic levels through cascading effects in the food web that are known to exist in both temperate and tropical aquatic food webs (Carpenter, Kitchell & Hodgson, 1985; Goldschmidt, Witte & Wanink, 1993). The problem of over-exploitation cannot be solved by abating cyanide fishing alone, as it is possible to deplete grouper stocks by other fishing methods (i.e., hook and line) as well (Sadovy 1993; 1994b). Therefore, it is our opinion that the overexploitation is a more severe problem than fishing with cyanide in the LRFFT. The problem of overexploitation can only be solved by putting a proper fisheries management and enforcement framework in place. We strongly support the recommendation in the recent TRAFFIC / WWF report (Lau & Parry-Jones, 1999) to protect spawning aggregations, but we regret that this recommendation is listed under 'Specific recommendations to address cyanide fishing'. Efforts to protect grouper stocks and other stocks targeted by the LRFFT should consider all fishing methods, not only cyanide fishing.

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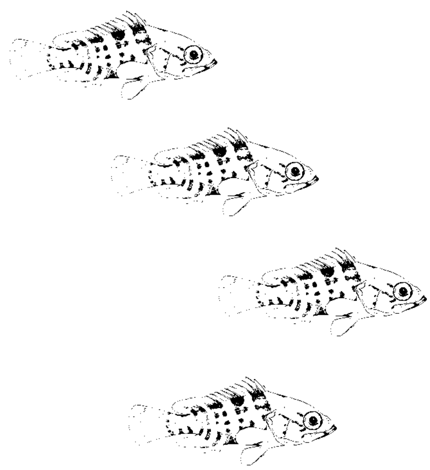


Appendix

Short review on the traded volume of live food fish

Johannes & Riepen (1995, p.4) presented a conservative estimate of total volume of the LRFFT of 20,000–25,000 tonnes per year, and they estimated that about 60 per cent thereof is traded in Hong Kong (Johannes & Riepen, 1995, p. 16). A significant amount of the total volume is cultured, but it remains unclear to what extent the culture is based on the grow-out of wild-caught fish (Johannes & Riepen, 1995, p. 16). For example, the country that is known to produce most of the cultured groupers, Taiwan (Johannes & Riepen, 1995, p. 16) is also an important importer of wild-caught grouper fingerlings from the Philippines (Bentley 1999, pp. 29–30).

According to the survey of Hong Kong Census and Statistics Department (HK CSD) data by Lau & Perry-Jones (1999, pp. 8–12), the total amount of live marine fish (HK HS Codes 0301 99-12, -21, -22, -23, -29, -31, -39, -41, and -99) imported into Hong Kong amounts to 21,000 tonnes, whereof nearly 90 per cent was imported by air. This figure of 21,000 tonnes underestimates the total volume of the LRFFT, as locally licensed, live-reef-fish transport vessels, estimated to import about 10,000 tonnes per year (Johannes & Riepen, 1995, p. 51), are exempt from declaration of imports of live reef food fish (Lau & Perry-Jones, 1999, p. 4).

By interviewing 39 of the 114 companies that trade live fish in Hong Kong, imports of the 11 most common species were estimated at 24,000 tonnes per year (Lau & Perry-Jones, 1999, p. 7).

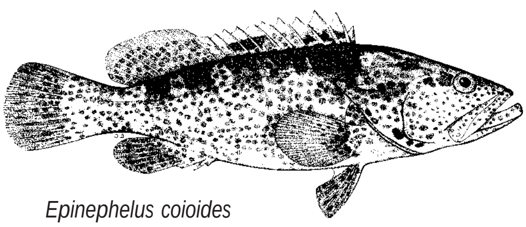
These species were: *Lutjanus argentimaculatus* (21%), *Epinephelus coioides* (20%), *Plectropomus leopardus* (18%), *P. areolatus* (9.7%), *E. bleekeri* and *E. areolatus* (both species grouped in one category, 7.6%), *E. fuscoguttatus* (7.2%), *E. polyphekadion* (5.0%), *E. akaara* (3.6%), *Cromileptes altivelis* (3.0%), *Cheilinus undulatus* (2.8%) and *E. lanceolatus* (1.9%).

Hence, according to the survey among traders, the total volume of live food fish traded in Hong Kong must have amounted to 32,000 tonnes annually. This is close to the sum of the estimate for the volume of live reef fish (10,000 tonnes) imported by locally licensed vessels (Johannes & Riepen, 1995, p. 51), and the total imports (21,000 tonnes) as estimated by the HK CSD (Lau & Perry-Jones, 1999, pp. 8–12), even though the latter includes a large category (*c.* 14,000 tonnes) of 'other live marine fishes' (Lau & Perry-Jones, 1999, p. 6). Perhaps problems with species identification caused a considerable part of the trade volume that should have been categorised in one of the other statistical categories to be entered under 'other live marine fishes'.

According to Hong Kong importers, Indonesia supplies more than 50 per cent of the wild-caught live reef fish to Hong Kong and Singapore (Johannes & Riepen, 1995, pp. 10 & 35). This figure was close to the estimate of 60 per cent from Bentley (1999, p. 28), which was based on fisheries statistics from the main exporting countries (Indonesia, Philippines and Malaysia).

In Lau & Parry-Jones (1999) Indonesia was listed as the only country that exported mouse grouper (*Cromileptes altivelis*) and giant grouper (*Epinephelus lanceolatus*), whereas it accounted for 35 per cent of coral trout and 20 per cent of all other groupers (Lau & Parry-Jones, 1999, pp. 8–10). However, as was mentioned earlier, these data pertain almost exclusively to imports by air.

