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LIVE REEF FISH

The live reef fish export and aquarium trade

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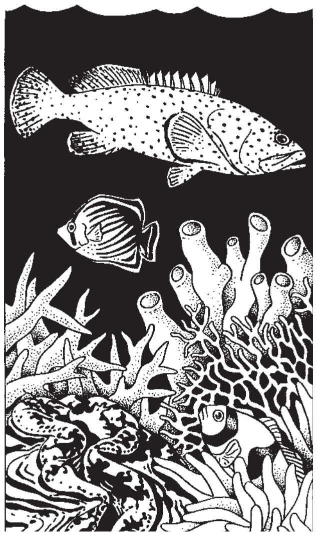

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Editor's mutterings

Breaking environmental laws

When faced with environmental problems, experts on marine resource management often recommend new laws. Yet most such laws, including those against using cyanide in the live reef fish trade, are broken routinely in Southeast Asia, and increasingly in the Pacific Islands.

Our management prescriptions often ignore this central problem because biologists (who for better or worse are usually the people who prescribe conservation measures) generally don't know how to deal with it. And social scientists who study natural resource-use patterns in the region tend to ignore it, leaving resource managers with nowhere to turn for insight or guidance in designing management measures that come to grips with it.

The only research I have come across that focuses squarely on the subject as it relates to destructive fishing in the coastal tropics is that of Galvez *et al.* (1989)[1]. These authors lived in two Philippine fishing villages long enough to gain the trust of the villagers. This enabled them to learn much about why destructive fishing was routine in the area, how it operated, and how participants viewed it. Published in the proceedings of a conference that focused on a single bay in the Philippines, their work has not received the attention it deserves.

The authors describe how local fishermen justified their fishing with cyanide or explosives by saying that it was a victimless crime, that without it 'how would our children live?', and that there was no other way of catching certain species. Fishermen also said that trawlers operating illegally in their waters, but towards whom the law turned a blind eye, did far more damage to marine habitat. The benefits of illegal fishing were widely distributed within the fishermen's communities, and were thus

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often seen by community members to outweigh the costs of environmental damage, bribes, and (less frequently) fines.

In addition, fisheries enforcement officers were poorly paid, providing strong incentives to overlook destructive fishing practices in exchange for money, fish or other favours from fishermen. In doing so they considered that they were doing the latter a favour. The military was reportedly also heavily involved in taking bribes, as well as in supplying fishermen with explosives.

Enforcement authorities considered legal penalties too harsh, enhancing the appeal to fishermen of bribery as an alternative. There were loopholes in the law. Politicians, who often financed illegal fishing activities, sometimes forced the release of arrested fishermen in exchange for political support from their communities.

The law-breaking was not confined, then, simply to fishers. Corrupt practices that encouraged their activities were operating in every key institution in the area except, perhaps, the church. Here, then, is an example of why natural resource management laws and regulations based solely on biological considerations often fail.

Education and co-operative management with the assistance of NGOs can assist some fishing communities to find satisfactory alternatives to illegal fishing. But such efforts appear to be too time-consuming, labour-intensive and costly to extend to the majority of fishing communities in the region. We have no alternative but to try to steer most of them away from these practices by simpler strategies.

To help us design such strategies, we badly need social scientists to replicate the research of Galvez and colleagues and to extend it geographically and culturally. It should focus not just on natural resource users themselves, but also on institutions whose corrupt practices encourage their environmental lawbreaking.

The primary object of natural resource management is to influence people. Better understanding of the human dimensions of environmental problems is thus essential if we are to improve our performance.

Ciguatera

Ciguatera seems to have quickly become perhaps the single biggest issue in connection with the live reef food fish trade in the Pacific Islands. Yvonne Sadovy's article in this issue provides an important perspective on it and poses some difficult questions.

TRAFFIC LRF report finally out

This issue includes a summary of Nokome Bentley's excellent and comprehensive report for TRAFFIC on the live reef fish trade in Southeast Asia. Unfortunately, bureaucratic delays held up its release for more than a year, weakening its impact. Nevertheless, it remains an important document. One of Bentley's findings for Indonesia that bears repeating is: 'for most regions, once exports began, it took only three to four years for them to reach a peak and then to decline. Like a wave, the industry has spread throughout the country; live fish exports rising and falling in its wake.'

Bob Johannes

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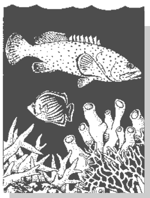
1. Galvez, R., T.G. Hingco, C. Bautista & M.T. Tungpalan. (1989). Sociocultural dynamics of blast fishing and sodium cyanide fishing in two fishing villages in the Lingayen Gulf area. p. 43-62. In: G. Silvestre, E. Miclat and T.-E. Chua (eds.) Towards sustainable development of the coastal resources of Lingayen Gulf, Philippines. ICLARM Conference Proceedings 17. International Center for Living Aquatic Resources Management, Makati, Metro Manila, Philippines.
   For an important perspective on a related form of corruption in the Philippines, see Gomez, E. (1999). Environmental charade. Marine Pollution Bulletin 38(1): 1–2.



Ciguatera – A continuing problem for Hong Kong's consumers, live reef fish traders and high-value target species

by Yvonne Sadovy[1]

Ciguatera poisoning (an illness caused by consuming fishes that contain naturally occurring ciguatoxins) continues to plague the live food fish trade in Hong Kong, and poses a threat to both consumers and, indirectly, to highly-valued target species. Moreover, there is little hope of an effective solution to the problem in the short term without legislative changes. This article examines the sharp increase in ciguatera cases in Hong Kong over the past three years, the impacts on retail prices, the inability of the Hong Kong Government to protect consumers from exposure to ciguatoxic fishes and implications for reef fishes that are frequently ciguatoxic. Potential impacts on the economic development of the nearshore resources of economies where these ciguatoxic fishes frequently occur have been addressed elsewhere (Dalzell, 1992).

Low levels of ciguatera have been recorded in Hong Kong for over 10 years, and were evidently associated with fishes caught locally or in the northern sector of the South China Sea. Cases were not common, however, and the condition was not considered a particular health problem. As local and regional reef fish stocks became overfished, however, and Hong Kong-based businesses searched ever further for rich fishing grounds, they unwittingly found themselves the conveyers of toxic fishes back to Hong Kong (Sadovy, 1998a).

By the mid-1990s, having largely depleted readily available stocks in the Philippines and Indonesia (e.g. see Bentley, this issue), businesses explored fishing possibilities ever further east into the Pacific and west into the Indian Ocean. By 1998 they had reached at least as far as the Seychelles at one extreme and were negotiating with Fiji at the other. Such distances from Hong Kong make for long (20 days or more) and costly transportation by sea and were only possible because of the high retail prices of live reef fishes, low prices paid at source, and the large capacity (up to 30 mt) of the cargo vessels used.

A problem arose when some of the western Pacific sites being exploited proved to be sources of significant numbers of ciguatoxic fishes producing hundreds of victims of ciguatera in Hong Kong. From an annual average of about 70 cases of ciguatera between 1993 and 1996, to 95 in 1997, the incidence rose to 425 in 1998 (*South China Morning Post*, 25 January 1998; Hong Kong Department of Health). Despite the fact that several of the newly-exploited areas are well-known sources of ciguatoxic fishes, both the Hong Kong Government and the Hong Kong-based live reef fish trade appeared to be unaware of, and certainly unprepared for, the problem of importing toxic fishes. Although dead fish are occasionally tested for ciguatoxins[2] for the Hong Kong Department of Health, there is no legal requirement for live fish to be tested because, for historical reasons, they are not considered to be 'food '. Moreover, since most importers use Hong Kong-registered vessels that do not have to declare their cargo on import, it proved difficult to trace the origins of the first contaminated shipments and to intercept shipments for testing.

Hong Kong has one of the highest *per capita* seafood consumption rates in the world and markets a wide diversity of fish and invertebrate species. About 80% of the fish consumed locally are imported. At the lower end of the price market are a few freshwater and cultured species, while a broad range of tropical marine reef fishes and invertebrates, maintained alive until cooking, command the top prices. These are imported in large volumes (live reef fish imports in the last couple of years are estimated at about 30,000 mt annually). In a survey of fish species and sizes marketed live for food, many of the more commonly encountered species being sold (e.g. tiger grouper *Epinephelus fuscoguttatus*; flowery grouper, *E. polyphekadion*, coral trout, *Plectropomus* spp.), were potentially ciguatoxic (Lee & Sadovy, 1998; Sadovy, 1998b). The risks to the public, in terms of both species and volumes being marketed, were clear.

Current laws and recent government actions cannot protect Hong Kong consumers from ciguatoxic fishes, if these are marketed alive. While it is illegal to sell contaminated food, since live fish is not classified as food, technically the Government has no

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2. Using a mouse bioassay, a reference level is set at 100 'mouse units' / kg, below which fish are considered to be safe for sale; there is, however, no international consensus on safe levels of these toxins.

authority to prevent their sale. In a recent incident, about 10 mt of contaminated fish were knowingly shipped to Hong Kong from Fiji by a Hong Kong company. Intervention by the Hong Kong Chamber of Seafood Merchants and informal action by the Departments of Health and Agriculture and Fisheries ultimately prevented sale of the fish in Hong Kong. However, the fish were eventually sold in mainland China with unknown impacts on consumers. And trade continues with Fiji!

This case revealed several areas for concern. First, some importers do not feel responsible for the risk they knowingly expose consumers to. Second, there is no authority in the the Hong Kong Government to prevent such sales and protect local consumers. Although there is now an informal process (currently under review by Dept. of Health) whereby fish may be screened for toxins prior to arrival in Hong Kong, the government has no legal power to prevent their sale by, or to prosecute unscrupulous vendors. To advise the public of the risk they might face in eating too many reef fish, or large fish of certain species which may carry ciguatoxins, posters were produced for distribution in appropriate areas. But when I recently made two visits to one of the two major retail outlets for live reef fish in Hong Kong, Lei Yue Mun, not one warning poster was displayed.

The problem of ciguatera needs to be addressed; the implications for business and for the public are obvious, those for the target species are less so but nonetheless significant. Following reports of ciguatera, retail prices became temporarily depressed by 20 to 60%. It was not only those species which pose the most risk which were affected, but all fish, including those that were cultured, freshwater species and locally caught fishes; the public does not appear to discriminate (Agriculture and Fisheries Department; Patrick Chan, pers. comm).

While businesses clearly suffer from reduced sales and lower prices and people become ill, it is also important not to overlook implications for certain exploited fish species. Since larger individuals of susceptible species tend to pose a greater risk of ciguatera than smaller ones (due to accumulation of toxins over time), there has, predictably, been an increase in demand for smaller fish. This trend is reflected in the greater proportion of juveniles being sold in retail outlets compared to three 3 years ago (Lee & Sadovy, 1998; pers. obs.). Among the top valued grouper species implicated in recent incidences of ciguatera, such as tiger grouper and coral trout, most are now being sold within their juvenile size range. Since juveniles have not had an opportunity to contribute to the next generation, this trend augurs badly for the long-term health of these fisheries; capture fisheries need to maintain spawning biomass and typically minimize capture of juvenile fishes.

A number of solutions can be considered for Hong Kong. The first is clear; classify live fish as food and close the loophole which allows their unregulated import. In this way, importers or traders who sell toxic fishes become responsible under the law for selling contaminated food and the government can use public money to test fish and to monitor imports. Possible control strategies include prohibiting the trade of susceptible reef fishes or import from areas where the incidence of ciguatoxic fishes is typically high (e.g. United States Food and Drug Administration, 1999 Food Code – HACCP guidelines), or prohibiting the sale of fishery products containing biotoxins, such as ciguatera (e.g. European Communities Directive 91/493/EEC). It is fairly well documented which species pose a high risk and which areas have been sources of ciguatoxic fishes, such that either approach is feasible for Hong Kong, given the appropriate legislation.

Ciguatera is a problem that is not going to go away. For consumers, traders and target species alike, the issue needs to be addressed. Since there is no quick and easy, widely-accepted test that traders can apply to check their own fish reliably, the assistance of Government and properly-equipped laboratories is essential in preventing the import of contaminated fishes into Hong Kong. On the other hand, because the Government has no legal authority to prevent the import or sale of contaminated live fishes, should the public be expected to pay for testing fish if they are not thereby protected? Where does the ultimate responsibility lie in protecting the public?

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The live reef fishery in the Seychelles

by Nokome Bentley[1] *& Riaz Aumeeruddy*[2]

Overview

The Republic of Seychelles consists of over 100 small islands lying north of Madagascar between four and ten degrees south of the equator. The population of about 80,000 people comes from a number of ethnic backgrounds including African, Chinese, European and Indian. Most live on the largest, granitic islands of the Mahe Plateau in the north. Most of the coral reefs in the country occur on the atolls several hundred kilometres to the south. These include Providence and Cosmoledo Atolls and the World Heritage listed Aldabra Atoll (Figure 1).

Fishing is an important part of the nation's economy and fisheries products account for 95% of the value of exports. This is largely due to the oceanic tuna resources within the large Seychelles Exclusive Economic Zone. However, coastal and coral reef fish species are an important part of the diets of local people. In 1997, the artisanal catch on the Mahe Plateau was about 4000 t and made up mostly of jacks (*Carangoides* spp.), jobfish (*Aprion virescens*) and mackerel (*Rastrelliger* spp.). Groupers (*Epinephelus* spp.) usually represent between 3 and 5 per cent of the artisanal catch. The Napoleon wrasse is not common around the main islands and is not usually targeted by local fishers.

Live food fish

The fishery for live reef fish in the Seychelles is very new. During 1997 there were a number of requests from Hong Kong-based companies to fish for, and export, live reef fish. However, according to Seychellois legislation, foreign companies are not permitted to fish for demersal species, and so all requests were denied.

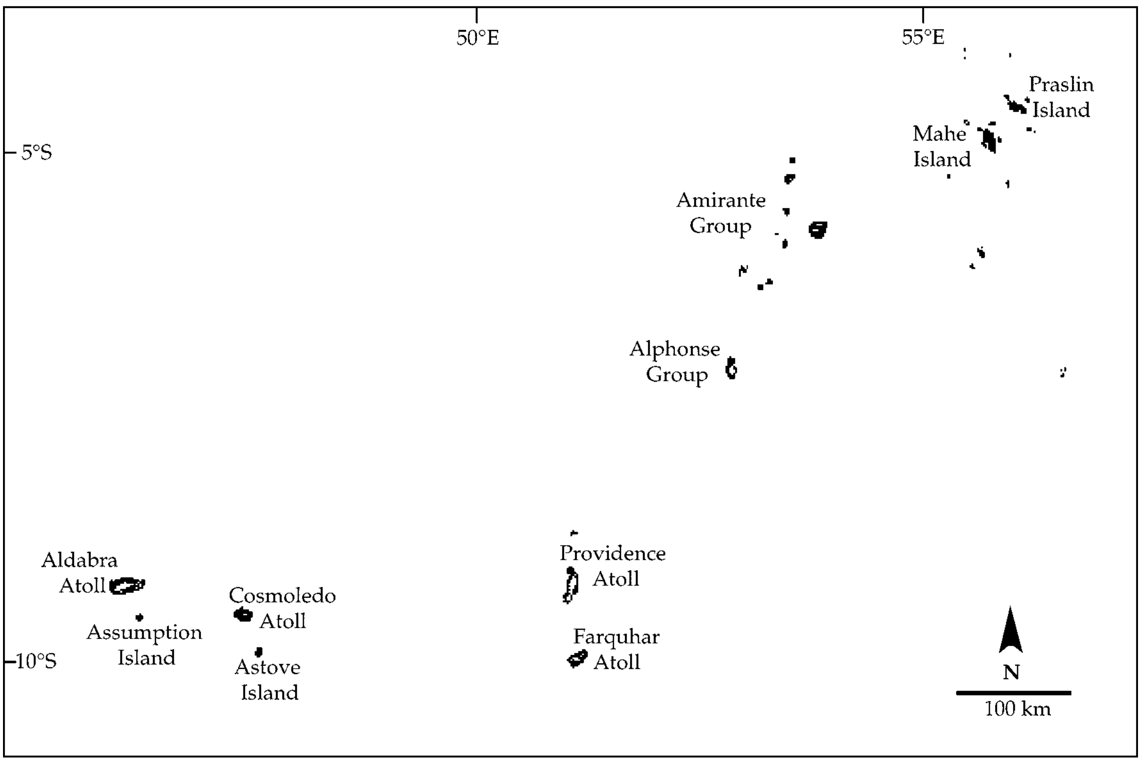

Figure 1. **Map of the Maldives.**

1. Trophia Research and Consulting, P.O. Box 60, Kaikoura, New Zealand
2. Seychelles Fishing Authority, P.O. Box 449, Victoria, Seychelles

In 1998, a Seychellois company made a similar request to the Seychelles Fishing Authority (SFA). The Government granted permission for the company to begin live food fish exporting on an 'experimental', or trial, basis. The fishery was limited to a maximum of 40 t of exports of fish caught from Farquhar Atoll only, for a period of seven months, February to August 1998. Farquhar Atoll was chosen because it had a sufficient area of coral reef to support such a trial, is visited only occasionally by local fishers because of the distance to Mahe Island, thus reducing the likelihood of competition for fish.

All the fishers for the trial were brought from China. The SFA felt that this was acceptable since local fishers did not have experience in the capture of live fish and were not being displaced from traditional fishing grounds. The operation had to be land-based, no mother-ship was allowed and all staff lived on land. Only hook and line was allowed and no compressed air equipment was permitted on vessels. The company chose to use leaded hooks and small dories with outboard motors and two crew each. These dories were not suited to the rougher seas outside of the atoll and all fishing occurred within the lagoon in about 10–15 m depth.

An observer from the SFA was based at Farquhar Atoll to monitor the fishing operations and record the daily catch, effort, fish mortality and exports. During the trial, a total of 33 t of live reef fish were exported consisting mainly of coral trout (*Plectropomus* spp.), grouper (*Epinephelus* spp.) and Napoleon wrasse (*Cheilinus undulatus*). It is estimated that an additional 8.7 t of fish died before export. The fish caught were of variable size ranging from 1 to 25 kg although those of 1.5 to 2 kg were most sought after because of their higher value.

After the trial fishery finished in mid-1998, the SFA assessed whether such operations should continue. In January 1999, the company was granted a licence to continue the fishery for another year in accordance with a 20-point contract specifying the conditions of operation (based on the recommendations of Johannes & Riepen (1995) and Smith (1997).

The reefs of Cosmoledo Atoll, Assumption Island, Astove Island and Providence Atoll are now open to the fishery (Figure 1). Farquhar Atoll was closed to provide it with a rest after the trial fishery in 1998. The total allowable exports are set at 100 t with a maximum of 25 t to be taken at Providence Atoll. A total of 25 t of by-catch, excluding sharks, can be taken but must be sold on the local market.

Only one mother-ship is allowed but there is no limit on the number of fishing dories. A mother-ship from Indonesia was used with 17 single-man dories and a foreign crew. Again, the SFA felt that this was acceptable as, due to poor living conditions, it was unlikely that local fishers would want positions onboard the foreign mothership. All vessels must be licensed by the Seychelles Licensing Authority and display registration numbers.