According to the Indonesian Directorate General of Fisheries, annual exports of live food fish from Indonesia averaged 3,500 tonnes over 1995–1996 (Bentley, 1999, p. 29), whereas Erdmann & Pet (1996, p. 6) present an even lower estimate for total exports of live food fish from Indonesia of 2,200 tonnes annually.



Epinephelus coioides

Cyanide-free, net-caught fish for the Marine Aquarium Trade[1]

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Abstract

The International Marinelife Alliance (IMA) has been training collectors in the Philippines and Indonesia to use barrier nets rather than sodium cyanide to capture marine aquarium fish. Despite the training, collectors have been slow to switch to using nets because they can earn more using cyanide. A new Philippine export company has agreed to pay the collectors more for net-caught fish and to adhere to standards being set by the USA-based Marine Aquarium Council. The IMA is monitoring the collectors and conducting cyanide testing to certify that the fish are net-caught and totally cyanide-free. Clearance certificates now accompany shipments of these marine-aquarium fish being shipped to wholesalers and retailers associated with the American Marine Dealers Association (AMDA) situated in the USA and Canada. AMDA members are being surveyed to assess whether the net-caught fish are more cost competitive compared to cyanide-caught fish for the marine ornamental fish trade because of reduced mortality through the chain from reef to retailer.

Introduction

The cyanide problem

Cyanide fishing has spread throughout Southeast Asia (Rubec & Pratt, 1984; Rubec, 1986, 1988a; Johannes & Riepen, 1995; Barber & Pratt, 1997, 1998). The application of 5,204 mg/L of cyanide for 10, 20, or 30 minutes killed corals within seven days (Jones & Steven, 1997). Lower concentrations (520 mg/L) resulted in the loss of zooxanthellae and impaired photosynthesis, which may cause corals to die over longer time periods (Rubec, 1986; Jones, 1997; Jones & Steven, 1997; Jones & Hoegh-Guldberg, 1999; Jones *et al.*, 1999). Cyanide is extremely toxic to fish (Duodoroff, 1980; Leduc, 1984) but about 50% survive the initial exposure if rapidly moved to clean water (Rubec, 1986, 1987c).

Most aquarium fish collectors use one or two 20 g sodium cyanide (NaCN) tablets in a one-litre squirt bottle, while food-fish fishermen use on average 3–5 cyanide tablets. A conservative analysis estimated that 150,000 kg of cyanide is spread on Philippine coral reefs each year (McAllister, 1988). Since not all of the cyanide initially dissolves, both dissolved hydrogen cyanide (HCN) and particulate NaCN is squirted on the coral heads as a whitish plume. Testing done by The Nature Conservancy on seized squirt bottles indicates that the dissolved HCN concentration leaving the squirt bottle is about 1500–2000 mg/L (Pet & Djohani, 1998).

Cyanide is known to impair enzyme systems, that facilitate oxygen metabolism (e.g., cytochrome oxidase) and other physiological functions in fish and invertebrates, and to damage the liver, spleen, heart, and brain of the fish (Dempster & Donaldson, 1974; Dixon & Leduc, 1981; Leduc, 1984; Hanawa *et al.*, 1998). Hence, cyanide fishing is believed to contribute to the high delayed mortality (>80%) of marine aquarium fish being exported to other countries (Rubec, 1987c, 1987d,1988a; Rubec & Soundararajan, 1991).

Community-based resource management (CBRM) programmes have been proposed as a means to conserve coral reefs, through more active participation of local people in the planning and implementation of fisheries management (White *et al.*, 1994). Despite its advantages, it is unlikely that local communities can implement CBRM on their own. Co-management was proposed, wherein the national government and the local community share authority, by using CBRM as a central element of co-management (Pomeroy, 1994).

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1. This article in condensed from an article of the same title that is in press with *Aquarium Sciences and Conservation*.
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To provide fishermen with an alternative to cyanide fishing, several NGOs have conducted net-training in the Philippines as part of CBRM programs over the past 15 years (Rubec, 1988b; Buhat, 1994; Pajaro, 1994). One of these NGOs is the International Marinelife Alliance (IMA). Its Destructive Fishing Reform Initiative (DFRI), funded by the Philippine government and foreign donors, involves a variety of village-level education / training programmes including the use of barrier-nets to capture marine-aquarium fish and hook-and-line methods for the capture of food fish (Pratt, 1996; Barber & Pratt, 1997). Over the past four years, the IMA has trained about 1,500 aquarium fish collectors in the use of barrier nets, and 500 in the use of hook-and-line capture methods.

As part of the DFRI, the IMA also maintains six cyanide detection test (CDT) laboratories for the Philippine Bureau of Fisheries and Aquatic Resources (BFAR) that have tested over 32,000 marine fish since 1993. Fish are sampled for CDT testing at various locations: from boats transporting fish, village holding sites, airports, and the facilities of middlemen and exporters. This reduces the possibility of fish being held longer to reduce cyanide concentrations, through urinary excretion. There has been a marked drop in the proportion of aquarium fish tested with cyanide residues present from over 80% in 1993, 47% in 1996, to 20% in 1998. However, many Filipino exporters continue to provide lip service to the benefits of net-caught aquarium fish while continuing to deal with middlemen who distribute cyanide to the collectors. Net-caught fish are being mixed with cyanide-caught fish in the exporters' facilities. The exporters then claim to be selling net-caught fish. Many retailers in the USA complain there is still a high rate of mortality in marine aquarium fish shipped from Indonesia and the Philippines.

Economic incentives

The IMA has been conducting net-training at various sites throughout the southern Philippines. During April 1999, the first author observed aquarium fish collectors being trained on IMA's 75-foot boat in the Davao Gulf, situated in southern Mindanao. He also visited Olango Island situated in the Central Visayas (Cebu-Bohol area), where IMA has been conducting barrier-net collection training and other alternative livelihood programmes.

Cyanide fishing started in Batangas (southern part of the Island of Luzon) and spread from the Central Visayas, where it has been used since 1962 (Rubec, 1987b). About 300 aquarium fish collectors and their families live in the villages of Santa Rosa, San Vicente and Sabang on Olango Island (Rubec, 1987b; Paras *et al.*, 1998; IMA, 1999). Many of the Olango Island collectors are third generation cyanide users and they have destroyed the coral reefs for over 300 miles in every direction. They have become economic slaves to middlemen, who provide food, boats, and other commodities, including cyanide, in return for high volumes of low-priced cyanide-caught fish. The middlemen sell the fish to Manila exporters. About 85% of the price paid by Manila exporters goes to the middlemen, and only 15% to the collectors. I learned that the collectors were eager to switch to nets, provided they could earn more to support their families.

Americans often blame the collectors for the cyanide problem, without realising that the problem lies with the middlemen, exporters and even North American buyers who refuse to pay more for net-caught fish. The result is the destruction of the coral reefs, which already has resulted in the disappearance of many species of fish in demand by the aquarium trade.

Most Filipino exporters do not believe they can make money selling net-caught fish. Hence, it becomes necessary for IMA to demonstrate what we have been preaching. The IMA is conducting a study to assess the mortality associated with net-caught fish, and to determine whether net-caught fish are a viable economic alternative to cyanide-caught aquarium fish. Some exporters who previously sold net-caught fish (e.g., Reg and Rix, Inc.) have reported mortality rates of <10% through the chain from reef to retailer. If the total mortality through the chain can be significantly reduced from over 90% to less than 10 per cent; then everyone in the trade will make more money.

Methods

Net-caught, cyanide-free fish

The IMA has been collaborating with a new Filipino export company to gather data concerning the survival and profitability of net-caught fish being exported to the USA and Canada. Asian Marine Resources Inc. (AMRI) has been buying net-caught fish from the collectors trained by IMA. By eliminating the middlemen, the collectors obtain more income for their fish. The company has created a new 20,000-gallon holding facility in Manila, and has also established collection stations in the southern Philippines. AMRI has been selling net-caught fish to foreign buyers for prices competitive with other Filipino exporters. Their export prices are similar to those recommended by the Philippine Tropical Fish Exporters Association. The IMA pledged its support to ensure that net-caught fish are shipped from collectors trained by IMA to the AMRI facility.

Aquarium fish are sampled at village holding sites and are then tested for cyanide at CDT laboratories situated in Davao City and Cebu City. The Manila CDT laboratory is also involved in testing fish randomly sampled from the AMRI export facility. Provided the fish are totally cyanide-free, each shipment receives a clearance certificate from the Manila CDT laboratory. The certificates are placed in the boxes containing fish that are shipped to the United States and Canada. The boxes are also sealed with tape indicating the fish are cyanide-free.

Surveys

The IMA has been collecting data to document fish mortality at each step of the chain from the villages, the Manila export facility, and at North American import facilities situated in Las Vegas-Nevada, San Jose and Los Angeles-California, in the USA, and Vancouver-British Columbia, in Canada. A telephone survey by IMA, during 1997, of over 300 US aquarium fish dealers, determined that mortality at the retail level of marine fish was on average: 60% on the east coast, 35% in the mid-west, and 30% on the west coast of the USA, during the first three days after their arrival at the stores.

The AMDA dealers are being surveyed concerning the mortality they experienced with fish purchased from wholesalers and trans-shippers, prior to their buying certified net-caught fish. This will be followed by a survey of their experiences with cyanide-free fish. In this way, we will determine whether net-caught fish survive better, and whether they are more profitable to retailers.

The IMA plans to analyse the data and publish the results. Hence, all the information will be summarised for the aquarium trade. We plan to conduct economic analyses that examine the effects of fish mortality on profit. Many dealers are unaware of its impact to their bottom-line. Hopefully, this will provide the scientific evidence needed to convince the industry that net-caught fish are a viable economic alternative to cyanide-caught aquarium fish.

Discussion

Heming *et al.* (1985) coined the term Sudden Death Syndrome (SDS) to describe the delayed mortality of fish after experimental exposure to thiocyanate ion (SCN^-). But there has been considerable controversy concerning which factors account for the high delayed mortality of marine fish in the marine aquarium trade. Fenner (1998) cited possible causes as '… cyanide, weeks of starvation, parasite loads, metabolite burn from holding and transporting fishes in polluted water, shipping stress, and lack of oxygen. The relative importance of these factors in causing mortality is largely unknown.'

About 50% of the exposed fish die from acute concentrations of hydrogen cyanide (HCN) applied on the reef (Rubec, 1986). The scientific literature indicates that concentrations greater than 5 mg/L are lethal, if the exposure time exceeds several minutes (Rubec & Pratt, 1984; Hall & Bellwood, 1995; Hanawa *et al.*, 1998). The Nature Conservancy study found that coral heads are being blitzed with HCN concentrations greater than 1,500 mg/L (Pet & Djohani, 1998). It seems likely that the surviving fish are those that try to avoid the plume.