The transport vessel is not allowed to carry out any fishing operations, and none of the vessels are allowed to possess, store, transport or use any explosives or noxious substances, including sodium cyanide. The mother-ship and dories are not to possess, store, transport or use any compressed air equipment for diving.

According to the contract, holding cages are only to be located at Farquhar Atoll where they can be monitored by an officer of the Seychelles Island Development Company or the SFA. The mother-ship is only allowed to unload catches at these holding cages, and all transhipments for export take place there under the supervision of SFA officers. As the live fish are transferred to the transport vessel SFA officers weigh all fish using their own scales.

The company is required to maintain logs of catch—effort, mortality and feeding. The catch—effort logs record the number and weight of fish in four species / species groups taken by each dory on each day and are submitted to the SFA each month. In addition, the mother-ship is required to regularly report its position to the SFA.

The contract includes the provision for the SFA to impose other restrictions such as size limits, species specific quotas or closed areas. The company is required to pay the SFA a royalty of Rs 3 (US$0.60) per kilogram of fish caught, excluding sharks, to assist with the costs of managing the fishery. The failure to comply with any of the conditions of the contract will result in a suspension of the license.

Several further enquiries have been made by Chinese companies for establishing live reef fish operations in the Seychelles. However, the SFA has declined any requests for further expansion of the fishery. They consider that it would be unlikely that more than one operation could operate given the current estimate of the maximum sustainable yield of 100 t. Furthermore, the SFA recognises that its regulations are far easier to enforce with only one company operating.

Aquarium fish

There have been several inquiries made to the SFA for the export of aquarium fish but these have all been declined. The Authority considers that the risk of damage to reefs, as suggested from experience in other countries, is greater than the potential benefits to the country.

Other threats to coral reefs

During 1998 there were extended periods of unusually high water temperatures on the Mahe Plateau. This caused the widespread bleaching of corals in the area. Around the islands of Mahe, Praslin and La Digue up to 90% of corals were bleached. However, the majority of the countries' reefs in the south of the country appear to have been less affected.

Dynamite fishing has not been traditionally used in the Seychelles, and its use as well as that of noxious substances is strictly prohibited by the Fisheries Act. The fishery on the Mahe Plateau for coral reef fish destined for the local and export markets is not considered to be heavily overexploited. However, the SFA is encouraging local fishers to shift towards offshore pelagic resources to reduce the pressure on demersal fish stocks.

Discussion

The Seychelles Fishing Authority has managed the fishery for live reef fish to minimise damage to coral reefs and reduce the risk of overexploitation. From the beginning, the SFA has maintained a high level of control over the fishery through the clear definition and effective enforcement of licence conditions. The risk of overfishing is reduced by placing limits on the area fished and the quantity of fish caught. Damage to reefs has been minimised by allowing only hook and line fishing. These central conditions are supported by ancillary conditions that make enforcement easier. Effective enforcement has been possible because the number of licences allocated—only one—is appropriate given the enforcement resources of the SFA. Considering that some of the islands are as far as a thousand kilometres from the main island, regulations would be difficult to apply if more licenses were allocated.

Despite the success in managing the fishery, the SFA is still considering its future. The situation will be reassessed at the end of the present license, but it is clear that the SFA will not encourage the further development of the fishery. With the present level of the export quota, the logistics and costs involved in fishing at the southernmost islands of the Seychelles and costs of transport of fish to the markets in Hong Kong, the fishing company itself is not sure whether the venture is viable.

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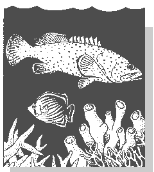

Live reef food fish trade in the Banggai islands (Sulawesi, Indonesia): A case study

by Mochamad Indrawan [1]

Abstract

A field survey of the live reef fish (LRF) trade in the Banggai Islands was conducted in 1997, ten years after the trade began to flourish systematically. Napoleon wrasse had initially been the main target fish, but attention had shifted more toward the groupers. The structure of the LRF trade was relatively simple, involving mainly exporter and buyer. Johannes and Riepen' (1995) indicators of decline were encountered during this survey. The impacts of over-exploitation will be borne mainly by resident fishing folks and not by the exporter, making it a classic case of externality. There seems to be no easy way out of this problem, but some priorities were identified for consideration including the need to develop local stewardship and alternative livelihoods.

1. WWF –Indonesia Programme, Jalan Kramat Pela No°3, Gandaria Utara, Jakarta Selatan, 12140, and YABSHI–Indonesian Foundation for the Advancement of Biological Sciences, Jalan Tanah Baru Raya 98, P.O. Box 103, Depok 16401.

Introduction

The Banggai Island group (between 1°8' to 2°15' S and 122°44' to 124°8' E) lies south of the eastern arm of the Indonesian Island of Sulawesi, from which it is separated by a 900 m deep channel. Administratively the archipelago forms part of Luwuk–Banggai District, Central Sulawesi Province. The rest of the Luwuk Banggai district is located on the mainland. The Banggai Islands have a land area of about 12 km^2. The islands are populated by 337,000 people including indigenous Banggainese as well as Saluanese and migratory Butonese and Buginese.

Recent surveys by Coral Cay in 1995 and 1996 (Harborne *et al.*, 1997) indicated that the islands' marine fauna is probably one of the most biologically diverse on earth. The island group contains barrier reefs, atolls, and fringing and patch reefs.

An overview of the live reef fish (LRF) trade was provided by Johannes and Riepen (1995) and Erdmann and Pet-Soede (1996), covering, respectively, Asia–Western Pacific and Eastern Indonesia. Whilst Johannes and Riepen emphasised on the ecologically destructive nature of cyanide used in LRF collection, Erdmann and Pet-Soede cautioned against the environmental consequences engendered by overexploitation. Both pairs of authors predicted that the LRF trade as currently practised would collapse at any given location within a few years due to overharvesting.

The present survey aimed to document the local nature and impacts of the LRF trade. Particular attention was paid to the socio-economic status of the stakeholders. The Banggai Islands were chosen as the study area due to the apparently high levels of diversity and productivity and my earlier familiarity with the island group and its people.

Between 1 November and 3 November 1997, I carried out informal interviews with actors and stakeholders in the LRF trade—seven traditional fishing folks, three commercial divers, three middlemen and four exporters involved with the LRF trade. A cold storage exporter and the director of the regional shipping agency (personally involved with the LRF industry, as a co-exporter) were also interviewed. To avoid eliciting interdependent responses, localities in which the interviews were conducted were chosen as far apart as possible and the respondents were usually selected from different islands. Five large holding pens (floating cages or 'rakit') in three different islands (Banggai I., Bandang I., Bangkurung I.) were also visited. One of these cages, in Bangkurung, had been abandoned two months earlier.

Since the accuracy of the given responses was unknown, cross-checking between the answers was repeatedly carried out whenever possible. For example, the local fishers' information that the import vessel came once or twice a month was checked with that from the regional fishing agency. A breakdown of costing for a holding pen cum regular catching operation which was obtained from a diver was matched with the figures from two different exporters.

Prices documented were in Indonesian Rupiah, and the rate of exchange was 2400 Rupiah to 1 US Dollar.

Cold storage venture in Banggai Islands

I did not consider in detail the cold storage business, but one exporter of fresh dead fish volunteered information of possible relevance to the LRF trade. The exporter was a resident expatriate who had been conducting business locally for the previous two years. He appeared to have no local competitor in the business. The venture included the same species that entered the LRF trade. The frozen fish were exported to Hong Kong either directly via a chartered Hong Kong vessel, or shipped to Jakarta or Surabaya and air-freighted onward. Export capacity was approximately 3 tons per shipment, once per month.

The exporter volunteered that the cold storage business could also profit from customers' willingness to pay high prices for live reef fish. He would buy fresh dead fish at 30% to 50% of the LRF price. In the destination country some restaurants would display LRF but discreetly serve the dead ones fish as their customers could not tell the difference[2]. The exporter claimed he could sell his fish at 70 to 90% of the live fish price and in that way make a good profit.

History and nature of the trade in live fish

Before the advent of LRF trade, Banggai Island fishers focused mainly on pelagic fish—mainly tuna, skipjack and squid. The LRF trade in the Banggai Islands started in 1987 and expanded in the early 1990s. In the mid-1990s an export peak was reached, followed by an immediate decline in the following

2. Editor's note: Hong Kong LRF connoisseurs maintain that they can readily distinguish between just-killed and frozen fish after they have been cooked. If this is correct, then restaurants that substitute one for the other would have to target only certain customers, such as less discriminating Western tourists.

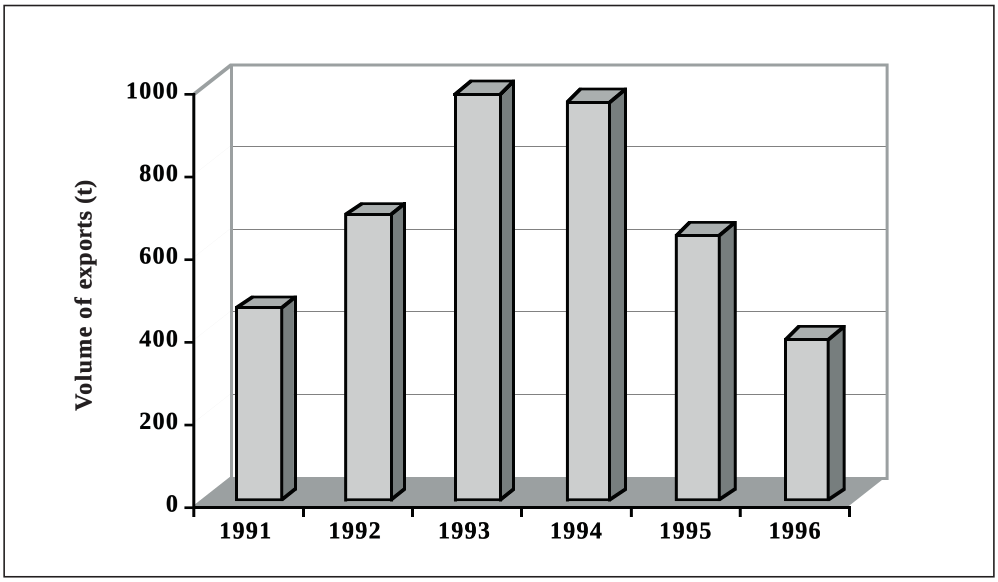

Figure 1. **Live fish export volume (in tons) from Luwuk Banggai District. Data covered the whole island group of Banggai and half the coast of eastern arm of Sulawesi**

years. This pattern of boom and bust appeared to be consistent with that for the whole district of Luwuk Banggai, as indicated by statistics displayed at the Fishery Services of the District Office (Fig.1).

There were an estimated ten large floating cages in the archipelago, all of which were owned and maintained by exporters. The fishes in the floating cages were kept and cared for two weeks to one month. Once the numbers held in the pens was sufficiently high, the exporter contacted a buyer (principally in Hong Kong but also sometimes from Taiwan, Singapore, Japan or another export destination) who would arrange shipment through a shipping agency.

The transport vessels usually visited each holding cage in the island group before heading back. In 1993 one of the largest exporters in Central Sulawesi attempted to ship live grouper by air, but this turned out to be expensive because the plane was able to hold only a total of 300 kg of live fish. Whereas an ocean shipment would take about two weeks to reach destination an air shipment might take a mere 15 hours. But an air shipment from this location involved numerous stops, namely Luwuk, Manado, Davao, Manila, Hong Kong, making the practice impractical.

Ten years earlier the average volume shipped per trip was of the order of 10 tons of live fish per shipment. But by 1997, 3 tons per shipment was about average. Based on an interview with-shipping agency and assuming that the 10 floating cages would produce approximately 3 and 6 tons per month, total export weight from the Banggai Islands would range between 30 to 60 tons per month. Assuming that exporters would make 80,000 Indonesian Rupiah per kilo for the average grouper, the export value would have been in the range of 2.4 to 4.8 billion Indonesian rupiah (or approximately 1 to 2 million USD) per month, for the Banggai Island group alone.

The LRF trade is characterised by a high degree of mobility. For example, of the ten known large floating cage owners, at least three had come from as far away as Riau (islands between Sumatra and Peninsular Malaysia) in the previous three years. Riau was the first area in Indonesia to be involved in the LRF trade beginning in the 1970s, and its own LRF resource had been severely depleted (Pet-Soede & Erdmann, 1996). One of the largest local Banggai owners who sold his business to a Riau operator moved out to another region. Fish-collecting operations whose business declined in Banggai moved east to, for example, Tomini Gulf (Togian Islands), Flores, Tual or Irian Jaya. This is a manifestation of the eastward-moving wave of depletion recorded by earlier observers (Johannes & Riepen, 1995; Pet-Soede & Erdmann, 1996).

Prices and catching methods

Species that entered the LRF industry in Banggai were primarily from the grouper (Serranidae) group, especially the subfamilies Epinephelinae (groupers) and Serraninae (coral trout). As elsewhere throughout the region, humphead wrasse were also targeted.

The most sought-after species was the humphead wrasse, followed by baramundi cod. Humphead wrasse were sold in the Hong Kong market at between 90,000 and 360,000 rupiah per kg, depending on the quality and size of the fish. The prices had been increasing steadily over the previous five years. At the end of the survey the price of this species was about to increase again, by close to 30%.Subsequently prices for live reef fish increased greatly in terms of rupiah, but dropped in terms of US dollars due to the Asian economic meltdown and severe rupiah devaluation (Pet & Pet-Soede, 1999).

Humphead wrasse were reportedly rarer in 1997 than 5 years earlier. Moreover, whereas maximum size for freshly caught wrasse was about 45 kg in the early 1990s, by 1997 25 kg was the greatest size obtainable according to fishers.

Recently attention had shifted more toward the groupers and coral-trouts, because divers had discovered that during spawning the groupers would aggregate in large numbers and were then much easier to catch (see Johannes, l997).

Catching methods can be classified according to the gear used, as follows.

- **Hand nets.** The fish were be chased and caught underwater by divers. Sometimes catching was done at night, using torches (flashlights) to spot the sleeping fish. Netting was considered effective for all species, including Napoleon wrasse.

- **'Bubu' (bamboo traps).** The traps were sunk to a depth of 7 to 20 metres and left for an unspecified time before checking. Traps could also be sunk to as deep as 30 metres but this would require divers with compressors, which only exporters could afford[3]. Bubu were not considered ideal for catching Napoleon wrasse and groupers because they were not specific enough for those species.

- **Handline.** This was the principal method used according to local fishers (who were not necessarily associated with fishing ventures). It was considered effective for most groupers, but risky for the humphead wrasse, which were prone to damaging themselves when hooked. In addition, larger ones are very strong and hard to land.

- **Poison.** The poison used was primarily potassium cyanide, which was water soluble. The solvents were kept in plastic bottles and once the fish was located and cornered the content was squirted to stun the fish.

I observed cyanide tablets being sold under the counter at some traders' shops in Banggai Island. In addition, a holding cage employee and a middleman both said that the Hong Kong vessels sometimes carried cyanide tablets for local distribution. More recently other poisons had been used, including 'tuba' roots (probably from the angiosperm *Derris* spp.) and a mixture of detergent and tobaccos, all of which were believed by the user to be less potent and environmentally less destructive than cyanide. In Eastern Indonesia the 'tuba' root is a traditional poison, widely used to catch fishes for local consumption long before cyanide fishing was introduced.

Floating cages and the catching operations

Live reef fish were occasionally obtained from local fishers, and more rarely from middlemen. But the main source was from the export company's own catching operations. At the base of operations were the floating cages. Associated infrastructure typically included a base camp, a 15 ton wooden boat which served as carrier skiff, several 4–5 m fiberglass speed boats and one or two diving compressors. All boats were equipped with fish holding boxes in their hulls. The floating cages consisted of wooden planks and nylon nets, tied to plastic drum buoys. One holding pen usually included 4 to 8 cages measuring 3 by 3 by 4 metres.

The cost of the infrastructure was estimated to be in the range of 50 to 100 million rupiahs. Based on interviews with two divers it was possible to figure at the typical cost of setting-up and operating a floating cage. Assuming that the floating cage had a team of five divers, each of which could locate and catch fishes on their own, monthly costings would be (mid-1997 prices, in Indonesian rupiahs).

Approximate costs for live fish collecting, borne by the exporter

- Floating cage (including wooden planks, plastic barrel and nylon nets) approximately @ Rp. 7,000,000
- 5 speed boats @ Rp. 200, 000
- 5 outboard motors @ Rp. 3,000,000
- 5 sets of skin diving equipment @ Rp. 400,000
- 15-tonne boat with diesel engine @ Rp. 10,000,000
- diving compressor and hose @ Rp. 20,000,000

3. Editor's note: Compressors are not truly essential to set traps at these depths, but are preferred because they enable positioning the traps optimally, and piling coral on top of them to secure and camouflage them.

- potassium cyanide, 2 kg for one month of operation diver's salary @ Rp. 150,000
- Fuel, each speed boat @ Rp. 200,000 per month

The above costing excludes packaging and shipment charges, as well as marketing fees.

Typically the boats went out together for as long as two weeks. Each speed boat would be manned by one or two divers. One man would drive and the other spot fish. If the diver was experienced enough, he would do both tasks as well as the diving itself. Sometimes one diver would chase the fish through a coral tunnel while the other waited on the either side, with a net in hand. Poison was considered by fishers associated with the camps to be an important tool due to its high efficiency, and the 'bubu' traps were only second to this.

Table 1. **Prices for the main species weighing 1–5 kg**

Species	Local price (rupiah)
Cromileptes altivelis Baramundi cod, 'Sunu tikus'	10,000 to 15,000
Plectropomus maculatus Spotted coral-trout	10,000 to 12,000
Plectropomus leopardus Leopard coral-trout, 'Sunu'	10,000 to 12,000
Epinephelus spp. Rock-cods (including *E. fuscoguttatus*) or flower- cod, 'Krapu'	7,000 to 10,000
Cheilinus undulatus Humphead (or Maori or Napolean) wrasse 'Maming', 'Langkowe'	12,000 to 15,000

Upon transport to and transfer to the holding pens, the fish were weighed by the divers. The air bladders of some fish had to be punctured (see Johannes and Riepen (1995) for details). Use of antibiotics was not observed.

Interviewed divers and exporters suggested that 10 to 50% of fish died between the point of capture and export shipment. Humphead wrasse were said to be more durable than serranids.

Profile of the players in the live reef food fish trade

The buyers were usually from Hong Kong, Taiwan, China, Singapore or Japan.

The exporters typically owned and operated their own floating cages, and employed their own imported divers. An operation in Bangkurung Island was known to have employed as many as 30 people on site. Dependency on middlemen and local fishers existed but this was kept to a minimum. Exporters did not rely entirely on the LRF trade, but typically ran other businesses as well.

The divers employed by the fish camps were mainly Bajonese and Butonese, most of whom had settled in the Banggai islands. Some were employed as full time members of the collecting team; they received salaries and bonuses and all of their equipment (including 'bubu', speed boat, fuel etc.) was supplied. Alternatively, some worked on commission, being loaned all equipment but receiving no salary.

Four middlemen operated in the Banggai Islands, fewer than half the estimated number of exporters. Their holding pen operations were less professional than those of the exporters. As a consequence, they said, they experienced higher fish mortalities, and much lower profits.