At the village level, marine aquarium fish are often held on land in plastic bags or buckets, on the floor or on wooden structures for three to five days (Baquero, 1995). During this time the water is changed once a day. Expensive species get two water changes a day. It seems likely that the fish are stressed due to the accumulation of the ammonia in the bags, and from salinity and temperature fluctuations. The collectors experience about 30% mortality on their fish prior to shipping them to Manila.

As part of the barrier-net collection training, IMA has been teaching collectors to hold fish in floating cages or in perforated buckets attached to anchor lines. AMRI has a building situated in the municipality of Santa Cruz, near the City of Davao, equipped with aquaria that receive running seawater from the bay. Further studies are needed to determine whether the means of handling and holding fish at the village level contribute to the delayed mortality observed on fish being imported into the USA.

Many exporters in the Philippines do not have advanced filtration systems, ultraviolet light sterilisers, or use ozone to control diseases in their systems (Rubec, 1987d; Baquero, 1995). The fish are often crowded and the water quality may not be ideal. Most companies use copper in the seawater to control parasitic protozoa like Cryptocaryon and Amyloodinium. When the fish arrive at the export facility, they are transferred from bags, and several days later they are put into plastic bags again for export. The water changes involve quick changes in salinity and pH. It is not clear what effect these water changes have on the fish.

Most marine aquarium fish enter the USA through Los Angeles, San Francisco, or New York. Traditionally, the fish are unpacked by the importer and placed in aquaria for a day or two, then repacked and sent to wholesalers, or retailers throughout the country. Starting in 1991, trans-shippers started a new approach. Brokers clear the fish through US customs; then the fish are taken to a facility where the water in the bags is quickly replaced. The fish are then put on the next airplane and sent to retailers. Sometimes, the fish are immediately forwarded to wholesalers or retailers without any water changes.

While trans-shipped fish are cheaper, retailers are faced with having to acclimate fish that arrive extremely stressed. Several retailers on the east coast of the US have reported higher mortality with fish purchased from trans-shippers (>60%) in comparison to fish obtained from traditional importers (30–40%) situated in Los Angeles. Generally, it takes 20–25 hours to ship fish from the Philippines to Los Angeles, and more than 40 hours for fish shipped to New York.

On top of all of the above, there are the usual horror stories of fish being left out on the tarmac in mid-winter by the airlines. Such fish are dead, of course, on arrival at their final destination. In short, we can safely conclude that more than one factor is responsible for the high mortality of fish (>90%) in the marine ornamental trade.

Hall and Bellwood (1995) conducted experiments with damselfish (*Pomacentrus coelestris*) collected with nets from the Great Barrier Reef in Australia. They exposed different groups of damselfish to cyanide (10 mg/L for 85 seconds), stress (coral rubble removed from holding tanks), or starvation (not fed). The mortality over a 13-day period was 37.5% for the fish exposed to cyanide alone, 25% for the stress alone group, and 0% for the starvation alone group. When all three factors were applied together the mortality was 41.7%.

The term 'stress' covers a complex range of phenomena. Robertson *et al.* (1987) recognised the 'stressor' that induces stress and creates the stress response. The stress response is characterised by the excretion of catecholamines and corticosteroid hormones in the fish. The elevated hormone levels induce secondary effects such as metabolic, osmoregulatory, and immune system changes. Tertiary effects, such as increased susceptibility to disease are evident after chronic exposure to stressors.

A variety of factors can act as stressors to fish including pollutants, heat and cold shock, pharmacological agents including anaesthetics, and those related to handling, restraint, or transportation (Robertson *et al.*, 1987). Corticosteroids are elevated by abrupt changes in water temperature, salinity, depletion of dissolved oxygen, or sub-lethal ammonia. Hence, biochemical stress responses can be induced by a deterioration in water quality.

The affects of multiple stressors are often additive, and can result in considerable mortality even though the individual stressors are sub-lethal. Lanno and Dixon (1991) found that levels of SCN^- that were not lethal to rainbow trout (*Oncorhynchus mykiss*) during a given exposure period became lethal after the application of a physical stressor, such as chasing the fish with a dip net. Fish that were not exposed to SCN^- survived netting and weighing. All fish exposed to 160 mg/L SCN^- died after netting and weighing. With trout exposed to 120 mg/L SCN^-, 40% died before the end of the 16-week growth trial.

Hanawa *et al.* (1998) likewise reported that groups of ten humbug damselfish (*Dascyllus aruanus*), pulse-dosed with 50 mg/L cyanide ion (CN^-) for 60 seconds, exhibited higher mortality (100%) after being stressed by bagging, than non-stressed control fish (0%). Under non-stressed conditions, pulse exposures of 25 or 50 mg/L CN^-, for 10 and 60 seconds respectively, significantly reduced liver oxygen consumption rates measured 2.5 weeks post-exposure. Under stressed conditions, liver oxygen consumption rates were significantly higher in cyanide-exposed fish than control fish. The combined effects of cyanide exposure and stress increased the mortality and placed an appreciable metabolic load on the fish. Hence, cyanide exposure in combination with handling stress could partly explain the high delayed mortality in the marine aquarium fish trade.

Exporters in the Philippines have reported high mortality of marine fish after turning on lights or associated with netting of cyanide-caught fish (Rubec, 1987a). Hence, cyanide exposure can be considered a factor that makes marine aquarium fish more susceptible to handling-related stressors. Cyanide fishing may induce the SDS, and contribute to the delayed death of marine fish in the aquarium trade.