Handlining was the main method used by Bajonese fishers who sold to LRF buyers. Ten years ago these fishers systematically targeted fish for the LRF trade. But due to the increasing scarcity of the latter, attention then shifted back to pelagic fishes. Fish that were not saleable to the LRF operators were sold at the local markets, sometimes as far away as Luwuk. The average income for these fishers was of the order of Rp. 50 000 per week at the time of the interview.

Law and enforcement

In 1995, three decrees from two governmental departments were issued to regulate the LRF industry. The Minister of Agriculture issued a decree (Surat Keputusan Menteri Pertanian Nomor: 375/KPTS/IK.250/5/95, dated 16 May 1995), which restricted the catching of humphead wrasse, whereas the Minister of Trade prohibited the export of this fish (Surat Keputusan Menteri

Perdagangan Nomor: 94.KP/II/95, 24 May 1995). This decree also claimed sole authority for trade in this species, in that exemptions could be made off the discretion of the Ministry of Trade, without even mentioning the Ministry of Agriculture. Later in the year, the Directorate-General of Fishery (under the Minister of Agriculture), issued a decree (Surat Keputusan Direktur Jendral Perikanan: Nomor: Hk 330/DJ.8259/95, dated 6 September 1995) which regulates the methods, sizes and locations for catching the humphead wrasse. In Central Sulawesi, the regulations were further elaborated by means of a provincial decree by the Governor of Central Sulawesi Province in 1996, which included the following points:

- Humphead wrasse could be caught only by scientists undertaking research, subject to permission from the Directorate-General of Fishery as well as the (Central Sulawesi) province's Fishery Office, or by traditional fishers with permission from the provincial Fishery Office.
- Registered fish cage ventures, that is those having a Fishing Venture Permit from the DG of Fisheries, could obtain live fish only from the traditional fishers, under a cooperative arrangement, in order to use these fish as parental stock for cultivation [sic].
- The LRF venture must be equipped with captive breeding facilities and employ breeding specialists.

The province's Fishery Office was authorised to issue catch permits and to decide where the fishing may take place, taking into account the carrying capacity of the chosen fishing ground(s).

Only fish with weight in the range of 1 to 3 kg were allowed to be traded, domestically or for export. Fish of sizes outside the range allowed for the LRF export trade could be traded domestically to breeding ventures. Gears allowed for catching live fish were limited to hook and line, 'bubu' and gill net. (Dipnets must have been meant here, since gillnets would be totally inappropriate.)

Although some motivated personnel were employed in the Banggai District's Fishery Office in the Investigations Unit, full enforcement of the regulations was impossible, given the understaffing.

Judging by my interviews and observations, violation of the regulations occurred routinely. The fish cages still operated their own collections and depended very little on the local fishers. The size limit for humphead wrasse appeared to be ignored by at least one large venture. Cyanide appears to have been used in all the fish cages visited. No evidence was observed that any of the fish cage venture farms attempted captive breeding programmes as required by the regulations.

Practically all interviewees understood that destructive fishing was outlawed by the government. However, few in the industry seem to have understood the environmental link between destructive methods and declining reef resources. Within the past few years, though, resident fishers have begun to relate cyaniding operations to coral damage and the death of non-target fish and invertebrates. Cyanide and dynamiting were thought to be equally destructive.

The most effective law enforcement against destructive fishing, according to both fishers and exporters, appeared to be the joint (or integrated) patrolling operations, which included local Police and Fishery officers and were led by the Navy. But given that the nearest Navy base was in Kendari (SE Sulawesi) the patrols were not frequent enough.

Discussion

Decrees from Ministry of Agriculture (MoA) and Ministry of Trade (MoT) concerning humphead wrasse were contradictory, and confusing. Whereas the MoT prohibited export and claimed sole authority for trade of this species, the MoA allowed catching under certain conditions. If the fish were caught only for export, local consumption would not be profitable, making the MoT's exporting prohibition difficult to implement. Although the MoA (c.q. DG of Fishery) cited the MoT regulation ('no export') as its legal reference, it did not follow up, and suggested measures that would lead to good exporting possibilities instead.

Government figures show the total LRF catch in 1996 was 400 tons. My estimate for 1997, based on surveying the fish cages, suggests a catch for that year of between 30 and 60 tons. Although 1996 was probably a better fishing year and covered a total area perhaps twice the size of the Banggai Islands, the difference is difficult to explain. Figure 1 shows the annual catch rates between 1991 and 1996

The overall picture of life fish trade fits the broader pattern drawn by Johannes and Riepen (op. cit.) and Erdmann and Pet-Soede (op. cit.), especially the methods for fish catching and keeping. The mobile nature of the trade and infrastructure was further illustrated by this study. Furthermore, as in the previous studies, this study identified that fish mortality was a major problem.

This study also highlighted several things that are important for LRF trade monitoring efforts:

- Firstly, the current structure of the LRF trade is relatively simple, involving mainly exporter and buyer.
- Secondly, humphead wrasse in particular appeared to be exclusively an export item; this species was not known to have a good local market.
- Thirdly, Johannes and Riepen's (1995) concern that collapse of the fishery would happen three to five years after their study was supported by this survey, especially given that statistics for the whole Luwuk Banggai district already suggested occurrence of the boom and bust pattern. Other indicators of overexploitation were apparent from this study: at least two (of the ten large) floating cages have been abandoned or moved to other regions. The fishermen had actually complained about the decline of the reef stock during the last three years, and alleged cyanide use as the cause. The maximum size of the humphread wrasse catch had been decreasing and the divers indicated that they have had to collect increasingly farther away than before, to the Bowokan group south of Banggai, for instance. That middlemen were few and decreasing might also indicate the business has not been so profitable.
- Fourth, overexploitation will affect the fishermen more than any other group. They are not as highly mobile as the others in the trade, nor able to switch to other venture(s) as readily.

The LRF industry is a classic example of unlimited entry. Careless use of technology and the driving forces of the cash economy have intensified the problem. As the market failed externalities arose so that the fishers did not make a good profit but had to bear the environmental cost of the industry.

As pointed out by Johannes and Riepen (1995) there seems to be 'nothing inherently wrong, environmentally or socially with supplying the demand for live reef fish', but the observed state of the fishery warrants careful managerial considerations. What are the management options for the LRF trade in Banggai?

If nothing is done the decline will probably continue until the business expires. The fish stock may or may not recover. If something is to be done, the following actions are needed.

More frequent patrols by the integrated team, led by the Navy, should be encouraged. This should be a high-level policy approach to which the Chief of Staff must be personally committed.

Research for captive breeding and business investment for mariculture should be encouraged. Some species of groupers can now be raised from the egg, but many other species, including humphead wrasse, are not yet raised from the egg on a commercial basis. Efforts should be concentrated on the humphead wrasse. The currently unpolluted Banggai islands offer plenty of first class sites for breeding.

NGO presence would be useful for local capacity-building of the fishers. There have been no conservation-oriented NGOs in the whole district. Aside from helping the local communities to empower themselves, NGOs would be able to review and advise on ongoing marine resource use. They could also help to raise awareness of conservation needs and sustainable use, as well as helping the local communities to diversify their marine harvest, identify alternative livelihoods and recognise the concept of externality.

Fishers should be encouraged to assume the role of fish wardens. The inclination is already present; in the island of Timpaus (South of Banggai), for instance, the local people have been known to throw bombs at fish bombers.

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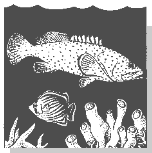

Grouper aggregation protection in proactive Pohnpei

by Kevin L. Rhodes [1]

Overfishing has been implicated in the disappearance of grouper aggregations worldwide, including the U.S. (Gilmore & Jones, 1992), Australia (Domeier & Colin, 1997), Belize (Carter, 1989), Mexico (Aguilar-Perera & Aguilar-Davila, 1996), the Caribbean (Olsen & LaPlace, 1978; Colin, 1992), western Atlantic (Sadovy, 1993) and Indo-Pacific (Wase[2], pers. comm.; Johannes *et al.*, 1999).

In the western Atlantic and Caribbean, overfishing has primarily been by local fishermen, whereas in the Indo-Pacific the driving force has generally been (directly or indirectly) the Hong Kong-based live reef fish trade (LRFT). Aggregation overfishing in the Indo-Pacific by locals for local consumption and sale, however, is less documented, but was recently observed by the author in Pohnpei, Micronesia, during a biological survey of marbled grouper (*Epinephelus polyphekadion*).

Until the 1960s, Pohnpei had fished aggregations under the traditional customary marine tenure system (CMTS) (Martin[3], pers. comm.). Under the CMTS, only one or a few master fishermen were allowed to venture to outer reefs where grouper aggregations typically occur. Catch was limited to the small number of fish needed to feed the clan or municipality for a brief period, which by nature conferred a reasonably high level of conservation on spawning stocks (Johannes, 1978). However, after the 1960s, the CMTS gradually dissolved, such that fishing pressure on aggregations increased as access to sites throughout Pohnpei became open (Ioanis[4], pers. comm).

By 1997, an unabated increase in aggregation fishing pressure for local sale and consumption and reports of illegal destructive aggregation fishing by Pohnpei's only licensed LRFT operator (Kingfisher Marine Products, Inc., Hong Kong) spurred the Pohnpei Department of Resource Management and Development (DRMD) to pass its first legislation directed at grouper conservation by limiting the impacts on aggregations. Under this new law, commercial catch and sale of grouper were prohibited during March and April, although catch was allowed for subsistence, i.e., personal sale and consumption. At the same time, the DRMD developed two new marine sanctuaries at two known spawning sites: (1) at the largest known site (hereafter, Site A) for marbled grouper, dusky grouper (*Epinephelus fuscoguttatus*), and coral trout (*Plectropomus areolatus*), and (2) the second at nearby Oroluk Atoll.

In 1998–99, however, a survey of spawning sites in Pohnpei found that aggregations at Site A form outside the ban period (March–April in 1998; February–March in 1999) and that marbled and dusky grouper aggregations lay just outside sanctuary boundaries (up to 400 m).

Between 1997–99, fishermen exploited this situation and over a seven-day period in February 1999 captured an estimated total of 4,000 individuals, roughly equivalent to one-third of the aggregation. Poaching was also observed frequently during the ban period in 1998, due to a shortage of conservation officers within the DRMD.

1. University of Hong Kong, Department of Ecology & Biodiversity, Hong Kong
2. Danny Wase, Director, Marshall Islands Marine Resource Authority, Interview, July 1997.
3. Valentin Martin, Chief, Pohnpei State Department of Marine Resources, Division of Coastal and Marine Resource Management, Interview, July 1997.
4. Benito Ioanis, Statistician, Pohnpei State Department of Marine Resources, Division of Coastal and Marine Resource Management, Interview, July 1997.

Following the 1999 survey, the DRMD was provided specific information about local aggregations, enabling them to institute several effective changes to enhance grouper protection. Most important among these were: (1) the inclusion of February in the sales ban period, (2) the enactment of a sales *and* catch ban for commercial as well as subsistence purposes during February–April, (3) the expansion of the Site A sanctuary by 900 m to encompass marbled and dusky grouper aggregations, (4) the inclusion of Ant Atoll within the marine sanctuary system, (5) the hire of additional conservation officers, and (6) the involvement of the Pohnpei State Police to assist in patrols of sanctuaries during spawning months. Additional measures currently under consideration include a live reef fish ban, a grouper export ban, a ban on the catch and sale of giant grouper *Epinephelus lanceolatus*, satellite tracking of foreign vessels, and the confiscation of catch and vessels found illegally fishing in Pohnpei waters, particularly those using destructive techniques.

Clearly, Pohnpei, like neighbouring Palau, has taken a proactive approach to grouper conservation and management. This strategy appears to stem from a long-term view of resource use (by all branches of government, including a conservation-minded DRMD) that replaces short-term economic gains with a long-term view toward sustainability and self-reliance, as the local food economy depends on a steady supply of grouper for subsistence. With a diminishing supply of healthy spawning stocks within the central Pacific brought on largely by the Hong Kong-based LRFT and it's destructive practices, it has become increasingly critical for local economies to ensure protection of their own resources. The loss of aggregations could affect food security and biodiversity both locally and regionally. Pohnpei, with its proactive approach to grouper conservation, has clearly positioned itself to be a leader in marine conservation and management in the region and should be looked to as a model for aggregation protection and marine resource use.

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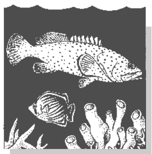

Adaptive management of aquarium fish collecting in Hawaii

by Brian N.Tissot [1]

Because aquarium fish collectors are highly selective and often capture large quantities of species of high value, the potential for overexploitation is high. Although many authors have discussed the potential impacts of the aquarium trade on reef fishes, there are no conclusive studies documenting the magnitude of impacts on natural populations, despite repeated calls for such studies to help develop sustainability in the aquarium trade industry. In Hawaii, the Division of Aquatic Resources (DAR) ignored public concerns about the aquarium industry for over 25 years largely due to the lack of a definitive study.

Concern over the effects of aquarium collecting on reef fish in Hawaii occurred in the early 1970s, principally regarding the Kona coast of the island on Hawaii (Walsh, 1978). Early concerns were based on multiple-use conflicts between collectors and recreational dive tour operators over apparent declines in nearshore reef fishes. These concerns prompted DAR to instigate monthly collection reports of all permit holders in 1973 and data from these reports have been the primary basis for management of the aquarium industry up to the present (Katekaru, 1978; Miyasaka, 1997).

Based on these reports about 90,000 fishes with a value of US$ 50,000 were harvested in 1973, with the annual harvest increasing to 422,823 with a value of US$ 844,843 in 1995 (Miyasaka, 1997). Moreover, during this period there was a shift in collecting from the island of Oahu in the 1970s and 80s, to the Kona and Milolii areas of the island of Hawaii in the late 1980s and early 1990s. Between 1993 and 1995 the harvest from Kona increased 67% and accounted for 59% of the state harvest (Miyasaka, 1997). Thus, increased harvesting of reef fishes was occurring in the prime tourist areas of the Kona coast.

Although a total of 103 fish species were collected state-wide in 1995, over 90% of the harvest was focused on seven species (in decreasing order of preference): *Zebrasoma flavescens, Ctenochaetus strigosus, Acanthurus achilles, Naso lituratus, Forcipiger flavissimus, Chaetodon multicinctus*, and *Zanclus canescens*, with *Zebrasoma* accounting for 72% of the total harvest (DAR, unpublished data). Thus, given the increasing rate of harvest focused on a small number of species, the potential for overexploitation of these fishes was high.

Beside the issue of fish harvesting, there was also concern over the effects of aquarium collectors on the reef community. Observations by local divers of large areas of broken and bleached coral in collection areas suggested some destructive harvesting practices. Moreover, because 80% of the catch consisted of herbivorous fishes (primarily *Zebrasoma*), and reductions in the abundance of herbivores can cause algal overgrowth of corals (Lewis, 1986), there were long-term concerns about impacts to overall reef health.

Impact assessment

Although efforts were made in the 1970s to estimate the impact of collectors in Kona (Nolan, 1978), flaws in experimental design prevented valid conclusions. In 1996, Leon Hallacher (Univ. Hawai'i–Hilo) and I conducted a state-sponsored study to provide an objective estimate of the impact of aquarium collectors on reef fishes in Kona (Tissot & Hallacher, 1999).

We used a paired control-impact design to estimate the impact of collectors on fish abundance by comparing differences in abundance at sites where collecting was known to occur (impact sites), relative to geographically adjacent sites where collecting was prohibited (control sites). We established four study sites that served as two replicate control-impact pairs where abundance was estimated using a visual strip-transect search method on four 50 m transects at each site. During each survey we estimated the abundance of 19 species, including ten aquarium species and nine species not targeted by collectors that provided data to support the assumptions of the experimental design (see Tissot & Hallacher, 1999). We also surveyed coral and macro-algal abundance before and after the study to detect the presence of destructive harvesting practices and changes that might occur due in reductions in herbivory.

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The results of our two-year study indicated that eight of the ten fishes targeted by aquarium collectors were significantly reduced in abundance at impact relative to control areas (Figure 1). The magnitude of these declines were high, ranging from 57% in *Acanthurus achilles* to 38% in *Chaetodon multicinctus*. In contrast, only one of the nine non-target species varied significantly between these areas, supporting our conclusions that aquarium collectors were causing significant reductions in targeted fishes.

There were no consistent, or significant, differences between control and impact sites in the extent of bleaching, broken coral, and changes in coral cover that indicated destructive fishing practices.

We also found no differences in the abundance of macro-algae between impact and control sites, suggesting that reductions in herbivory associated with harvesting were not having a significant effect on algal abundance. However, we did not obtain data on the abundance of filamentous algae, sea urchins, or nutrient concentrations; factors which must be examined to adequately test this hypothesis.

Adaptive management

Based on the results of our study the current system of monthly catch reporting appears to be providing poor data for the management of aquarium fishes. Because these reports are not compared to actual catches, there is no quality assurance that the reports are accurate. Based on an evaluation of the reported catch relative to a rough estimate of potential yield from our impact assessment, the 1998 harvest could have been generated from ~1.5% of the available reef area in west Hawaii (Tissot & Hallacher, 1999). Because this number appears low relative to the observed activities of the ~50 aquarium collectors operating in west Hawaii, the catch reported by collectors may be underestimated, perhaps by an order of magnitude.

In response to continued strong public outcry over the aquarium collecting issue and the results of our study, the state legislature passed a bill in 1998 to improve the management of fishery resources in west Hawaii. A major thrust of the bill, which became Act 306, was to improve management of the aquarium industry by protecting a minimum of 30%

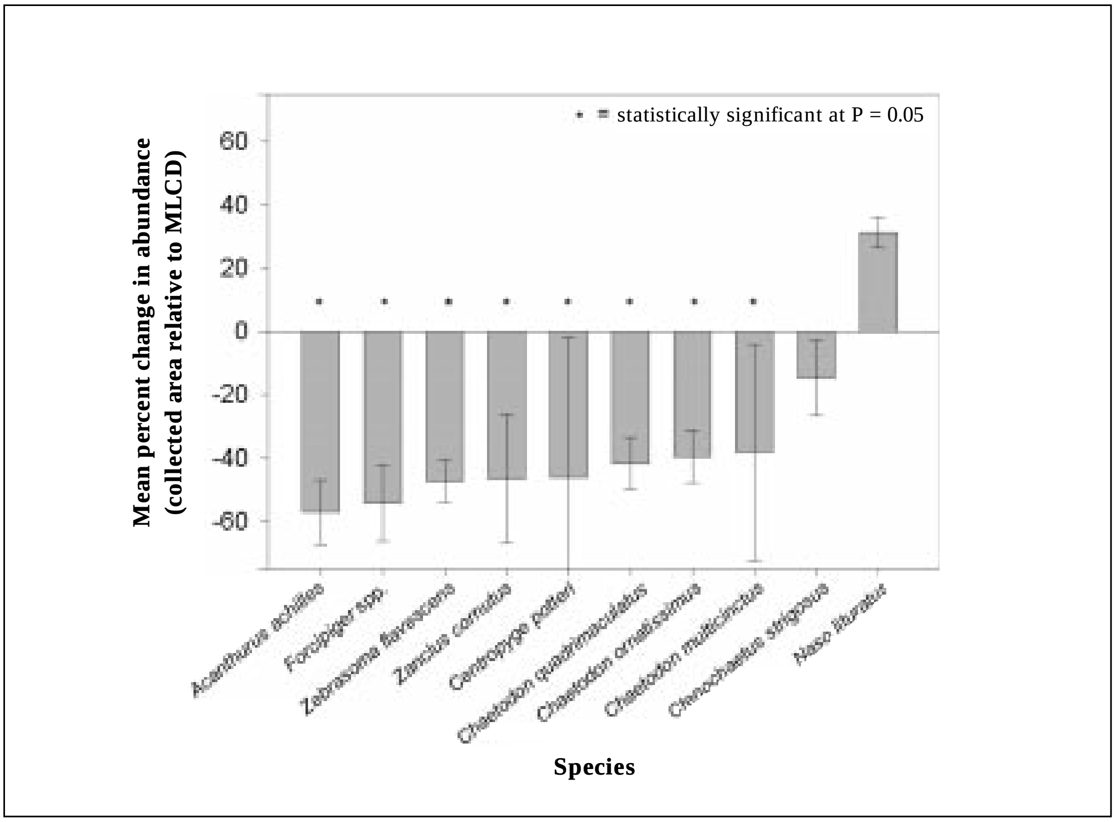

Figure 1. Mean percent change (± S.E.) in collected aquarium fishes at impact relative to control sites in Kona, Hawaii. Significant impacts were detected using a two-way repeated measure ANOVA with impact and study areas as factors and surveys as repeated measures (see Tissot & Hallacher, 1999)

of the west Hawaii coastline through the establishment of Fish Replenishment Areas (FRAs)—marine reserves where aquarium fish collecting is prohibited. Because the life history of aquarium reef fishes is poorly known, marine reserves have been widely recommended as the best approach for promoting the sustainable harvest of aquarium reef fishes (Randall, 1978; Wood, 1985; Andrews, 1990) and reef fishes in general (Bohnsack, 1998).

The design of the reserve network in Hawaii was generated from a community-based group, the West Hawaii Fishery Council. This council, which was organised by Bill Walsh (DAR), and Sara Peck (Univ. Hawaii Sea Grant Extension Service), consisted of representatives from the aquarium, dive tour, and hotel industries, plus shoreline gatherers, recreational divers, and representatives from each of the coastal areas in west Hawaii. Based on scientific input, the Council proposed a network of nine FRAs to minimise conflicts between the aquarium and dive tour industries and promote a sustainable fish harvest. In April 1999, ~1000 people attended a public hearing on the proposed reserve system—the largest attendance at any fishery management hearing in Hawaii — with 93% of the testimony in favor of the proposed management plan. If approved by the government, the reserves could be closed effective October 1999.

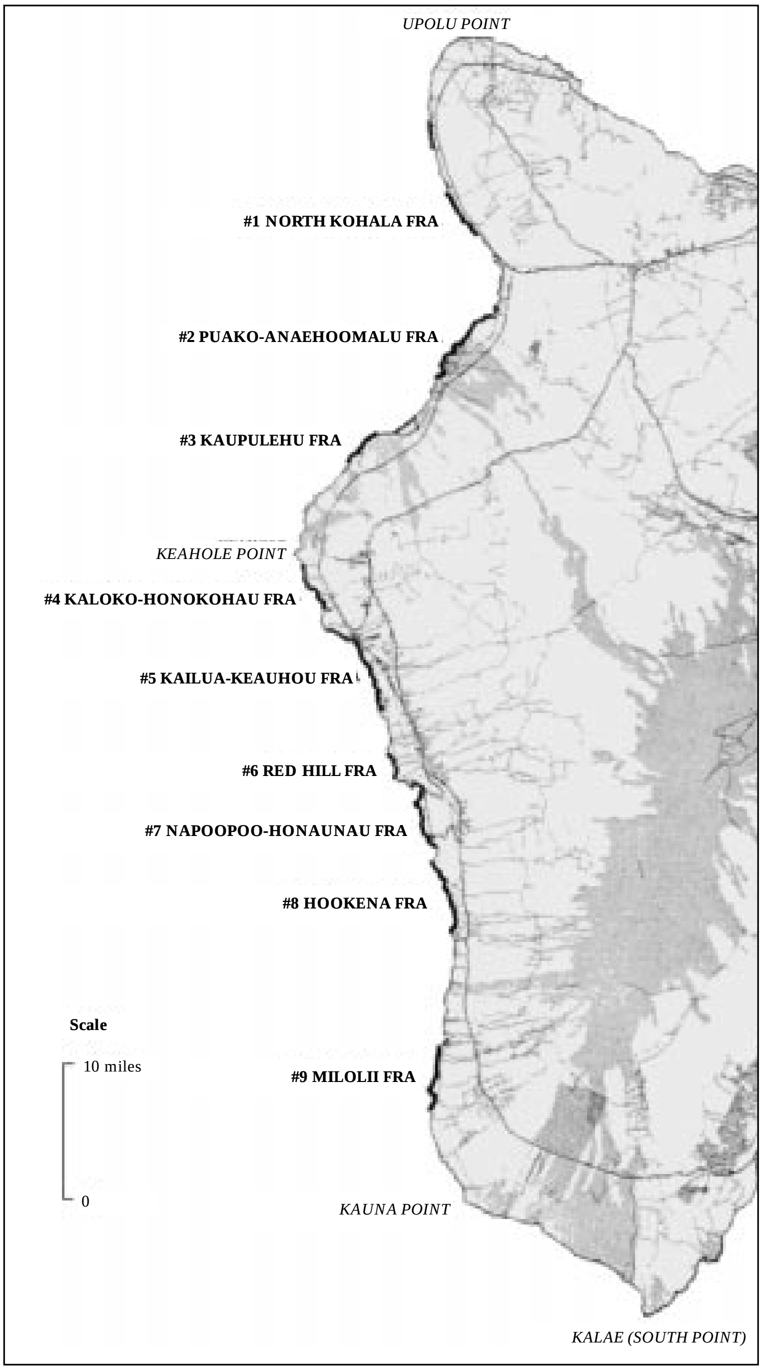

Figure 2. Map illustrating the nine Fish Replenishment Areas (FRAs) proposed by the West Hawaii Fishery Council in relation to existing protected areas. If enacted, 35% of the west Hawaii coastline would be closed to aquarium fish collecting. Source: Hawai'i Division of Aquatic Resources.

Our current efforts are focused on monitoring these areas to evaluate the effectiveness of the reserve network to increase the abundance of aquarium fishes. In 1998, a group of researchers including Bill Walsh, Leon Hallacher and I, established 23 study sites in the nine proposed FRAs, eight sites where fish collecting will continue (impact sites), and six existing protected areas where aquarium fish collection is currently prohibited (control sites), to order to evaluate changes in abundance as the reserve system is implemented.

Our initial studies, which constitute baseline surveys before closure of the reserve system, confirm that aquarium collectors are causing significant reductions in abundance in four of the six proposed FRAs that could be adequately studied. Ongoing monitoring of these sites as Act 306 is implemented will provide an evaluation of the effectiveness of each reserve in the network. After five years, Act 306 mandates an evaluation and refinement of the management plan; at that point we hope to adapt the design of the reserve network based on the results of our studies to maximize the multiple-use of aquarium fishes.

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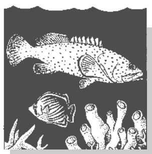

Live reef fish developments in Fiji

By Being M.Yeeting [1]

*Condensed from an article originally printed in the S*PC Fisheries Newsletter *88: 25–36 (1999).*

Background

Fiji is one of the very recent countries in the Pacific to get into the Live Reef Food Fish (LRFF) trade. With interest being shown by some overseas LRFF companies, it was identified as a potential income-generating project to pursue by the Fiji Fisheries Department under their Commodity Development Framework (CDF) programme in 1998. With the preliminary arrangements being negotiated for one overseas LRFF operator to start, Fiji has wisely decided to look seriously at the management and regulatory issues relating to this fishery based on experiences and lessons learned from other countries. The primary aim is to set up a LRFF industry that is sustainable in the long term. Fiji Fisheries therefore decided that the first step was to know about the extent of their LRFF resource and to set up a management structure in the form of policies, regulations and legislation for the trade.

Request for assistance

In August of 1998, a letter of request for assistance was received by the Secretariat of the Pacific Community (SPC) from the Ministry of Foreign Affairs and External Trade in Fiji on behalf of the Fiji Fisheries Department.

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The request was for SPC to assess the potential for LRFF in an allocated fishing area in the Bua Province of Vanua Levu, and draw up some management guidelines that would be useful in the formulation of a management policy and regulations for the trade. The agreed terms of reference (TOR) are briefly outlined below:

1. To find out where the spawning aggregation sites are for coral trout and cod species and the times of the year when they occur.
2. To give an approximate existing stock estimate for the potential target species.
3. To design catch data forms and establish a monitoring programme for catch, effort and export.
4. To set up a database for the live reef fishery in Fiji that can link and exchange information on a regional level.
5. To formulate guidelines and make recommendations towards a management policy and regulations for the live reef fish trade in Fiji.

The SPC Integrated Coastal Fisheries Management Project (ICFMaP) was given the task of providing the necessary advice and assistance to Fiji Fisheries under the given terms of reference.

The target area

The Province of Bua is one of the three provinces of Vanua Levu, the second biggest island in the Fiji Group. The province forms most of the southern part of the island. It contains 54 villages with a predominantly Fijian population of just over 9,000. The Bua Provincial Council, the administrative body for the province is in Nabouwalu, the administrative centre, which is located near the southernmost tip of the island.

The main target fishing area is in the Lekutu and Navakasiga District and is owned by the vanua (tribes) of these two districts. The total area of the Lekutu and Navakasiga District fishing rights area is about 1,600 km^2. The actual total reef area in the fishing area that was surveyed is made up of about 432 km^2 of inside reef areas and about 84 km^2 of reef on the barrier reef area. Thus the total reef area in the fishing rights area is about 516 km^2 or about 30% of the total fishing rights area. This area is regarded as prime fishing ground.

The LRFF company and their plan

The partners in this new Live Reef Fish venture are *Satellite Seafoods (Fiji) Ltd.* an Australian owned and based company, and *Altracor (Fiji) Ltd.* which is a fully locally-owned local Fijian company. Shares are 70% and 30% respectively. The company will utilise local fishermen and their existing boats for catching fish. Assistance would be provided by the company to modify boats and in training of fishermen in catching and maintaining the fish alive. About 20 – 25 fish cages will be set up, of 4 m x 4 m x 6 m (depth), each with a capacity of holding up to 500 kg of live fish.

A live fish transport vessel (F / V *Crested Tern*) capable of holding up to 4 tonnes of live fish, would be brought in from Australia, to collect the fish from the fish cages and transport them to a main holding facility in Vanua Levu.

The live fish will then be shipped overseas using a 'live fish' carrier vessel. The *Yong Sheng Lai 18* owned by *Yong Shing Fishery Co.* based in Hong Kong has indicated their interest in transporting the fish.

The fishing company is hoping to export a minimum of 10 tonnes of live fish each shipment, which will include coral trout species, groupers, rock cods and the humphead wrasse.

A memorandum of understanding between the people of Galoa in the District of Lekutu and *Satellite Seafood Pty (Fiji) Ltd.* has been drawn up. This outlines the payment procedures, training and other assistance that the company will provide and what the people of Galoa are required to do.

Target species

Generally, the target species are all those fish species that have potential to sell to the live reef fish markets. The main species of interests for Fiji were the coral trouts, *Plectropomus* species and the humphead wrasse (*Cheilinus undulatus*). The highly-valued *Cromileptes altivelis* is not common in Fiji.

Survey Methods

Visits were made to the Bua fishing area from 12 September to 2 October and from 17 to 26 November 1998 to do the required fieldwork.

The fieldwork conducted in the target area included informal interviews with fishermen to collect basic local information that could be useful in the preliminary assessment of the live reef fish potential. Fishermen were asked questions relating to fishing activities, fishing seasons, spawning seasons and spawning grounds for different species, but with emphasis on the live reef fish target species. Questions were chosen carefully in order not to 'lead' fishermen. In addition fish outlets in Suva were also visited and the managers or owners were interviewed in order to get an idea of the importance and value of the LRF target species on the local market. Particular attention was paid to those fish dealers that purchase fish from Bua Province.

A broad-brush survey of fish using underwater visual census (UVC) 50 m x 5 m transects was conducted. Sampling stations were selected haphazardly in both the inner reef areas and the barrier reef. Sampling was also designed to look at the effects of depth (less than or equal to 10 m (shallow), greater than 10 m (deep)) in both reef areas.

Densities and mean length of fish were estimated from the UVC surveys. From these biomasses were then calculated using length–weight relationships for the same species in New Caledonia (Letourneur *et al.*, 1998). Where data on this relationship were available, the one for the closest species was used. Stock sizes were then estimated for the reef areas.

Results

Fishing activities

Seven fishermen were interviewed; three from Galoa Island and 4 from Tavea. Their ages ranged from 39 to 65. From the interviews it became apparent that the community of Tavea did more fishing than Galoa. Part of the reason was that the fishermen of Galoa have recently become very involved in diving for bêche-de-mer, which has taken a lot of their fishing time.

The dominant fishing activity for both islands was handlining on the nearby reefs from small skiffs. The bigger boats on the islands were all used for going out further from the shore to dive for bêche-de-mer especially in Galoa.

On Galoa there were about 20 individuals taking part in bêche-de-mer diving. All bêche-de-mer diving was done using hookah. The divers were fully aware of the dangers in using this apparatus (accidents had happened) but most of them felt it was the best way of getting good income for the family.

Other fishing activities included gillnetting on the shallow reef areas and spearfishing, which were more commonly practised by the fishermen from Tavea. In Galoa many women fish, mainly gleaning on the nearby reefs for clams and crabs. Most fishermen fish mainly for subsistence.

However, when they have more than enough for themselves, they sell it locally to other people in the community. On Tavea there are part-time commercial fishermen who catch fish to sell to the middlemen based in Lekutu, who then sell them to fish shops in Suva. Fishermen do not seem to target any particular species..

Spawning aggregations and sites

Although fishermen interviewed claim that they were not fully aware of spawning seasons of fish species, the information they provided in relation to the quantity of a particular fish at different times of the year suggested strongly that spawning seasons and aggregations do exist.

All but one fishermen interviewed claimed that they had come across big schools of *donu (Plectropomus areolatus, P. laevis or P. leopardus*) while out fishing.

Although information given by fishermen about spawning seasons was not very consistent, for *Plectropomus areolatus* especially, there seems to be some common agreement that summer is spawning season. Ovatoa passage and Nauqina Reef were the sites mentioned most often in this connection. Sampling is needed to confirm these assertions.

Underwater visual census (fish transects)

A total of 39 fish counting transects were carried in 13 sampling stations. Twenty-four transects (8 stations) were conducted on inner reefs and 15 transects (5 stations) were on the barrier reef area, yielding a sampling area of 9.75 km^2 (2% of the total reef area in the fishing area).

Fewer than 10 individuals of most species of interest to the LRFF trade were seen during the survey. Twenty-seven *Plectropomus areolatus* were seen, however.

Relation of **P. areolatus** *sizes and biomass to habitat*

For *P. areolatus* a simple t-test compared the mean length of fish from the deep reef areas against shallow areas. The results confirms that there is a high significant difference ($P<0.05$) implying that larger *P. areolatus* are more likely to be found in deeper reef fishing areas.

The density of *P. areolatus* was higher in the inner reef areas than the barrier reef areas (Table 1). Biomass, however, was higher on the barrier reefs than the inner reefs. This is because the fish were larger on the barrier reefs than on the inner reefs.

The total stock estimate for *P. areolatus* comes to just over 1,600 tonnes of which 58% comes from

Table 1: Densities and biomass of *P. areolatus* on the inner reefs and the barrier reefs (± standard errors).

Reef area	Densities (nos/1000m^2)	Biomass (kg/1000m^2)	Estimated stock (tonnes)
Inner reefs	10.33 ± 3.08	2.15 ± 0.47	928.29 ± 204.19
Barrier reefs	5.07 ± 1.48	8.04 ± 2.79	675.81 ± 233.91
TOTAL	8.72 ± 2.00	5.12 ± 1.31	1604.10 ± 438.10

the inner reefs and 42% from the barrier reefs (Table 1).

Findings and recommendations

The study was intended to give a snapshot view of the current status of the reef fish species with potential for the live reef fish trade. The actual stock estimates of the different fish species are expected to provide some basis for management decisions before more information becomes available. The information gathered from the interviews and the underwater surveys, although preliminary, provide some baseline data that can be used to help direct further research on the live reef fish species.

The interviews revealed that local fishing effort is concentrated on the nearby reefs. The shortage of big boats, the cost of fuel and the safety consciousness of fishermen were major factors that contributed to concentrated fishing efforts on the nearby reefs. Unfortunately it seems that one of the most commonly fished nearby reefs is a possible spawning aggregation site for the *Plectropomus* species, and some of the other serranids.

Based on the information collected from the local fishermen, there appear to be spawning aggregation sites in the area. The Fisheries Division should try to verify their locations and timing. Once this has been done then it is recommended that a ban be put on fishing at spawning aggregation sites.

The accounts of some fishing trips given by some fishermen indicate that there may have been considerable fishing over spawning aggregations done unintentionally. This may have taken its toll on the stocks (as it has in the Solomon Islands (Johannes & Lam, 1999)). The Fisheries Division should therefore find out more about these spawning aggregation periods and sites. This could be simply done by monitoring fish catches from the area and by visiting the potential aggregation sites at least once a month[2] (for a year) as a start and possibly more frequently during those months that have been reported to be spawning aggregation times.

It was also evident that many fishermen from Galoa Island are involved with bêche-de-mer diving. All use hookah. It should be ensured that this hookah gear is not used in the live reef fish trade. To deal with this problem, Fiji Fisheries should undertake an education programme showing the dangers of using hookah, using examples from Asia, and ban its use in the live reef fish trade.

The results from the underwater surveys provided some first estimates of the status of the stock. The results of the surveys showed that among the serranids, *Plectropomus areolatus* is the most abundant species both in the inner reef and barrier reef areas.

For the live reef fish trade, *Plectropomus areolatus* is likely to be the main target species, being the only one that was abundant and also being a preferred species in the trade. The estimated total of the species for the total fishing area is just over 1600 t. This is equivalent to a wholesale value of US$ 56 m in the Hong Kong market (based on 1994 prices in Johannes & Riepen, 1995). The maximum sustainable yield for the area was difficult to estimate with the current available information but is expected to be much less than the estimated biomass. A monitoring programme is clearly needed to refine these figures.

The size of this fish is an important factor to consider in the LRFF trade. The mean size of *P. areolatus* in the inner reef areas is about 23.6 cm compared to 45.4 cm on the barrier reefs. This equates to weights of 0.26 kg and 1.6 kg respectively. With the preferred weights of fish in the LRFF market being between 0.8–1.5 kg, then the best area to fish would thus be the barrier reef.

For the inner reefs, the smaller sizes of coral trouts should be investigated further. Considering the

2. Editor's note: At the appropriate moon phase—probably during the days just prior to the new moon judging by the lunar timing of spawning aggregations of several species, including *P. areolatus*, elsewhere in the western Pacific.

small sizes of fish and the possibility of spawning aggregation areas being located in the inner reefs, the suspension of fishing for coral trout species and the imposition of size limits for subsistence fishing is a possible management option. Once the spawning periods and sites have been worked out, they should be marked and set up as marine reserves where fishing is banned.