Carmichael *et al.* (1984) monitored corticosteroid and plasma chloride levels in largemouth bass (*Micropterus salmoides*) associated with handling and transport. Corticosteroids and glucose levels in the blood increased immediately after the fish were crowded and loaded for transport. The hormone levels remained high during 30 hours of simulated hauling. Although no fish died during hauling, high mortality (88%) occurred within four days after the hauls. It took 5–7 days for corticosteroid and glucose levels to return to baseline levels. Stress was reduced significantly and the mortality eliminated, when the fish were: treated for diseases; held 72 hours without food, and then anaesthetised before they were loaded; hauled at a cool temperature in physiological concentrations of salts with an antibiotic and a mild anaesthetic added; and allowed to recover in the same medium minus the anaesthetic.

Several importers interviewed by IMA have reported a marked reduction in the mortality of the marine fish sold to retailers, by quarantining the fish they receive for 5–7 days. This may indicate that mortality can be reduced, if fish are held in an import facility long enough to allow stress hormone concentrations to return to baseline levels. Net-caught fish usually recovered, when properly held and acclimated to deal with low pH (5.5–6.0) and elevated ammonia levels in shipping water (K. Goldsmith, pers. comm., 1995). Cyanide-caught fish often died, despite the use of acclimation protocols and being held for a week at the import facility. Goldsmith had <10% mortality on net-caught fish and >30% mortality on cyanide-caught fish imported from the Philippines to the US east coast (New Jersey).

The importers and AMDA retailers cooperating with IMA have agreed to hold fish for 5–7 days prior to shipping them to retailers. They have also agreed to adhere to water quality standards and holding procedures being developed by the Marine Aquarium Council (Resor, 1997). The present study with AMRI and AMDA seeks to reduce fish mortality in the trade, resulting from all contributing factors.

The Haribon Foundation found that a large proportion (71%) of 176 collectors who received net-training from 1991–1993 reverted to the use of sodium cyanide (Pajaro, 1994). This was attributed, in part, to the fact that fine-mesh barrier nets were not available, and to the fishermen's lack of skill in the use of accessory gear (steel pokers).

The IMA is also experiencing backsliding. About 30% of the collectors who have received net-training from IMA have reverted to the use of cyanide. The collectors get paid by the number of fish caught, and they can catch more fish per day using cyanide than using nets. It seems apparent that fishermen using nets should be paid more for their fish, to offset the loss in income associated with switching from using cyanide.

Many collectors sell their fish to middlemen, who distribute cyanide. The IMA has assisted the collectors in some areas to set up fisherman associations that allow them to sell directly to exporters seeking net-caught fish. AMRI is paying the collectors in the Davao area 50% more for aquarium fish; compared to what they could obtain from middlemen. Further studies are needed to determine the economic incentives needed to prevent backsliding.

The IMA believes that net-caught fish can be economically viable. This depends to a large degree on reducing the mortality at each step of the chain from collector to retailer, in the most cost-effective manner. The IMA also plans to evaluate the addition of chemicals to the shipping water and the use of breathing bags (which expel carbon dioxide), to assess whether this helps to reduce fish mortality rates (Teo *et al.*, 1989; Rofen, 1996). Provided the fish are net-caught, the trade should be able to minimise the stress associated with handling and transport. The measures discussed in the present paper should help to make the marine aquarium fish trade more sustainable.

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Fiji Cabinet considers total ban on coral and live fish export

Source: *PacNews*, 7 Sept. 1999

A Cabinet sub-committee has been set up in Fiji to look at the impact on Fiji's natural marine live through commercial harvesting of coral and export of pet fish. A statement from Cabinet said the sub-committee will consider a total ban and revocation of licences because at the moment, there is no effective form of monitoring the trade of coral and aquarium fish in the country.

'Almost all other countries have imposed a total ban on the harvest and export of coral and aquarium fish. Fiji is one of the few countries that continue to allow it through regulation. Government has taken these steps in view of reports of possible ecological damage to the marine environment from these activities,' the statement said.

Coral and aquarium fish exports: what certification holds for Fiji

Source: *Fiji Daily Post*, 25 September 1999

Fiji is one of 70 countries which export coral and aquarium fish, that will develop and apply practices which companies will have to follow. This is the result of a proposal put forward by the Marine Aquarium Council on future international trade in fish and coral for aquariums.

The council said that trade may only be possible if it meets strict environmental and shipping standards. The council is a non-profit organisation based in the United States, composed of collectors, exporters, importers, retailers, aquarium hobby clubs and environmental organisations such as the World Wide Fund for Nature.

A three-year timetable to introduce certification of exporters, importers and retailers was agreed to by the council at its board meeting in Kentucky, USA, last week. Once the certification process is introduced, customers will know which coral and fish to collect in a way that is environmentally friendly and sustainable.

The World Wide Fund for Nature's Pacific director, Peter Hunnam, said WWF is promoting and assisting with the certification approach.

'People who buy live fish and coral specimens for their aquariums are discerning consumers who are willing to pay more if they can be sure that the animals they buy were harvested sustainably,' Mr Hunnam said.

'Certification will provide that assurance. The aim is to certify that a coral is being harvested in a way that also conserves the reef, no rare or endangered species is collected, and the fishery is operated with minimum wastage. The local owners of the reef will share properly in the benefits from the fishery.'

He said certification can help bring consumer power to assist the conservation efforts of government agencies and local communities.

'Each coral harvesting operation can try to meet these high standards for ecological sustainability. Certification would cover the whole chain, from the reef, the collectors, the exporter, the importer and the retailer,' said Mr Hunnam.

Certification will be conducted by independent companies, accredited to the Marine Aquarium Council. Council advisory board member, Walt Smith, who is the director of Walt Smith International, Fiji's largest exporter of coral and fish, said the certification would be voluntary.

'It will not stop non-certified companies from exporting at first, but the council is working to get the certification accepted at government level. It hopes that, eventually, governments of exporting countries will only give licenses to certified exporters, and importing countries' government will only allow imports and sales by certified companies,' he said.

'Even if that doesn't happen, the council is creating a group of informed importing companies, particularly in Europe and the USA, that will buy only from certified companies, because they will know the quality is right and the buyer is not getting substandard products collected unsustainably.'

'Once there is a critical mass of companies and countries participating in the certification, companies that don't get certification will be rejected in the marketplace.'

Mr Smith added that there had been much controversy about exporting coral and fish from Fiji, and the government has a Cabinet sub-committee currently looking into the matter.

'I feel it's time to set the record straight. The aquarium industry has been largely responsible for raising international concern about coral reefs, because it has brought the reef ecology into homes, public aquariums and research aquariums. It would be a great shame if this same public awareness is the cause of our destruction, because of people being misinformed about our effect on the environment,' Smith said.

'Certification is one of the best ways of proving to the world that the industry can be sustainable.

There are operators, such as us, who are willing to be certified as proof that they are doing things properly.'

Mr Smith said Fiji, Hawaii, Indonesia and the Philippines have been chosen as the pilot areas for testing the chain of custody of coral and fish exports. Their industries are relatively small and easily monitored.

'Fiji has five companies that export live fish or coral and they employ over 500 people. The industry is worth over $12 million to the Fiji economy per year, and it is in everyone's interests to ensure it is done sustainably. At present, we have an excellent reputation for high quality products that reach their destination in very healthy shape,' he said.

Over 70 countries export live fish, and about 20 also engage in the live coral or dead coral rock trade. There is a big task ahead to get certification for a majority of companies within the three-year time limit. It will be done on a regional basis, with Fiji as a coordinating hub for the rest of the South Pacific,' Mr Smith said.

The council has received support and funding for the certification development from the WWF, the Packard and Henry Foundations, the World Bank, the American Zoo and Aquarium Association and other large corporations and conservation organisations.

Grouper aquaculture in Korea

by Lee Young Don
Cheju National University, Cheju-Do Korea

Source: *aquaculture Asia* (1999) vol. 4(4): 44.

Grouper aquaculture in Korea may be described as the state of collecting young grouper 5–20 cm in length, usually for the sea and raising the in netcages for a certain period of time. Fishing of young grouper is closely related to the spawning season and the Kuroshio current that develops from May–June. This current has influence even on the Korea south sea, from the coastal Cheju Island.

The spawning season of grouper is around June–August at the southern coast of Cheju Island. Young grouper move even to the Korean south sea along the Kuroshio current. Young grouper inhabit the rocks and reef in the southern coast from May to November.

Young fish collected at the southern seacoast are raised in netcages in the Korean south sea seashore and some areas in the Cheju Island.

Grouper aquaculture production is about 50–100 metric tonnes in Korea. The harvest of wild groupers of 700 to 3,000 grams is about 30 metric tonnes.

Seven species of grouper and 10 species of reef fish are distributed along the coast of Cheju Island and the Korean south sea. These groupers are *Epinephelus akaara*, *E. awoara*, *E. chlorostigma*, *E. fario*, *E. fasciatus*, *E. moara*, *E. septemfasciatus*. Grouper usually caught include convict grouper, longtooth grouper and red grouper. But the harvest of wild groupers has decreased gradually as a result of overfishing using line and hook, and spear gun.

As to growth rate, daintiness and market value, convict grouper and longtooth grouper are among the most important future mariculture fish in Korea. The demand for aquaculture groupers is increasing rapidly in Korea. Many researches have been focused on their reproductive biological characteristics.

Our studies on grouper to date include those on sex maturation, sex reversal, spawning induction, and broodstock management for the production of the fertilized egg, development of live-food organism and culture technique development of larvae and juvenile of grouper will continue.

Animals suffer as aquariums flounder

by Jennifer Erhlich

Source: Condensed from the *South China Morning Post*, 10 April 2000

Hundreds of aquariums have sprung up in China's largest cities in recent years as investors seek new opportunities to snare the increasingly disposable income of mainland Chinese. But in case after case, aquariums are not proving to be as lucrative an investment as the money-men first anticipated. When profits wane or partnerships turn bad, aquarium animals are mistreated or abandoned.

Two Sichuan provincial aquariums were abruptly closed recently, killing all the fish and animals inside. In one case, the managers failed to pay the electricity bill and the animals died when utility workers cut off the power. When the second aquarium went bankrupt, its managers simply locked the doors and cleared out, leaving the animals with no food or attention until they died.

'A lot of unscrupulous entrepreneurs decided aquariums are a way they can make money and they invest without doing any market research,' said Grace Gabriel, Beijing director of The International Fund for Animal Welfare (IFAW).

IFAW, which tracks aquariums in China, said death rates are far higher than those at similar facilities in the West because of a focus on profits rather than animal protection.

'Aquariums run into financial trouble because inexperienced mainland investors over-anticipate visitor numbers and underestimate the high expense of looking after health-sensitive animals,' said Anthony Aucutt, manager at Aquarium 21, an Australian joint venture project in Beijing.