The valuable *Cheilinus undulatus* was seen in very low numbers. Although our survey results need to be verified by additional research, the low numbers should be noted and a total ban on fishing for this species should be considered as a precautionary approach. Research is needed on the ecology and biology of this species.

Considering the other serranids and other species, the numbers counted on the transects were too low to be able to give reliable estimates. The general low density could be a result of underestimation relating to the sampling method used where the width of the transect is fixed at 5 metres and therefore with limited time the total sampling area is very small relative to the total fishing area. This might be improved by doing many more UVC transects in future and possibly by adopting a transect method of unfixed widths which would enable surveying of more extensive areas.

The industry, being new, should be carefully monitored and controlled. Information and experience from South East Asia should be utilised to avoid making the same mistakes and to make the industry a sustainable one.

There is a strong need to set up some management regulations backed up by specific legislation for the trade. The legal framework already exists under the Fisheries Act for the imposition of specific legislation and regulations for better management of this trade.

The customary fishing rights law provides an effective local mechanism for keeping control of fishing activities in the fishing area and for enforcing regulations. A small council is made up of all the different parties involved legally for the protection of resource owners' interests. A coordinated plan for enforcement of regulations together with an outline of the different responsibilities should be established to ensure that enforcement efforts are well supported at both community and government level.

A set of management policy guidelines for the LRFF industry is proposed[3]. Along with management regulations and enforcement, a good monitoring programme is essential to ensure that the companies are continuously in compliance with the rules, and to collect basic information useful for the future management and development of the industry. A data collection programme is proposed below. The relevant forms can be obtained from the Reef Fishery Assessment and Management Section of the SPC Coastal Fisheries Programme.

The Data Collection Programme

A data collection system is therefore proposed that involves most of the stakeholders in the fishery. Data collection should be one of the requirements and responsibilities of any LRFF company. The Fisheries Division is however the main authority, taking charge of regular monthly record submissions by the company, collecting biological information on fish that died during the handling stages, processing and analyses of the data and the review of management decisions and options.

The proposed data collection programme consists of four data sheets, described below.

1. Fishing Data Sheet – To be filled in by the fishermen as they go out on a fishing trip. It basically details information on fishing effort, fishing conditions, fishing location(s) and fish catches (species, length and weight). This is to be handed in to the LRFF company site manager on arrival to the LRFF holding cage site after the trip.

2. Catch Summary Form – To be filled in by the LRFF company site manager when stocking the holding cages. It records the number and weight of fish put into the holding cages by species and also records the species, number and weight of fish that are dead at this stage of handling. The dead fish are to be kept aside for further data collection. Dead fish consequently found in the holding fish cages should also be recorded on this form.

3. Biological Data Sheet (Dead Fish) – This is to be filled by the Fisheries Division officer in charge of the LRFF industry. It contains biological information on the dead fish collected during handling. On it are recorded species, length, weight, sex, maturity stage, gonad weight and stomach contents. The Fisheries Officer is expected to be responsible for this. However we anticipate problems in keeping dead fish frozen before the fisheries officer vis-

3. Editor's note: In the article from which this is extracted, a long series of recommendations follows, based largely on those given by Johannes and Riepen (l995) and Smith (l977).

its the holding cage station rather than selling it fresh. The ideal solution is to train someone on site on how to handle the fish, sex measure, weigh and gut. We therefore propose that the fisheries officer arrange with the site manager for the dead fish to be processed. The guts can then be frozen in a sealed plastic bag properly labelled for later identification.

4. Export Data Sheet – This is the final sheet to be filled in before the live fish is exported overseas. It is to be filled by the LRFF Company Site Manager and is basically a record of what species of fish; numbers and weight are exported live overseas.

The data sheets have been designed for filling in with the minimum effort. The sheets to be filled in by the Site Manager are records that the company would need for itself anyway. Certain coding, which is a desk job for the Fisheries Officer, is required and a list of codes is provided.

The SPC Reef Fishery Assessment and Management Section would continue to provide assistance where required to establish the monitoring programme and in the analyses of the data. All information would be kept confidential.

Resource assessment

This forms the second part of the monitoring programme and is basically the Fisheries Division's responsibility. The purpose of the assessment is to track the long-term impact of the industry on the reef fish stocks, to check regularly for signs of destructive fishing methods such as cyanide–fishing, and to build up information on spawning seasons and spawning aggregation sites.

It is recommended that field assessment should be done twice a year for the first 2–3 years and then once a year after that.

The fieldwork involved would utilise the underwater visual census (UVC) method. Some training on the UVC method used was given to the local village divers and fisheries personnel involved in the study.

The SPC Reef Fishery Assessment and Management Section would, however, be able to provide further training on an improved version of this method that would be standardised as a package (field method and analyses methods) throughout the region for possible comparison with other areas.

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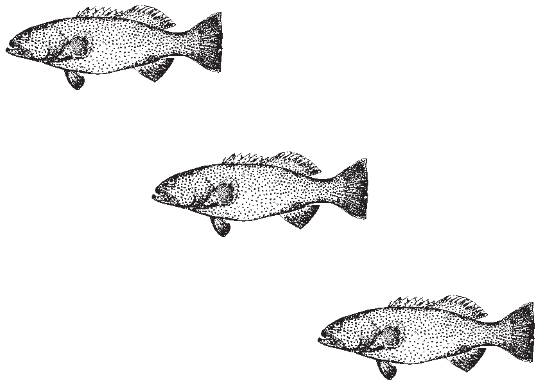
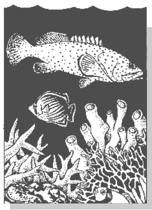
Note

Copies of the MOU and data collection forms are available upon request from:

The Reef Fishery Assessment
& Management Section
Coastal Fisheries Programme
Secretariat of the Pacific Community
B.P. D5, 98848 Noumea
New Caledonia

Website: http://www.spc.org.nc
E-mail: spc@spc.org.nc
Fax: +687 26 38 18





Fishing for solutions: Can the live trade in wild groupers and wrasses from Southeast Asia be managed?

by Nokome Bentley [1]

Executive summary of a report recently published by TRAFFIC *Southeast Asia*

The expansion of the live reef food fish industry had its beginnings in Southeast Asia. As the waters around Hong Kong and China became depleted of wild stocks, fishing vessels targeted the coral reefs of the Philippines, Malaysia and Indonesia. With the possible exception of small isolated reefs and well-guarded reserves it is now unlikely that any coral reef in Southeast Asia has not at some time been fished for live reef food fish.

The pervasiveness of the fishery is one of the few generalisations that can be made about it. The industry is diverse and dynamic. Characteristics ranging from the methods used to catch fish through to the mode of export vary over time and space. This report aims to describe the trends, patterns and diversity of the live reef food fish industry in Southeast Asia. This analysis is then used to identify appropriate management interventions at various points in the trade to ensure the sustainability of the fishery.

The four major Southeast Asian countries involved in the industry were investigated in detail for this report: Indonesia, the Philippines, Malaysia and Singapore. Most of the information presented was collected during 1997 and describes the industry up to that year. Official government trade statistics were complemented with interviews with members of the industry to provide a broad overview of the temporal and spatial trends and patterns in the live reef food fish industry. Although attempts were made to validate this information, it should be remembered that these data are not conclusive and are to some degree inaccurate.

To provide details on the exploitation and trade of live reef food fish at the local level, several localised case studies within Southeast Asia have been done. These provide insights into the diversity of methods used to catch live fish, and the local trading structures. Where possible, locations for case studies were chosen where there were existing links between researches or non-government organisations and the industry.

The official export data suggests a rapid expansion of the live reef food fish industry during the early 1990s. Exports from Southeast Asia rose by more than one order of magnitude, from an estimated 400 t in 1989 to over 5000 t in 1995. Despite this impressive increase, it appears that the industry's boom has come to an end. In 1996, there was a 22% decline in total recorded exports from the region.

Exports from individual countries reflect this overall trend. Between 1991 and 1995, the vast Indonesian archipelago provided about 60% of the live reef food fish harvested from Southeast Asia. The country's main areas of coral reef lie in the east and the west and the live reef food fish operations in each area have operated relatively independently. The western reefs of Indonesia were the first to be targeted in 1985. But the industry quickly became established amongst the extensive reefs of eastern Indonesia, and by 1993 this area accounted for more than three-quarters of the country's exports. The bubble finally burst in 1996 when exports from eastern Indonesia fell by over 450 t.

The Philippines was the first Southeast Asian nation recorded as being fished for live reef food fish. However, between 1991 and 1995 it accounted for only 27% of the region's total exports. Until 1993, annual exports increased significantly, but after remaining steady at around 1100 t for three years, they then fell by almost 50%.

Malaysia has coral reefs around its peninsular states and Sarawak, but the greatest area of reef occurs around its easternmost state of Sabah. Malaysian companies first started exporting live fish from Sabah during the mid-1980s, but it was not until 1987 that the industry really developed. Exports reached a peak in 1993 at around 500 t, but have since declined by over 30%.

Singapore is the primary live reef food fish consuming country within Southeast Asia. Increasing amounts of live fish are demanded by Kuala Lumpur and other centres with large Chinese pop-

1. Trophia Research and Consulting, P.O. Box 60, Kaikoura, New Zealand

ulations. However, these amounts are small compared to Singapore's consumption of around 500 t per year. Most of the live reef food fish imported by Singapore comes from nearby Indonesian islands.

The industry has progressively expanded into the more remote areas of the region. This is illustrated well in Indonesia where official export data are available for each port. Analysis of these data reveals some striking trends. For most regions, once exports began, it took only three-to-four years for them to reach a peak and then to decline. Like a wave, the industry has spread throughout the country; live fish exports rising and falling in its wake.

The live reef food fish industry in Southeast Asia is complex, involving several tiers of trade, the characteristics of which vary from region-to-region and have changed over time. Although the fishery began with foreign vessels and crew, there was often a rapid turnover to local operations. The high value of live reef food fish, was a persuasive attractant to local fishers. At the same time, exporters found it cheaper to employ locals than bring in their own crews. Thus the fishery, which had been dominated by large, self-contained foreign vessels, soon became a local-based industry in many areas. The mode of export of live reef food fish has also changed considerably. When foreign vessels dominated the industry, they often took fish to the market themselves. However, with the shift towards local operations, live fish transport vessels have taken over this role. Although these vessels are still important in some areas, air shipments have become increasingly common. Airfreight is now responsible for all of the live fish exports from Sabah and most of those from the Philippines. In Indonesia, exports by air rose from 5% to 40% between 1991 and 1995.

The dominance of Hong Kong as the main export destination has also diminished. China and Malaysia in particular are demanding increasing quantities of live reef food fish. Although much of the product that is exported to China first travels through Hong Kong, an increasing proportion goes there directly. For instance, direct exports to China from Indonesia increased from 0% to 27% between 1991 and 1995. This was probably facilitated by the shift towards air exportation.

The shift to local operations was accompanied by an inevitable increase in the industry's diversity. The influence of local fishing methods was particularly strong. Although some local fishers were trained by foreign fishers to use cyanide as a stupefacient, others found that they could catch live reef food fish using traditional methods, or variations of them. Several methods are currently used to catch live fish and they vary among regions, villages and fishers. The most common methods are cyanide, hook and line and trap fishing.

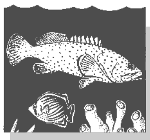
The available evidence suggests that there has been widespread overexploitation of live reef food fish stocks in Southeast Asia. Global experience has shown overexploitation often occurs when access to the fish stocks is open to all and when commodity prices are high. This situation is exacerbated by the poverty of many coastal communities in Southeast Asia. A fisher's considerations of the long-term sustainability of the resource are often overridden by the need to feed his family. In the unlikely case that the live reef food fish stocks of Southeast Asia are not already overexploited, then without some form of management, they will be in the near future.

There is further concern that some of the methods used to catch live reef food fish cause damage to the coral reef ecosystem. The use of such destructive fishing methods not only impacts directly on the industry itself by degrading the reef habitat on which the fish rely but also impacts on the wider coral reef ecosystems. Coral reefs are an important resource for Southeast Asia; their value extending far beyond the extraction of fish. Destructive fishing methods associated with the industry need to be eradicated.

It is easy to dismiss the overexploitation that is currently occurring in the live reef food fish industry as another example of the 'tragedy of the commons'. The lack of data on which to base management decisions could also be used as an excuse for inaction. Such procrastination would be irresponsible. Export quotas provide an effective means of controlling exploitation rates of live reef food fish that could be implemented soon. Initially, they could be set conservatively based on existing information and then refined as further information becomes available on the population dynamics of reef fish. Complementary regulations on the allowable sizes of fish and their method of capture could be applied across all trading levels.

The involvement of members of the live reef food fishery is critical to the success of these management strategies. They already recognise that overexploitation has occurred, and have a vested interest in ensuring the sustainability of the stock. Given the forecasts for increases in wealth of the Chinese population, demand for live reef food fish is likely to increase significantly. This combined with the fact that live reef food fish are goods associated with 'conspicuous consumption', means that suppliers may be able to demand higher prices if market quantities are restricted. If this is the case then there are incentives for the live food industry, from fishers through to wholesalers, to reduce the current catch to ensure the industry's sustainability in the future. Co-operation at an international level is imperative; some reef fish stocks are likely to straddle borders as will fishing effort and the transport of live fish. Without formulation under an international agreement, voluntary reductions in trade are unlikely to arise or to succeed.

The live reef food fish industry is a valuable fishery for Southeast Asia. Effective co-operation of governments, industry and other stakeholders, has the potential to ensure live reef food fish stocks are sustainably managed, to provide a sustainable livelihood for coastal fishers and thus an incentive for coral reef conservation throughout Southeast Asia.



The Hong Kong trade in Live Reef Fish for Food

by P. Lau & R. Parry Jones[1]

Despite world-wide concerns about the methods used of catch live reef fish and the portable unsustainability of the trade, scant detailed information was available at the consumer end. This project was thus carried out, from May 1997 to February 1998,[2] to collate available information on the trade, to put forward recommendations with a view to strengthening current regulations where appropriate, and to highlight areas in need of further research. The study focuses upon the quantity, species and origin of LRFF imported into an re-exported out of Hong Kong, the structure and dynamics of the Hong Kong trade, and demand in Hong Kong market. Research was conducted through questionnaires with restaurateurs and traders of live reef food fish and through analysis of available import and re-export statistics.

Hong Kong is believed to be the largest consumer of LRFF in Asia as well as an important entrepôt for re-export of LRFF (Johannes & Riepen, 1995). Hong Kong imports LRFF from over 10 different countries / regions. The majority of these fish are caught in tropical reef habitats in the Southeast Asian countries and increasingly in the remote Pacific archipelagos. Southeast Asian countries were found to be the main countries of origin.

Indonesia and the Philippines were, respectively, the main sources of LRFF imports into Hong Kong as well as the main sources for Giant Grouper *Epinephelus lanceolatus*, High-finned grouper *Cromileptes altivelis* and for Humphead wrasse *Cheilinus undulatus*. Of concern is that exports of Humphead wrasse are in fact prohibited from the Philippines and specimens of a certain size are prohibited in exports from Indonesia. Capture of this species and its export from the Maldives, another Hong Kong supplier, are also prohibited. Traders noted that they were aware it was illegal for this species to be exported from certain areas and noted that smuggling is a common phenomenon.

Import data from the Hong Kong Census and Statistics Department (HK CSD) record the largest quantities of 'other groupers' and 'other marine fishes' as being imported from Thailand. Malaysia was reportedly the main source of Coral trout imports. Thailand and Malaysia are also important sources for so-called 'cultured' species such as Brown spotted grouper *Epinepbelus areolatus/E. bleekeri*, Green grouper *E. coioides*, Malabar grouper *E. malabaricus* and Mangrove snapper *Lutjanus argentimaculatus*, which are mostly grow-out specimens of wild-caught juveniles. Taiwan appears to be the only place where significant amounts of groupers are hatchery-reared. China was the major source of snooks and basses to Hong Kong in 1997, supplying over 96% (by weight) of total imports.

Faced with declining stocks in traditional fishing grounds such as the Philippines (Barber & Pratt, 1997), fishers and traders have been forced to look ever further afield to meet growing demand. Papua New Guinea and the Solomon islands, as well as the Maldives, are becoming increasingly important source countries for live reef fish, although with the former two this may also be due, in part, to the recent

1. This document is an executive summary (slightly condensed) of:
LAU, P. & R. PARRY JONES. (1999). The Hong Kong trade in Live Reef Fish for Food. TRAFFIC East Asia and World Wide Fund for Nature Hong Kong, Hong Kong

2. Although this report was published in June 1999 it is based on 1997 data. Another report on the same subject, but based on l998 data, was published after this issue of the Information Bulletin went to press. It is:
PAWIRO, S. (1999). Trends in major Asian markets for live grouper. Infofish International 4/99: 20–28.
The author describes a number of problems that hit the live reef food fish industry in l998 and predicts that consumption, already falling in l998, 'will continue to fall for the next few years.'

push by Pacific Island Countries (PICs) to increase exports of LRFF (G. Sant, pers. comm., Sept. 1998).

Air transport has become increasingly important for transporting fish as it enables a faster and more reliable supply. Transport by sea, however, is still used for imports of the larger specimens of Giant grouper and Humphead wrasse as larger specimens fare better if transported by sea. Although transport methods have, in general, been developed to a high standard, very high rates of mortality, up to 90% (Sadovy, *in litt.* 1998) can occur when juveniles are transported for mariculture and for adult fish transported prior to sale. Mortality is an issue of conservation concern because it is live fish, which are in demand. Hence, more fish need to be caught to compensate for those that die in transit in order to meet demand.

In 1997, Hong Kong imported an estimated 32,000 tonnes of live reef fish for food, of which an estimated 3200–6400 tonnes were re-exported to China. Local consumption is estimated to be around 25,600–28,800 tonnes per year, and LRFF traders estimated that 75% of imports were comprised of the 11 most commonly available species in Hong (traders, however, use the same common name—Chi Ma Ban (Brown spotted grouper)—for *E. bleekeri* and *E. areolatus).* Thus, although they spoke of the 11 most commonly available species there were in fact 12. These were Humphead wrasse *Cbeilinus undulatus,* Leopard coral trout *Plectropomus leopardus,* Spotted coral trout *P areolatus,* High-finned grouper *Cromileptes altivelis,* Green grouper *Epinephelus coioides,* Flowery grouper *E. polyphekadion,* Brown spotted grouper *E. bleekeri/areolatus,* Tiger grouper *E. fuscoguttatus,* Giant grouper *E. lanceolatus,* Red grouper *E. akaara,* and Mangrove snapper *Lutjanus argentimaculatus.*

Trade data from the HK CSD show that Hong Kong recorded imports of 21,000 tonnes only of live marine food fish (except eels)—a discrepancy of 11,000 tonnes with this study's estimate. Analysis and comparison of officially recorded imports with interviews with traders provide an insight into the shortcomings of the current monitoring system in Hong Kong. Traders revealed that although Indonesia and the Philippines were the main countries of origin for Humphead wrasse imports, other countries exporting this species also included Australia, China, Malaysia, the Maldives, Papua New Guinea, the Solomon Islands, Thailand, and Vietnam. These countries are not recorded in the CSD data. Discrepancies in the two data sets may also be attributed to other factors: locally licensed fishing vessels and locally licensed live fish transport vessels in Hong Kong are exempt from declaration of imports of live reef food fish—the main mode of transport for Humphead wrasse. Furthermore, under the current Marine Fish (Marketing) Ordinance (Chapter 291), the category 'marine fish' does not, ironically, include 'live fish'. There are no inspections of live food fish imported into Hong Kong and declarations by species are not checked. There is, however, no obvious reason for deliberate misdeclaration of imports into Hong Kong as imports are not subject to taxation and, although it is illegal to export Humphead wrasse from certain countries, this does not make it illegal to import the species into Hong Kong.

Giant grouper *Epinephelus lanceolatus,* Humphead wrasse *Cheilinus undulatus,* High-finned grouper *Cromileptes altivelis,* Red grouper *Epinephelus akaara* and Coral trouts *Plectropomus* spp. were, respectively, the most highly valued fish.

Wholesale prices, in 1997, ranged from US$ 38/kg for Spotted coral trout to over US$ 100/kg for the smaller specimens of Giant grouper. Overall average wholesale price for reef fish was US$ 20/kg (Sham, *in litt.*, 1997). The estimated total annual value of live reef fish imported into Hong Kong for food therefore exceeded US$ 500 million. The value of this fishery industry far exceeds Hong Kong's total annual seafood production by its entire traditional capture fleet (Lee & Sadovy, 1998).

Retail prices for the 11 most commonly consumed reef fish species ranged from around US $30/kg for a large Tiger grouper to around US$ 175/kg for a small (< 1 kg) Humphead wrasse. As fish served whole are preferred to slices of fish, the larger specimens of Giant grouper *Epinephelus lanceolatus,* Tiger grouper *Epinephelus fuscoguttatus* and Humphead wrasse *Cheilinus undulatus,* have a lower wholesale price per kg than smaller specimens of the same species. Interviews with restaurateurs revealed that Leopard coral trout *Plectropomus leopardus* and Green grouper *Epinephelus coioides* were the two most popular species and Humphead wrasse and Giant grouper the least common species consumed in Hong Kong restaurants. Most consumers eat Giant grouper and Humphead wrasse as a status symbol due to their rarity and high price rather than for their the taste and texture.

Demand for reef fish peaks during festivals with demand highest on Mother's Day. Second to festivals are special events such as celebratory banquets—the two most important banquets being Wedding banquets and Birthday banquets, respectively. Traders also noted that consumers apparently preferred wild-caught individuals over cultured species, and wholesale and retail prices are adjusted accordingly. Retail price for wild-caught Red grouper, for example, is 60% higher than for cultured Red Grouper, apparently due to the rarity of this species in the wild and the relatively poor texture of cultured specimens. Findings of blind taste tests, however, showed that overall, people preferred cultured Malabar grouper *Epinephelus malabaricus* to wild-caught specimens (Omni' Trak Group Inc., 1997).

The preference for the smaller, and thus sexually immature, specimens of Giant Grouper and Humphead wrasse is an issue of great concern. Both these species are naturally scarce and particularly vulnerable to overfishing. Specimens of other species in the Hong Kong market, such as Malabar and Tiger groupers, were also found, in large part, to be sexually immature. Given the low density of species naturally occurring on coral reefs, the preference for sexually immature fish and the large quantities in trade, current catch levels may not be sustainable. Although Coral trout commonly consumed in Hong Kong are within the range of sexual maturity, the high demand for this species may make it susceptible to overfishing. An additional issue of concern is the increase in supply into Hong Kong of certain groupers during the spawning season. Targeting spawning aggregations can be devastating for stocks. Range states for coral reef fish will have to take the main initiative and responsibility to protect and use wisely their marine resources. Recommendations agreed upon at the 1997 APEC Workshop on the Impacts of Destructive Fishing Practices on the Marine Environment should constitute the basis from which range states work-towards conserving their coral reef resources. Consumer countries, however, such as Hong Kong, also have an important role to play. As the main consumer of reef fish, Hong Kong could take the initiative in working with member-nations of APEC towards establishing a comprehensive and standardised monitoring system for reef fish in trade. Although Hong Kong already monitors imports of certain species of reef fish, this monitoring system could be improved upon.

Recommendations

The primary recommendation for Hong Kong is to amend the licensing and classification system for locally registered fishing vessels and locally registered transport vessels bringing in live marine fish so as to enable recording of all LRFF imports into Hong Kong. The term 'marine fish' in the Marine Fish (Marketing) Ordinance (Chapter 291) also should be redefined so as to include 'live fish' in the definition of 'marine fish'. Although Hong Kong already monitors imports of certain species of reef fish into Hong Kong, trade records should be amended to specify:

a. Tiger grouper, *Epinephelus fuscoguttatus*
b. Flowery grouper, *Epinephelus polyphekadion*
c. Leopard coral trout, *Plectropomus leopardus*
d. Spotted coral trout, *Plectropomus areolatus*
e. Green grouper, *Epinephelus coioides*
f. Mangrove snapper, *Lutjanus argentimaculatus*

Tiger grouper, Flowery grouper, Leopard coral trout and Spotted coral trout are among the most important live reef food fishes in the Hong Kong industry and subject to intense fishing pressure.

The Government of the Hong Kong (SAR) also should be encouraged to share its expertise and to work with other member-nations of the Asia Pacific Economic Cooperation (APEC) to establish a comprehensive and standardised system for monitoring trade of live reef fish in the region. Imports from countries newly entering the trade, such as the Maldives, Papua New Guinea, the Solomon Islands, US Oceania and Sri Lanka, should be monitored as exports of LRFF from these countries develop.

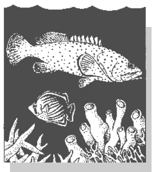
The Government of the Hong Kong (SAR) could strongly recommend that nations which have banned the export of Humphead wrasse and Giant grouper explore the possibility of listing these two species on Appendix II or Appendix III of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Despite the fact that exports of Humphead wrasse of a certain size are banned from Indonesia, that all exports are banned from the Maldives and certain areas of the Philippines, this species is still found in trade from these locations into Hong Kong. A CITES listing would aid the HK SAR Government's regulatory efforts.

An identification manual should be prepared to assist government officers in the recognition of fish species and to assist traders in making consistent declarations. Confusion between Malabar grouper and Green grouper is but one documented example where an ID manual would be a useful tool.

Effective channels of communication should be established in Hong Kong between stakeholders in the live reef fish industry. The Government of the Hong Kong (SAR) should also maintain dialogue and conduct regular exchanges of information with governments of exporting nations. Research should be conducted to determine consumer attitudes towards the consumption of reef fish to ascertain the most effective means of involving the public in the protection of coral reef habitats, the impact of destructive fishing methods, and the consequent impact on the trade and consumption of LRFF.

Countries exporting LRFF should establish quotas to ensure the long-term sustainability of their fisheries. Lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation (FAO, 1996).

Further research into hatchery-based mariculture should be encouraged as currently all mariculture operations, with the exception of mariculture operations for Green grouper *E. coioides* and Malabar grouper *E. malabaricus* in Taiwan, are based upon grow-out of wild-caught juveniles.



The use of chemicals in the live fish export industry

by Katherine Kelly [1]

Attention has recently been drawn to the use of chemicals in the live fish trade. This article will attempt to clarify the use of chemicals, the Australian Quarantine and Inspection Service's (AQIS) role and the National Registration Authority's (NRA) requirements.

The live fish trade has an annual export income of about AU$ 20 million accounting for 15% of the total commercial landings of demersal reef fish in Queensland, with catches primarily of coral trout in north Queensland. In the reef/line fishery about 110 licensed fishing boats have changed over to live reef fish operations, with production in 1997 at 369 tonnes (*QLD Fisheries News*, Issue 2, June 1998).

The pressure to use chemicals such as anaesthetics and antibiotics has increased with the reduction in airfreight capacity due to the down turn in tourism flights from Asia to far north Queensland. Purpose-built cargo boats are currently used to transport fish to Hong Kong.

Transportation time has increased resulting in a greater need for water conditioners to remove ammonia, antibiotics to reduce infection and anaesthetics to sedate fish.

Asian companies are pressuring exporters to use chemicals banned for use in Australia. Chemicals used for veterinary or agricultural purposes during the production of food intended for human consumption must be approved and registered for use by the NRA. The NRA is responsible for registering chemicals for that 'use pattern' (this means for a particular species and purpose).

A chemical may be used 'off label' if prescribed by a veterinarian or if the user has obtained a 'minor use permit' form NRA. According to legislation, it is an offence to possess and use an unregistered chemical product or unapproved active ingredient, or to use a registered product in a manner not included on the label.

One chemical registered for use in the handling and harvesting of Salmonids is 'AQUIS-S', an aquatic anaesthetic. This chemical may currently be used for other species in a 'off-label' capacity (with a veterinarian prescription) or with a 'minor use permit' obtained from NRA. Restrictions apply on when and how the chemical is to be used and permission for use is only for the applicant concerned.

There are currently no antibiotics registered for use on fish destined for human consumption. As the NRA can only deal with drugs and chemicals that have a direct effect on animals, the debate over water conditioners being a NRA issue continues.

The process to register a chemical with NRA is currently expensive and time consuming. It has been argued that no single manufacturer is likely to invest in registering new uses for existing chemicals because their share of an increased market will be too small, to warrant the investment. In addition, once chemical is registered, all competing companies can expand their own label claims without significant expense.

The process of obtaining a 'minor use permit' for a registered chemical to be used in another 'use pattern' is less costly and more acceptable than 'off label' veterinary prescriptions.

AQIS is responsible for ensuring that exported fish is safe and wholesome for human consumption, under the Commonweatlh's *Export Control Act's 1982* and its subordinate regulations the *Export Control (Processed Food) Orders*. The 'Orders' require that exported fish may not contain contaminants or residues potentially harmful to humans or in quantities exceeding limits determined by relevant domes-

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tic importing country or international food standards authorities. The onus of responsibility to prove that an export consignment is safe for human consumption rests entirely with the exporter.

The use of unapproved chemicals in the live fish trade can be considered hazardous due to the potential consumption of fish before the allowable ‘withholding period’ is complete. If exporters fail to comply with NRA approval protocol, ‘Control of Use’ legislation at the State / Territory level and AQIS regulations, they can jeopardise the overall viability of Australia’s seafood export trade.

The question of unregistered chemical use in the live fish export trade surfaced in Australia on 11 May 1998 following the release of a public notice by AQIS to exporters of live fish. The notice issued a warning about the inappropriate use of Sodium Nifurstryrenate, an antibiotic, on live fish during containment. The Chemical Residues Section of the Victorian department of Natural Resources and Environment generated a report following analyses of the chemical. The report stated that Sodium Nifurstryrenate might cause cancer, birth defects, and liver disease in humans particularly if consumed before the recommended withholding period.

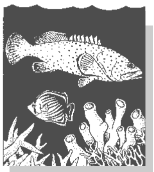
Interestingly, a few years prior, this chemical was classified as ‘not permitted for aquacultural use’ by the Registration liaison Committee (RLC) of the NRA due to its deleterious side effects.

A National Task Force on Aquaculture Drugs and Chemicals was established in 1995 to address the registration of drugs and chemicals for use in aquaculture and live fish export. A joint industry and government project funded by Fisheries Research and Development Corporation (FRDC) titled *Registration of Aquaculture Chemicals* was initiated in 1996, aimed at gaining registration or permits for 12 or more drugs or chemicals. The relatively small demand for these products compared to the cost of registration has resulted in a general lack of interest by drug and chemical companies.

When dealing with the use of chemicals in the live fish export trade, the task force states that this industry currently has not drugs or chemicals registered or with permits for the use pattern required.

The task force is due to meet again in mid-February 1999 to address this issue. If there is any appearance of chemical residues in the flesh of exported live fish it will potentially damage a developing and lucrative export and lucrative export industry.

Source: *The Queensland Fisherman*, March l999, page 32.



The capture and culture of postlarval coral reef fish: Potential for new artisanal fisheries

by Johann Bell[1], Peter Doherty[2] & Cathy Hair[3]

Introduction

There has been much debate about the merits of harvesting and growing wild juvenile coral reef fish to supply the aquarium market and live fish trade. Arguments centre on whether the harvesting of juveniles will affect natural replenishment of coral reefs, and the effects of removing juveniles of different ages (Sadovy & Pet, l998; Johannes & Ogburn, this issue). The age of the juveniles is pivotal to the debate; harvesting of postlarvae from the water column is considered to have a much lower (negligible) impact on rates of replenishment than the removal of the larger juveniles from benthic habitats because the postlarvae have yet to undergo severe mortality.

The effects of harvest levels and times are not the only factors to be considered in assessing the scope for capturing and culturing wild juvenile coral reef fish, however. The acceptance and success of such ventures will also depend on cost-effective methods for rearing the juveniles to market size. Postlarval groupers are removed from artificial habitats designed to attract them and then sold to growers (Johannes & Ogburn, this issue) but there is little documentation of culture methods. We need to know more concerning whether postlarvae can be collected in a way that does not damage them, whether they can be weaned easily onto simple diets, and whether they can be grown at low cost to create new artisanal enterprises.

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In this article, we summarise the reasons why the removal of postlarval coral reef fish should be sustainable and identify those conditions that may require restrictions to fishing for postlarvae. We also outline why the capture of wild postlarvae complements initiatives underway to sustain the production of coral reef fish through the cultivation of juveniles reared in hatcheries. We conclude by describing research underway in Solomon Islands to develop methods for the grow-out of postlarval coral reef fish.

The rationale for harvesting postlarval coral reef fish

It is now widely accepted that coral reef fish have two periods during their lives when they are subject to high levels of mortality. The first is during the pelagic larval development phase, which lasts weeks to months (Leis, 1991). Fewer than 1% of larvae survive this process to be potential colonists of coral reefs (Doherty, 1991).

The second is the settlement and establishment on coral reefs at the end of the pelagic phase, when the juveniles suffer intense predation by larger fish associated with reefs. Mortality rates are highest during and immediately after settlement, but can be substantial for much of the first year (Doherty & Sale, 1986; Hixon, 1991). Caribbean grunts, for example, have been shown to lose at least 95% of the juveniles that settle (Shulman & Ogden, 1987).

Clearly, one way of increasing the productivity of high-value coral reef fishes would be to 'quarantine' a proportion of the settling juveniles from predation. Although it was once considered feasible to boost production by providing additional refuges for newly-settled fishes in the form of artificial reefs, such structures have not proved to be cost-effective (Bohnsack 1989, Pickering & Whitmarsh 1997). Instead, the most practical way is to harvest a portion of a year-class and rear it in some form of aquaculture until the fish are either marketed or returned to the sea (Maroz & Fishelson, 1997; Munro & Bell, 1997; Doherty, 1999).

The basic concept of catching a proportion of the juvenile year-class and rearing them in captivity is already being applied in several other fisheries. The milkfish industry, a crucial source of protein, employment and income in the Philippines, is largely dependent on the harvest of wild 'bangus' fry using push nets in shallow subtidal embayments (Rabanal & Delmendo, 1993). The shrimp aquaculture industry in South America is also based mainly on the collection of wild postlarvae (e.g. Larsson *et al.*, 1994).

The development of sustainable methods for the capture and culture of coral reef fishes depends on finding efficient ways to catch the juveniles before they suffer high levels of mortality, and the development of cost-effective methods for rearing them to useful sizes. Although the early larval stages of coral reef fish can be collected easily with towed nets (Choat *et al.*, 1993), the retained larvae are too fragile to be cultured. On the other hand, the postlarvae that settle onto reefs are relatively robust—they are similar in size and development to marine fish weaned from a diet of live plankton to a formulated diet in aquaculture (Barnabe, 1988; Foscarini, 1988).

Two methods developed initially as research tools, appear to be suitable for catching live pelagic juvenile fishes. Doherty (1987) designed submersible light-traps which attract the animals from the water column. Light-traps can collect large numbers of young reef fish from relatively small volumes of water (Milicich, 1988), but are effective only for species that are photo-positive, and relatively strong swimmers (Carleton & Doherty, 1997). Dufour and Galzin (1993) used stationary 'crest' nets behind the surf zone of fringing barrier reefs in French Polynesia to catch postlarvae crossing over to back-reef lagoons. Crest nets capture large numbers of fish, including valuable species like groupers, and some small taxa not sampled well by light-traps (Dufour *et al.*, 1996). The use of crest nets is, however, limited to shallow reef crests with unidirectional wave action. Both light-traps and crest nets can be modified easily to ensure that their catches remain alive. At this stage, the relative costs and benefits of the two techniques for catching fish for subsequent grow-out, and the overlap in species composition of the catches, is not well known.

Concerns about overfishing of postlarval coral reef fish

Although the high mortality of juvenile fish settling on coral reefs provides a strong incentive to use the postlarvae in more productive ways, harvesting should not be allowed to jeopardise natural rates of replenishment. Research is needed to provide information on the distribution and mean abundance of postlarvae arriving on reefs, and the proportion of these juveniles surviving to adulthood. Such information will then enable managers to calculate the area of reef required to provide regular replenishment of wild stocks. Studies of this nature are currently being done by the Australian Institute of Marine Science (AIMS) and other research groups elsewhere in the Pacific. Until the appropriate experiments are complete, conservative levels of harvest will be required.

The easiest way to impose conservative levels of harvest is to restrict the amount of reef used for catching postlarvae. Such management dovetails well with the methods for catching postlarval fish because only small areas of reef are needed to supply large numbers of juveniles. For example, Dufour et *al.* (1996) obtained a mean of > 200 large postlarvae per night from crest nets with a mouth gape of 1.125 m^2 deployed around Moorea, French Polynesia. However, limits to the amount of reef that can be fished alone may not prevent overharvesting of postlarvae. Several studies of the spatial distribution of recently settled fish show that a subset of sites consistently receive a high proportion of the postlarvae. Thus, over-exploitation of postlarvae may occur within a country if relatively few sites contribute the bulk of recruits to wild stocks, and these sites are identified and fished excessively. In such circumstances, overfishing can be prevented by introducing seasonal closures, rotational fishing of areas, limits on the number of fishermen (or nets per fisherman) and/or regulations regarding the distance between nets. Such measures are commonplace in other fisheries worldwide and should not be difficult to implement in the Pacific.

Another concern is that the removal of a proportion of juveniles could destabilise coral reef food webs, which are usually nutrient-limited. However, controls on the catch of juveniles, and the very small size of the fish involved, should mitigate any such effects.

Why not produce juveniles in hatcheries?

Is it necessary to investigate the capture and culture of wild postlarvae when aquaculture is working on the production of juveniles in hatcheries? The answer lies in the fact that there are two main steps in the aquaculture of marine fish—the propagation (or collection) of juveniles and the grow-out of the fish to market size. Propagation of most species of groupers in hatcheries is proving difficult (e.g. The World Bank, 1999) so it is important to verify that a species is amenable to growth in captivity before investing in methods for larval rearing. This is done most easily by capturing and growing wild juveniles. Thus, experimentation on the capture and culture of postlarvae should identify a wide range of valuable coral reef fishes that are amenable to culture without having to incur the high costs of propagating them in hatcheries.