'In this industry if you don't have experience, you get into trouble,' said Mr. Aucutt. 'A lot of Chinese managers got into the aquarium business before they realised how much market research was needed.'

Animals are dying more quickly in Chinese aquariums because of inadequate investment in facilities and because many are caught in the wild in places where cyanide is commonly used for fishing some overseas managers claim.

Mr Aucutt said that at Chinese aquariums a cycle tends to emerge where the facility opens using up-front money to bring in a wide range of healthy animals from Australia, the US and elsewhere. Then, when revenues do not meet expectations, Chinese aquariums begin to replace the foreign fish with those caught off Hainan Island or in the Pearl River Delta. These fish may be affected by cyanide said Jeff Archer, JV China's aquarium curator and former curator at the Blue Zoo, a competing Beijing aquarium.

Other factors contributing to animal deaths are water treatment and filtration systems, both of which require intensive maintenance, well-trained staff and expensive equipment.

Some say the greatest hazard to the animals is the overblown expectations of investors in the face of waning interest in aquariums internationally. Investors say backers of China's aquarium projects are routinely promised that each aquarium will attract seven or eight million visitors a year, when one to 1.5 million would be a more realistic estimate for a good year. Australian, Hong Kong and Singaporean investors are the principal backers of China's aquarium boom.

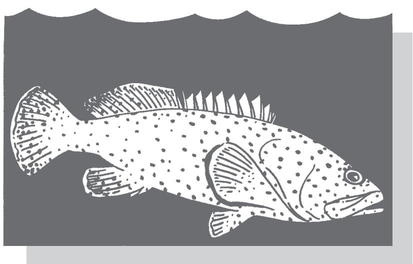
Aquariums in the United States, and around the world, are not as popular as they once were. They sprung up all over the country in the l960s and 70s. They began to collapse when the economy wavered in the 1980s. Underwater World's high profile aquarium in the Mall of America in Minnesota teetered on the edge of bankruptcy after it opened in the mid-1990s. The huge facility had lured few visitors to a mall that recently beat out Disneyworld as America's most visited tourist spot.

Australian first for Reef Fish Research Program

by Elizabeth Cox & Mike Rimmer
Northern Fisheries Centre, Cairns, Queensland, Australia

Since 1997 the Reef Fish Aquaculture Project at the Northern Fisheries Centre in Cairns has focussed on breeding techniques for two reef fish species, barramundi cod *Cromileptes altivelis* and flowery cod *Epinephelus fuscoguttatus*. Flowery cod broodfish held in covered, outdoor tanks at ambient conditions performed poorly over two years—females developed eggs for only two weeks during this period. Performance was greatly improved when broodfish were moved to tanks with environmental (temperature and photoperiod) control. This shift triggered the production of sperm and eggs 4–6 weeks after relocation.

The 1999 breeding season started early and successfully when the flowery cod spawned in late September on the full moon whilst held in environmental (temperature and photoperiod) control. The broodfish tanks have full covers and are located in a shed preventing any exposure to natural environmental conditions. Male fish exhibited well-defined pre-spawning behaviour, which continued for a period of two to three weeks prior to spawning occurring. The male frequently approached the female turning on his side and flashing past her with the lower half of the body turning white. Spawning appeared to be linked to the lunar cycle with two groups of fish held in two separate tanks under environmental control spawning on the full or new moon. Spawning from one pair continued over four nights producing 20 million eggs (92–98% fertilisation). Spawning continued for two months with one group of fish maintaining gonad condition for a further two months. This is the first time that this species has been spawned in captivity in Australia, and only the second time anywhere, that any grouper species has been spawned using environmental control.



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live reef fish

LAU, PATRICK P.F. & L.W.H. LI. (2000). Identification Guide to Fishes in the Live Seafood Trade of the Asia-Pacific Region. WWF Hong Kong and Agriculture Fisheries and Conservation Department, Hong Kong. 137 pages.

This magazine-sized guide provides a comprehensive, illustrated list of 98 fish species that are found in the live seafood trade in the Asia Pacific region. It is intended for use by customs and fisheries officials, traders, fishers and other stakeholders in the industry. Photographs of each species, of generally high quality, are provided, along with scientific names, English common names and common names used in Australia, China, Hong Kong, Indonesia, Malaysia, the Philippines, Singapore, Taiwan and Vietnam. The main purpose of the guide is to ensure accurate and comprehensive monitoring of the trade. Printed on high-quality paper and sturdily bound, it is designed to withstand rough handling. A limited number of copies is available from Alex S.K. Yau, Senior Conservation Officer, WWF Hong Kong, No. 1 Tramway Path, Central, Hong Kong.

HAMBRY, J., L.A. TUAN, N.T. NHO D.T. HOA & T.K. THUONG. (1999). Cage culture in Vietnam: How it helps the poor. Aquaculture Asia 4(4): 15–17.

Of particular interest to some readers will be the finding that production of all six species of juvenile groupers collected from the wild for growout were positively correlated with seagrass cover, but not with mangroves. These species were *Epinephelus akaara, E. malabaricus, E. coioides, E. merra, E. sexfasciatus, E. bleekeri* and *Cephalopholis miniata*.

RIMMER, M. (1999). Reef Fish Aquaculture. Potential, Constraints and Status. Queensland Aquaculture Information Series QI99076. 15 pages.

Copies may be obtained from Manager, DPI Publications, Department of Primary Industries, GPO Box 46, Brisbane, Queensland 4001, Australia.