There are also other reasons to investigate the scope for culturing wild postlarvae. First, it may be possible to obtain juveniles of some species more economically by catching postlarvae than by hatchery production. This applies particularly to species in demand by the aquarium trade that have an extended pelagic larval phase. Second, benefits to small-scale fish farmers in developing countries are likely to be increased if they can catch postlarvae using rudimentary materials rather than buying juveniles from hatcheries. Third, the use of wild fry reduces the risks of alterations to gene pools and the transfer of diseases that are often associated with the use of juveniles from hatcheries (Munro & Bell, 1997).

Research on the capture and culture of postlarval coral reef fish in Solomon Islands

The International Centre for Living Aquatic Resources Management (ICLARM), AIMS and the Ministry of Agriculture and Fisheries in Solomon Islands are currently investigating the potential for capturing and culturing postlarval coral reef fish. The three-year project is funded by the Australian Centre for International Agricultural Research (ACIAR) and is based at ICLARM's field station at Gizo in the Western Province of Solomon Islands. The project has three main aims:

1. To document variation in abundance and diversity of fish settling to coral reefs in the vicinity of Gizo for a period of 2.5 years.
2. To compare collections of postlarvae from light-traps and crest nets to determine differences in the types of species, and the proportion of live fish in good condition, caught by each type of gear.
3. To develop methods to culture postlarvae of species known to be of high value to the aquarium market and live fish trade.

The specific goals of the third aim are to determine which species are: robust in handling, amenable to grow-out at low cost by coastal villagers, able to reach minimum marketable size rapidly at good rates of survival, and compatible with other species during grow-out.

The project is designed to benefit coastal villagers in the Pacific. By capturing a sustainable proportion of the postlarvae as they settle from the plankton, and then rearing them to the minimum marketable size, villagers could have up to three new options to derive income. They could sell species of high value to the aquarium market to local dealers, export juvenile groupers to growers of live reef fish in Asia, or sell juvenile groupers to local growers who have access to a supply of fishmeal or trash fish. Another potential benefit of capturing and culturing postlarvae is that juvenile fish which have been reared to a size where they escape most predation could be released onto protected reefs to enhance natural spawning stocks, or for subsequent harvest.

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Collecting grouper seed for aquaculture in the Philippines

by R.E. Johannes[1] *& N.J. Ogburn*[2]

Abstract

Fourteen collection methods for grouper post-larvae, fry and fingerlings (collectively referred to as seed) for growout were studied in 60 coastal towns and cities in the three regions of the Philippines. Green groupers, especially *Epinephelus coioides*, dominate the catch in all areas. Peak seasons vary widely geographically, but generally occurred during wetter months. Interannual variation in catches occurs, with the worst catches in El Nino or drought years. Some collection methods cause high mortalities of by-catch, damage to habitat, and / or allow monopolisation of the local fishery by a few individuals. These include scissors nets and fyke nets, which are already banned in some areas. Mangrove nets and lift nets are also destructive, particularly in terms of by-catch.

Although devices that attract (rather than trap) seed do not show obvious negative effects, significant destruction of by-catch is possible in all but bamboo shelters; when harvests are not handled properly unnecessary mortalities occur. This can be addressed (and in at least two areas has already been addressed) by educating fishers. Grouper seed collection from the wild provides employment for fishers, middlemen and fish farmers and has several environmental benefits. Farm production of groupers reduces the demand for wild-caught adults and the attendant impacts of cyanide fishing and targeting of spawning aggregations. The seed fishery also provides an alternative livelihood to fishers who might otherwise be using cyanide or explosives. Grouper seed fishers often patrol their fishing areas to prevent the use of these methods by others because of negative effects they are seen to have on their grouper harvests. Grouper seed fishing using *gangos* and miracle holes (types of seed aggregation devices) have been officially encouraged in one province as a means to tide fishers over while they wait for their mangrove reforestation plots to mature. Methods that target post-larvae (or 'tinies') seem less likely to deplete wild stocks because of the high natural mortality that probably characterises this stage in the wild. However, no evidence was found that there is indeed depletion of wild stock when fry and fingerlings are harvested.

Fishers using *gangos* or miracle holes reported no declines in catches per unit effort except in areas where substantial environmental degradation resulting from human activities such as pollution and accelerated erosion had occurred. Perception of grouper fry and fingerling shortages is at least partly due to a mismatch between seasonal and interannual availability and demand. If and where a real decline in grouper numbers has occurred, it should be determined whether this decline is due to overfishing of seed, overfishing of adults, habitat degradation and / or pollution. Information concerning the sustainability of fisheries for grouper seed requires research on a range of harvest methods over several years (to account for interannual variability), for a variety of species, and in a number of countries. In this connection many grouper seed collection devices constitute convenient objects for replicated and controlled experimental manipulation.

Introduction

The demand for live reef food fish has grown enormously in the past decade. The environmental impacts of the resulting fisheries are of great concern, especially because of the targeting of spawning aggregations and the use of cyanide (Johannes & Riepen, 1995; Pet-Soede & Erdmann, 1998). Increased farm production of groupers is one means of reducing this damage. However, hatchery technology for groupers is not yet well established.

Many grouper species have been spawned in captivity. But, despite more than a decade of research in at least sixteen different countries, commercial success has proved elusive because of the fragility of grouper larvae, the difficulty of obtaining suitable food for them, disease, and high rates of can-

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nibalism. Typically, mortality rates have been either uniformly high or very variable.

Taiwan has had some modest success in the hatchery raising of some species of groupers commercially. Most of its hatchery production consists of the two species *Epinephelus coioides* and *E. malabaricus* (The World Bank, 1999). The price of hatchery-raised seed (this term is used in this report to refer collectively to post-larvae, fry and fingerlings) has been too high for them to compete with wild-caught grouper seed in many cases. So grouper farming in Southeast Asia continues to rely heavily on wild-caught seed. Indeed, Taiwan itself still imports wild-caught seed of grouper species that it has not yet been able to produce in sufficient numbers in its hatcheries (The World Bank, 1999).

Despite the importance of fisheries for grouper seed in tropical Asia (see below) and concern about their sustainability (e.g. Sadovy & Pet, l998) published information on their nature and sustainability is limited and cursory. To be environmentally sustainable, fisheries for wild-caught grouper should not deplete wild stocks of the target species (e.g. Sadovy & Pet, 1998). Nor should they cause significant environmental damage to habitats or to stocks of other species. The information needed to determine whether these conditions are being met is unavailable for any grouper seed fishery. To obtain it would require several years of field research in a number of Asian countries, on a number of species, and with reference to a variety of harvest methods.

Here, as a beginning, we describe a number of methods used in the Philippines that appear undesirable environmentally and / or socioeconomically. We describe others that seem less problematic but that require more research before definite conclusions can be drawn about their sustainability. We also describe fishers' perspectives on the advantages and disadvantages of the different methods.

We conducted our main survey in September–October 1997. Briefer surveys had been carried out in 1989–91 by N.J.O. and in April 1996 by R.E.J. In total we covered 60 coastal towns and cities in three regions of the Philippines: Luzon, Visayas and Mindanao. Research at N.J.O.'s former Artemia – Finfish Integrated (ARTFIN) Farm in Medellin, Cebu (Ogburn & Ogburn, 1995) also yielded some of the information used in this report. This report is a revised and condensed version of a report to The Nature Conservancy (Ogburn & Johannes, 1999).

Information was obtained primarily by interviews with experienced local grouper seed fishers and grouper aquaculture investors, managers and researchers, and secondarily from literature and record searches.

Study area and grouper species

Except for areas where massive damage to coastal waters has occurred, groupers are collected throughout much of the Philippines for export, local consumption and for aquaculture.

The major species used for aquaculture in the Philippines are the green groupers, *Epinephelus coioides* Hamilton (also referred to as *E. suillus*) and *E. malabaricus* Bloch & Schneider (often confused in the literature with *E. tauvina*). In this report the word 'grouper' refers specifically to the two green grouper species unless otherwise indicated.

The unscaled post-larvae of green groupers, which are transparent or reddish, usually average 1 to 2.5 cm (<1 inch) total length; the scaled fry, which begins to darken, range from around 2.5 to 7.5 cm (1–3 inches) (often measured from the eye to the caudal peduncle) and fingerlings from 7.5 to 12.5 cm (3–5 inches). The term 'tiny' used as a noun, (the plural is 'tinies'), is commonly used to refer to the post-larvae. *E. coioides* usually dominates the seed catch (90–100%), while *E. malabaricus* rarely occurs in large numbers. In some places, the flowery cod (*bantolon*), *E. fuscoguttatus* Forsskäl, may be found in similar numbers to *E. malabaricus.*

Green grouper fry and fingerlings are usually found near river mouths or in muddy estuaries and bays, whereas the seed of many other grouper species are reported in the scientific literature as being found in deeper more saline water associated with coral reefs.

In 1997 grouper fry sold live to traders at US$ 0.03–0.24 / inch (conversion is approximately Philippine pesos 38 / US$) and fingerlings sold live for about US$ 0.08–0.25 / inch. Tinies sold from the source for US$ 0.05 per fish when in large numbers or US$ 0.18–40 per fish when less abundant, or for US$ 0.18–0.32 per fish in Manila. In some towns, per-inch sizing starts only at 3 inches or is used only when the catch is low. During peak production periods, the price is fixed for a range of sizes to minimise processing delays, which could stress the fish.

During the 1997 survey, seed prices had decreased considerably compared to the boom period in the early 1990's when exports to Hong Kong and other Asian countries were at their peak. The formation of a grouper buyers' cartel in the Philippines, the increased Taiwanese hatchery output of fingerlings and the start of El Nino (which is associated with poorer grouper production) in 1997 had reportedly resulted in the lowered prices. Current (1999) grouper seed prices have returned to the higher levels of the early 1990's because of expanding grouper fry and fingerling demand locally and internationally. Importers from Korea and Singapore have joined the original group from Hong Kong and Taiwan.

Grouper collection devices

Fourteen grouper seed collection devices were observed during this study. The different devices select different grouper seed stages. Where trading of one stage is dominant in a particular locality, the other stages are often not collected or bought, or if they are, it is on a minimal basis. If any trading does occur for the minor catches, the price is usually not as good as for the preferred stage. This is because each stage requires somewhat different handling procedures and the buyer is often set up for handling only one stage.

The different grouper collection devices we examined, and their uses, history and location are described below.

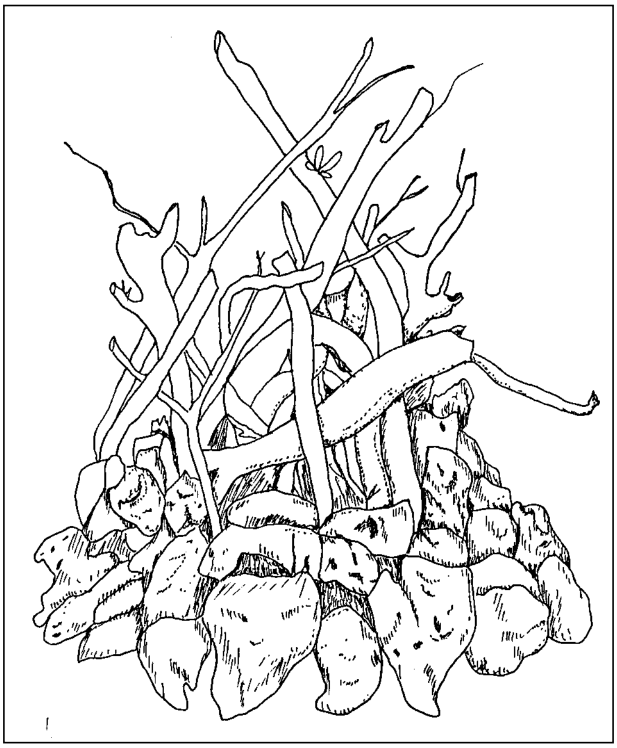

Figure 1. **Diagram of a gango set-up used in Mactan, Sebu**

Fish nests or gangos

Synonyms: Micro-fish aggregating devices (micro-FADs), artificial nurseries, *arong, atob, dugmon, padugmon, tambon, amatong, awung*

Gango set-up

A *gango* is a conical pile of waterlogged, criss-crossed wood or of rocks, sometimes used in combination, together with old car tires, PVC pipe cuttings, bamboo sections or other shelter materials (Fig. l). The wood includes different kinds of mangrove, which is used green and lasts 4–5 years. Land-grown wood is not used if it floats. Wood is preferred on muddy bottoms where rocks are more easily buried during heavy rains. Rocks are used more often on sandy substrate.

Because of their preference for certain species of mangroves, most *gango* operators we interviewed reported that part of their work is to replant mangroves to replace mature trees that are cut. Not all parts of the mangrove trees are for *gango* construction. The larger diameter portions are used for house construction or repairs, or other domestic purposes. In some cases, wood is bought from other owners of mangrove micro-forestry projects. In other cases, mangrove trees are merely pruned.

Gangos vary from 5–10 m^2, with a 2–3 m diametre, or 2.5–3 m x 2-3 m base and 0.5–1.5 m height. The largest may be 5 m diameter at the base. There are many regional variations in the composition and design of the device. They are typically built and harvested during low spring tides at spots where the water is no deeper than neck-deep, i.e. where it is easy for fishers to work on foot. They may also be built in areas that become uncovered at low spring tides, provided trenches are dug around the base so that fish can retreat there when the *gangos* are exposed. Depending on the area, 2–3 people can construct two *gangos* per day.

Gango *harvest*

Harvest starts 2–3 months after construction when the epibiota that is thought to attract fish is well established. The *gangos* are then harvested once every 2–4 weeks, depending on the season. For the harvest, operators use a short beach-seine-like net, 1 m or more in height, 6–8 m long with 1.5 cm stretched mesh, to encircle the *gango*. Both ends of the net are attached to vertical 2.5 m bamboo poles. The bottom of the net is weighted with sinkers while the top is kept above water by floats.

After encircling the *gango* with this net, the operator climbs inside and tosses the gango materials out over the net. Any hiding areas like bamboo sections and holes in the wood or rocks are carefully checked for fish. After the removal of the *gango* materials, fish are now without shelter and can be chased into a 2–5 m-tapered pocket in the middle of the net. The net is then gathered up, the pocket is undone and the fish collected. A new *gango* is then reconstructed with the same materials. In some places a flexible fence of bamboo slats is used to surround the *gango* instead of a net.

An experienced fisher harvests 1–2 *gangos* at very low spring tide, but in many cases the fisher is assisted by at least one family member or a partner and up to 5 units are harvested in a day.

The harvests from *gangos* usually include the green groupers, especially *Epinephelus coioides,* which makes up 90–100% of total grouper catch and *E. malabaricus,* which sometimes makes up 5–10% of grouper catch. Flowery cod, *E. fuscoguttatus,* are also occasionally caught.

A variety of other fish can be found, and sometimes dominate the catch. These include various species of siganids or rabbitfishes, particularly *Siganus vermiculatus, S. guttatus* and *S. canaliculatus*; mangrove snappers, especially *L. argentimaculatus*; gobies and flatfish. Also found are lower numbers of small species, fry / fingerling of some bigger species like eels, surgeonfish, puffers, sweetlips and many others, together with crabs and shrimps. Occasionally, fry / fingerlings of coral trout or mouse groupers are found in *gangos.* An average grouper catch from a single *gango* is 10–15 grouper fry and fingerlings, with a good day bringing 20–30. During the season, groupers typically make up between 10–50% of the total fish catch from *gangos.*

The non-grouper catch in *gangos* are either:

a) eaten or sold, especially bigger sizes of mangrove snappers, siganids and other commonly eaten species,
b) returned alive to the water or to the *gangos*, especially tiny stages of fish or species not used for food, or
c) dried for use as trash fish if already weak or damaged.

Experienced *gango* operators are critical of new or young operators who, wanting to rush the harvest, are not careful in handling the catch, resulting in mortality of fish. They disapprove of those who do not bother returning unwanted species back to water while still alive. From two years purchase records of groupers and other species for nursery / pond culture at ARTFIN Farm and from interviews done during the survey, it was noted that many older or long-experienced fishers routinely return non-grouper species (except selected big-sized fish for food) to the water with the belief that they will be blessed with a more productive water if they do not destroy everything they find. Some even refused to sell grouper tinies from *gangos* and insisted on returning them to other unopened or newly-reconstructed *gangos* to let them grow bigger. G*angos* usually bring in fewer grouper than attractants like the *habongs* and *pailaw* (see below) which catch mainly tinies. But prices for the larger, *gango*-caught fish are higher.

In Ibo, Mactan, Cebu the biggest harvest was obtained during a Signal # 2 typhoon, with 60 kg of fish (mainly siganids and groupers) taken from a 6.25 m^2 *gango.* An *amihan* or northeast wind onshore is reported to increase the likelihood of a good *gango* harvest. During the survey, a sample harvest from a 6.2 m^2 unit produced about 17 kg of fish, mostly siganids (it was off-season for groupers). An average of 15–20 *gangos* out of 62 was harvested per month at this location. Since *gangos* are well guarded in this area, poaching is not a problem and harvests per *gango* have not decreased over the years, according to *gango* owners.

In Ormoc, Leyte, *awung* are similar to a traditional wood and rock *gangos.* They are not ‘opened’, however, but used rather as artificial reefs for recreational fishing, and installed in the Naungan River.

In Guiuan, Western Samar, *gangos* and *arongs* are used to collect big groupers (0.5–1.0 kg), and are thus left unopened for periods of 6 months or more.

For fishers who open *gangos* more frequently and harvest fry instead of fingerlings, the term fish nest was coined because it indicates grouping together of young fish. Because tinies and grouper fry are observed to grow inside the *gango* to fingerling size, the term artificial nursery is sometimes used to describe the *gango* instead of fish nests.

Once *gangos* are installed and aged enough (i.e. have sufficient coverage of epibiota) to attract fry and fingerlings, bigger fish are also seen to be attracted to the *gango.* Fishers sometimes collect these fish for food, and sometimes find newly eaten grouper fry in their stomachs.

Gango history

In some parts of North Cebu, *gangos* were in use at least as long ago as 1939. In Mactan, Cebu, Councillor Reynaldo Lauron introduced *gangos* in the Ibo export-processing zone in 1981. From the two *gangos* he started with, he has increased operation to his current 62 units. For his pioneering efforts he was awarded by the Bureau of Fisheries best fisherman of the year in the region for 1987.

In Bohol, fishers report the use of *gangos* as early as they can remember, which is at least 50 years ago.

Yao and Bohos, Jr. (1988) reported that *amatong* fishing (referring to both *gangos* and miracle holes, see below) was introduced in Banacon Island by Damang Ismael, a Muslim who was apparently stranded in the island.

In Bulalacao, Mindoro Oriental all-wood *gangos*, or *dugmon*, were used for 5 years in the 1980s, but this was discontinued because buyers preferred the numerous tiny groupers obtainable from post-larvae attractants such as *habongs* (see below) rather than the fewer fingerlings caught in *dugmon*.

In Tubod, Lanao del Norte *gangos*, or *gala*s, were in use by 1985. In 1990, the Municipal Fisheries Office studied *galas* and found them to be good aggregating devices for fish. But since it was feared that their uncontrolled use of *galas* led to the removal of too many fish, the Fisheries Office recommended *galas* be used mainly for fish protection and not for collection.

Before grouper trading became a lucrative business, *gangos* were used in all the above provinces mainly to collect fish to be eaten or sold in the local seafood market. Typically, fishers left the *gangos* unopened for much longer (at least 6–9 months) than since the mid-1980s, when the market developed for grouper seed.