Grouper and Napoleon Wrasse Spawning Aggregation Sites (1998–1999) in the Komodo (Indonesia) National Park.

Contains monitoring and potential management programme for various reef fish food fish species that aggregate to spawn, including *Epinephelus polyphekadion, E. fuscoguttatus, Plectropomus laevis, P. leopardus, Cromileptes altivelis* and *Cheilinus undulatus*. For full report contact Jos Pet of The Nature Conservancy Indonesia Field Office, E-mail: jpet@ibm.net.

GREEN & SHIRLEY. (1999). The Global Trade in Coral. World Conservation Press. Cambridge, U.K. 70 pages.

Available from World Conservation Monitoring Centre. E-mail: info@wcmc.org.uk.

JONES, R.J., T. KILDEA & O. HOEGH-GULDBERG. (1999). PAM chlorophyll fluorometery: a new *in situ* technique for stress assessment in Scleractinian corals, used to examine the effects of cyanide from cyanide fishing. Marine Pollution Bulletin 28: 864–874.

AQUARIUM FISH AND CORAL FISHERIES WORKING GROUP. (1999). Queensland Marine Aquarium Fish and Coral Collecting. Queensland Fisheries Management Authority Discussion paper # 10.

This discussion paper is part of the management planning process and is the first stage in public consultation leading to the preparation of a management plan for marine aquarium fish and corals in Queensland.

GLAMUZINA, B., V. KOZUL, P. TUTMAN & B. SKARAMUCA. (1999). Hybridization of Mediterranean groupers: *Epinephelus marginatus* x *E. aeneus* and early development. Aquaculture Research 30: 625–628.

PAWIRO, S. (I999). Trends in major Asian markets for live grouper. Infofish International. 4/99: 20–28.

TOLEDO, J.D., MA.S. GOLEZ, M. DOI & A. OHNO. (1999). Use of copepod nauplii during early feeding stage of grouper *Epinephelus coioides*. Fisheries Science. 65: 390–397.

JAMES, C.M., S.A. AL THOBAITI, B.M. RASEM & M.H. CARLOS. (1999). Potential of grouper hybrid (*Epinephelus fuscoguttatus* x *E. polyphekadion*) for Aquaculture. Naga 22: 19–23.

Grouper Culture in Brackishwater Ponds

This is a 17 page manual and includes information on sourcing fry and fingerlings, site selection, pond preparation, nursery operation, grow-out culture, harvest and post-harvest. It also describes the economics of one grouper crop, marketing and transport techniques and diseases. Price (including postage): 80 pesos in the Philippines, US$ 30 in other countries. Available from SEAFDEC Aquaculture Department, Tigauan 5021, iloilo, Philippines. E-mail: sales@aqd.seafdec.org.ph.

A new e-mail discussion group on the Live Reef Fish Trade

by Tim Adams
Director, Marine Resources Division, SPC

The Secretariat of the Pacific Community (SPC) has just set up an e-mail discussion group to service its 'Live Reef Fish' (LRF) network—a special interest group covering the live reef fish trade. This network originally set up to cover the LRF trade in the Pacific Islands only but now covers a much broader area.

The *Live Reef Fish Information Bulletin* is published by SPC on a 6-monthly schedule and, whilst it is an excellent resource for substantial news items and primary information, it cannot possibly respond rapidly enough to cover some of the shorter-term issues arising in this rapidly-moving trade. This e-mail discussion group has been set up at the SPC hub to provide a more immediate way of exchanging news and information between members of the network, and to enable a more rapid response to issues arising.

The purpose of the list is to provide a way of disseminating announcements and information quickly amongst a group of like minded people; a way of asking questions in the reasonable hope of getting a useful response from someone who is reasonably expert; and of generally arguing with each other about the best way of doing things.

If you send an e-mail message to the list address it will be automatically copied to everyone else on the list. It is very simple in principle but can be remarkably effective.

You can subscribe to the list by sending an e-mail to the address **join-live-reef-fish@lyris.spc.int** and the list-server computer will automatically add your name to the group and send you an e-mail with instructions on how to send messages to the group, unsubscribe, or find out who else has joined the group, etc.

Alternatively you can enter the address **http://www.spc.org.nc/cgi-bin/lyris.pl?enter=live-reef-fish** in your web-browser's address bar and follow the instructions on the page.

SPC is the figurehead of the 'Pacific Islands Live Reef Fishery Initiative' a loose association of organisations devoting part of their capacity to the LRF issue in the Pacific. SPC's particular interest is in assisting and advising its Pacific Island member countries and territories to assess, develop and manage fisheries in an environmentally and economically sustainable way, and the live reef fish trade is naturally a topical subject in many islands, particularly in the west and north of the region. SPC recently entered into an understanding with The Nature Conservancy, the International Marinelife Alliance and the World Resources Institute about more formally implementing part of this 'Pacific Islands Live Reef Fishery Initiative', supported by funding from each organisation and, in the coming months, through a project of the Asian Development Bank as well.

There are several other agencies associated with SPC in the family of Pacific Island regional intergovernmental organisations called 'CROP' (Council of Regional Organisations in the Pacific), and other CROP agencies, including the University of the South Pacific, the Forum Secretariat and the South Pacific Regional Environment Programme, have roles within the Initiative. The Forum Secretariat, for example, is collaborating with the Marine Aquarium Council to investigate the potential role of consumer-targeted sustainability certification in the aquarium fishery. Other organisations actively associated with the Initiative include the International Center for Living Aquatic Resources Management (ICLARM) South Pacific branch, which is carrying out research on reef fish larvae.