According to our interviews, many *gango* owners had used cyanide to collect fish in the past, but renounced these practices when they saw the advantages of using *gangos*. Indeed, *gangos* operators in various provinces said they routinely police their areas against the use of cyanide and explosives by others because they experience significantly lower harvests from *gangos* constructed where these other, illegal fishing methods are used. Moreover, they volunteered, grouper seed caught with cyanide usually die after a few days. Buyers sometimes blacklist the suppliers of such fish.

In over 50 years of continuous *gango* operation, F. Neiz of North Cebu has never observed a marked decline in catches of grouper and other fish. On the contrary, he says, fish numbers in adjacent waters increased as more *gangos* were introduced. He, like other gango operators, does, however, report year-to-year variation in catches apparently related to interannual variations in weather conditions (see below).

Fish fences, on the other hand, have shown significantly lower catches since he began to use them 40 years ago. Of the collectors he has used, including scissors nets (see below), *gango* is the best and most consistent moneymaker he reports. As his main source of income, *gangos* enabled him to rear and educate 11 children, who he could not support adequately with produce and profits from his farmlands and fish fence. Similar observations were made by younger *gango* operators around San Remegio and in Medellin, Cebu. In Carles, Iloilo, S. Palaver similarly reported with pride that the profits from his *gangos* enabled him to raise and educate (in one case through university) 10 children. This is no small feat in communities where most houses have dirt floors and education is not free.

In Bohol, as in North Cebu, fishers and researchers have never observed a marked decline of grouper and other fish associated with the use of *gangos* (C. Pahamutang, pers. com.). They do report interannual variation, however, with significantly more fish collected every 3–7 years. Best catches according to most fishers are associated with wetter years.

The number of *gangos* or *padugmon* in Tinagong Dagat, Capiz has greatly declined with time due to increased siltation in the area; the water has become mostly too shallow for their operation (e.g., in Palungpong Bay). Unlike other provinces, harvests reportedly never exceeded 5 kg per unit.

Miracle holes

Miracle holes (the English term is preferred by fishers to any local name) are man-made holes, excavated with hand implements, optionally diked with the dug-up substrate, and filled with coral rocks, mangrove branches, coconut fronds and other waste material that attract fish seeking shelter. They are usually excavated in the shallow sides of estuaries or bays on bottoms that are exposed on spring low tides. The holes are typically 1–3 m wide, 2–3 m long and 1 m deep, although we saw some larger ones. Variations in shape and dimensions have developed as the technology spread. Coconut or buri palm fronds are often used to cover the holes to reduce fish disturbance. The holes are described as miracles because no effort or fry stocking expenditure is involved, and the harvest is looked upon as a gift from nature. Yao and Bohos, Jr. (1988) refer to both miracle holes and *gangos* as *amatong*, which, they say, originated in pre-WWII days.

Like *gango* owners, users of miracle holes carefully guard them against poachers, who sometimes use cyanide or other poisons to steal their fish. Sometimes, a guard hut is constructed near the holes. Harvesting is similar to that for *gangos* in that a net is used to encircle the hole prior to removal of aggregating materials inside. They are harvested every 2–3 months, usually starting 4–6 months after establishment. The hole is refilled with the shelter materials after harvest.

Harvests from miracle holes are usually similar in species composition to those from *gangos*. Peak grouper production in Cebu is from August to December although smaller numbers are available year-round. The miracle holes are covered in March / April and uncovered starting May–July. As with *gangos* grouper catches from miracle holes were often reported to be lower in drought years.

The Central Visayas Regional Project office in Cebu City introduced miracle holes in Bohol and south-western Cebu starting 1984 as part of its World Bank–funded rural project to increase agricultural productivity and create employment opportunities while maintaining ecological stability and conserving resources. According to fishers interviewed in Cebu, the use of miracle holes has been increasing since then (when 2 people had 10 and 20 units respectively). Some miracle holes have been in use for over 10 years. Approximately 100 units exist at present in Badian alone. Owners stated that they stopped using cyanide and explosives when miracle holes were introduced.

Fish (post-larvae) shelters

a) Habong

Synonyms: *Bon-bon, palumpong*

Habongs are formed by hanging brush, nets, or clusters of grasses or leaves or other materials (Fig. 2). They provide hiding places for grouper tinies as well as smaller numbers of grouper fry. They are used with or without lights. They are the most widely used grouper collection device in Bulalacao, Mindoro Oriental. *Habongs* were introduced in 1983–84 from San Jose, Mindoro Occidental where Taiwanese and Japanese grouper buyers who preferred tinies were based.

Those without a light are generally made of nets hanging from a rope suspended from a float. They are set on the substrate in shallower river portions. At low tide they are lifted gently one-by-one into a scoop net where the tinies are shaken out. Adults can catch an average of 2,000–7,000 tinies per fortnight with up to 10,000 caught per person in peak season.

Fishers say that good tiny weather is windy but not stormy, with light rain. Tinies do not accumulate during typhoons. When the weather bureau issues typhoon alerts, tinies are still found if it is around the time of the new moon and the rain / wind is not yet too strong. During the season, tinies are usually most abundant from 4 days before until 4 days after new moon. The main season occurs in the relatively wetter months, although some tinies may still be found mixed with larger groupers in *habongs* in the less rainy months of summer when collection stops.

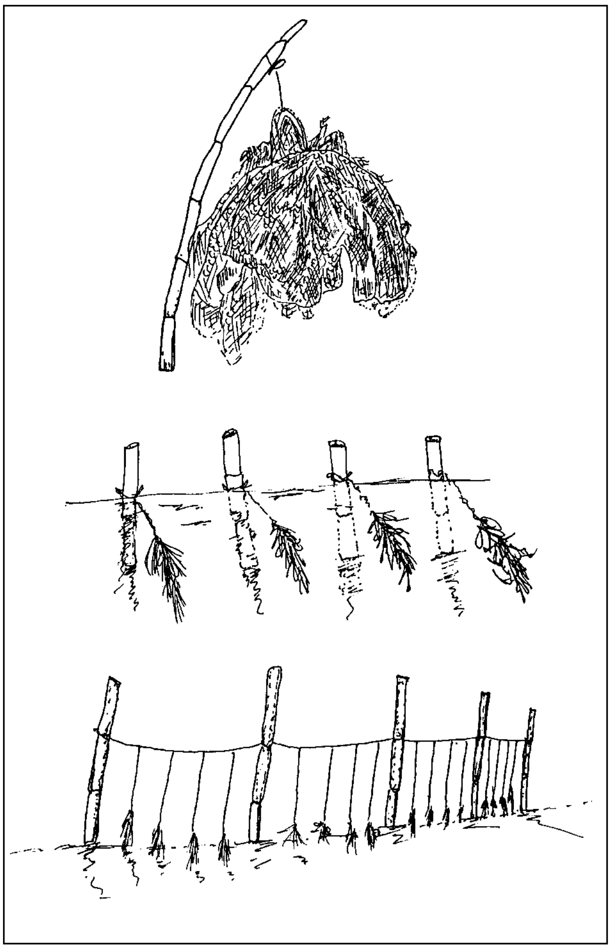

Figure 2. **Different types of fish shelters (*habong*)**

In Sapian Bay, Capiz, where mussel culture is widespread, the mussel clusters serve as attractants for tinies. The mussels are harvested from November to February, while the tinies peak in production in September according to the fishers. They also report that the Bay's productivity of tinies and other fish has decreased over time due to siltation and human activities.

In Tubod, Lanao del Norte, coconut fronds and many kinds of debris are used in fish seed shelters based on the Mindoro *habong* design. They are called *galas* and are used for both groupers and prawns. They may be suspended from the surface with floats, or anchored to the bottom.

In Pagadian City, *habong*-like tiny attractants known as *palumpongs* are made of certain weeds (*sagbot*) and a local fern commonly found along fishpond or estuary dikes, known as *pagaypay*. Less wave-resistant materials than coconut fronds can be used there because waves action is much less than in more exposed waters.

Tiny grouper collection started in 1983 when a Japanese buyer taught children to catch these fish. It stopped when the Japanese ceased operation after 1985. Other grouper buyers set up in the late 1980s.

Usually there are four seasonal peaks for tiny groupers reported in Pagadian City—April, August, September and December. Year-to-year variations in catches are observed, with more tinies in drier years. This is contrary to observations in many other provinces where small groupers are more abundant in wetter years. However, it rains relatively uniformly throughout the year in this area. Thus, dryer periods are still relatively wet compared to dry periods in provinces with more pronounced seasons. Since collection of tinies began in 1983, no significant decrease in numbers has been noted. Tinies are reported to be less hardy than the 1-inch fry collected in the area.

In Tagabuli, Davao del Sur, where *habongs* are also widely used, there are also 3–4 tiny seasons per year, with interannual variation relating, fishers say, to rainfall. Tiny numbers are highest in wetter years and lowest in El Nino years. The collection period is from 3 days before until one week after new moon. The *habongs* are made of used nets as in Mindoro. They are not laid directly on the muddy bottom, but rather suspended from bamboo sticks about 10 cm above the bottom. Sometimes, guava branches are used, but they last only 3 days. *Habongs* are installed one day after the presence of tiny groupers in the bay is observed. They are harvested on the next low tide. A similar system is found in Palembong, Sultan Kudarat.

After introduction of intensive milkfish / grouper cages in Tagabuli Bay in 1996, operators expanded from two to more than 40 cages. Tiny grouper production has reportedly become increasingly erratic, with unpredictable peak production months. Water quality is reported to have deteriorated with intensive feeding in the densely–packed and often overfed cages, so that the skin lesions and fin rot sometimes found in groupers in warm periods now occur year-round. Tinies stocked in cages often develop these lesions, red bloody mouth and whitish eyes, within 3 months of stocking.

In Balasinon Bay, *habongs* are made of buri / coconut fronds, used sacks and *pagaypay* fern. Used together with *pailaw* (see below), habongs can yield 15,000 tinies per season per operator.

In Tinagong Dagat, Capiz, *habong*-like fish shelters known as *bon-bons* are made of coconut fronds with the ends tied together with a nylon rope, and connected to a stake in the substrate. *Bon-bons* are well guarded by their operators to prevent poaching.

In Hagonoy, Bulacan, income from *bon-bons* was sufficient until installation of numerous big grouper seed collection devices (e.g. mangrove nets—see below) led to a decline in the number of fish entering the *bon-bons*.

b) Pailaw

Synonym: *Paapong*

A *pailaw* consists of a series of *bon-bons,* i.e., small shelters for tinies made of nets or vegetation, hanging from ropes attached to the outrigger of a pump boat located in 3–6m deep water. An average pumpboat may have as many as 40 *bon-bons* hanging from each outrigger. They are harvested at night after lighting *Petromax* lamps (2–4 units) on the boat, fixed near the outer support of the outriggers. Half an hour after lighting, one *bon-bon* is tested by lifting up slowly into a scoop net. If tinies are numerous, all *bon-bons* are lifted consecutively.

Pailaws are commonly used together with unlighted *bon-bons* in Bulalacao, Mindoro Oriental where in season, one can collect as many as 15,000 tiny groupers per night from a boat with 40 *bon-bons* per outrigger. *Pailaws* are used mainly in deeper, clear coastal waters.

In Balayan, Batangas, where there are no rivers nearby and collection is along the coast, the *pailaw* is the only device used. Around new moon prior to our September survey, 300,000 tiny groupers were collected in the bay over a period of 3 nights.

In Tagabuli, Davao del Sur, *paapongs (*another name for *Pailaws)* hang from the boat only about 10 cm above the bottom as the bay has become increasingly shallow. In good seasons, as many as 3,000 tinies can be collected from the bay each night.

For both *habong* without light and lighted *pailaw*, non-green grouper species make up as much as 25% of the total catch. *E. fuscoguttatus* as well as some banded groupers are considered rejects because attempts by many Filipino farmers to culture them yielded in far slower growth than green groupers fed and grown under similar conditions.

In many provinces possessing suitable habitat for catching grouper fingerling and fry using gangos or miracle holes, the use of other collection devices such as *pailaws* or *habongs* is found only where buyers prefer tinies over larger seed (e.g., in Bohol;

Bulalacao, Mindoro; Mindoro Oriental, and Balayan, Batangas).

Lift net or paapong

Synonym: New look

Very large lift nets for collection of small groupers are similar to those used widely in the region for other fish and squid, except that finer-mesh (2–5 mm) netting is used (Fig. 3). Large quantities of tinies and fry can be obtained in season—hundreds to thousands per lift. A *Petromax* light is used during harvest to attract the fish. This device results in wastage of large numbers of non-target species due to priority for processing of green grouper tinies.

Figure 3. Lift net or *paapong*

Bamboo shelter or sugong

Synonyms: *pasok*, fish *lagung*

Different configurations of cut bamboo segments which serve as fish shelters range from assemblages of bamboo flotsam to deliberately cut and shaped wood. Sometimes, coconut shells and cans replace or add to the bamboo, as in Isla Verde, Batangas and Ormoc, Leyte.

In Tinagong Dagat, Capiz, *pasok* are usually made of several layers of bamboo sections, arranged one on top of the other. Holes are drilled to allow the fish in. A simpler design is a 2.5-inch diameter bamboo internode with both ends open and a hole through the middle where a stick is inserted for use in staking the bamboo in the mud to anchor it (Fig. 4). This is similar in design to the fish *lagung* in Tubod, Lanao del Norte. One person usually operates 200 *pasok*, with an average catch of 1–3 grouper fingerlings per *pasok* per harvest.

Unnecessary fish mortalities seldom occur in connection with these devices. During typhoons, however, most *sugong* are blown away, even if they are anchored to the substrate. Poaching can be a problem due to easy removal or movement of these small shelters.

Figure 4. Bamboo shelter or *sugong*

Mangrove net or sira-sira

Synonyms: *Bukatut, tampung, lapad*

In Bohol, *sira-sira* are nets about 2 m high and may be 100 m or more long. The mesh is fine, around 5 mm. They are placed so that they run along the outer edges of mangrove communities. As the tide drops and fish are forced to leave the mangroves, they are trapped in the net pocket.

Although harvest figures using this method have not been obtained, catches of groupers are reported to be high. As with many other collecting devices, the catch often contains an assortment of other species. The mangrove net poses the problem of wastage of much by-catch, since rescuing the large numbers of groupers in the catch before they die has priority.

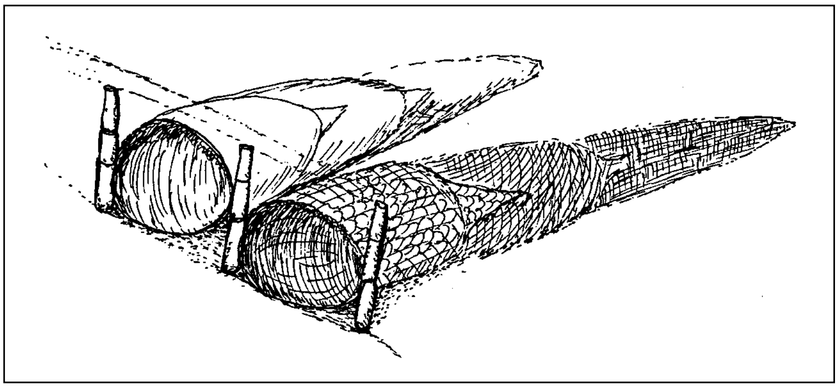

Figure 5. **Diagram of the fyke nets or *sangab***

Fyke net or sangab

Synonyms: Filter net, *tangab, kimpot, bayakon, puyo*

Fyke nets or *sangab* are big collectors, consisting of a group of stationery nets installed in river mouths during high tides. Figure 5 shows a *sangab* that consists of only two nets. *Sangab* are held to the substrate with hooks, with weights and a bamboo support along the bottom edge of the opening, and are suspended from the surface by a rope and floats, with a stake support in front. Three mesh sizes are usually used, beginning with larger mesh at the aperture followed by medium and finally finer net at the end. They are installed at low tide, two days before new moon, and harvested at high tide at night. They are used primarily for tinies. Collection lasts until 4–5 days or more after new moon.

Such nets are also heavily used in Pola and Mansalay, Mindoro Oriental where they are known as *kimpots*. Units may line entire river mouths. An average of 15,000 to 40,000 tinies can be collected in one night per *kimpot*, mostly in good condition. As many as 1.4 million tiny groupers can be collected using ten *kimpots*, together with *pailaw*, in one collection period—or up to 2 million fish in total, including rejects (damaged tinies or non-green grouper species).

In Ormoc, Leyte, fyke nets called *sangab* are smaller than those in Mindoro Oriental. A 7 m *sangab* with a 1.5 m pocket equipped with a ring is commonly used in November–December when tinies are abundant. The average yield is around 5,000 tinies per *sangab*. The catch also includes crabs and shrimps. Tinies can be held awaiting buyers for at least a week and up to a month if well fed with mosquito larvae, brine shrimp nauplii or tiny shrimp (*uyap*).

In Ormoc, more grouper seed are caught in rainy years than in dry, hot years. More fry, including those of milkfish and shrimp, are collected during storm warning/signal days, just before the storm hits. Around the new moon prior to the September 1997 survey, 10,000 tiny groupers were reportedly collected using this method.

The fyke net is a very effective device for collecting tiny groupers and other small fish and invertebrates. It can easily obstruct river mouths and estuaries, especially as the net dimensions increase, thus imperilling entire runs of tiny or small fish. Any unwanted species for aquaculture will likely die because post-harvest processing, which is a time-consuming process, gives priority to the massive numbers of groupers caught.

Fyke nets, therefore, appear to be of questionable ecological soundness. They can also reduce social equity in the fishery since a few people can dominate the operation. With smaller gear, in contrast, many fishing families can be supported.

For these reasons, fyke nets have been banned in some municipalities, like Bulalacao, Mindoro Oriental and Tubod, Lanao del Norte where many fishers need to share the fisheries resources or where *sangab* has reportedly led to an apparent reduction in seed of many species, including prawns, shrimps, crabs, etc.

In Pagadian City, only a few *sangab* can operate in the small Kawit estuary, which is connected to Bulanit, the river/estuary mouth. Five *sangabs* are enough to block the river almost completely.

Scissors net or sudsod

The *sudsod* is a modified version of the scissors net commonly used for milkfish fry collection. A triangular net is attached to two crossed bamboo poles. Wooden 'shoes' are fitted to the bottom ends of the poles to enable them to be pushed along rough bottom. One person pushes the *sudsod* like a lawn mower in shallow water near shore or in estuaries and certain open coastlines at low tide (Fig. 6). *Sudsod* are used mostly for collecting tiny groupers and 1-inch fry. Five-to-ten groupers can be harvested per lift, with an average of 500 small groupers per day being caught per unit.

In Tubod and Panguil Bay, Lanao del Norte, *sudsods* are the major and often the only collector used for tinies. When there is a boom in tinies, *sudsod* are sometimes operated from motorised boats. *Sudsod* are usually operated during the daytime, starting at dawn. Harvested tinies are temporarily stocked in pails and fed boiled egg yolk or formulated feeds provided by buyers. Peak tiny grouper season in this area is in November–December, with fingerlings increasing towards February. In the boom year of 1992, as many as 100,000 tiny groupers were collected with *sudsod* per day by around 1,000 people. Fry and fingerling groupers are found from March to October, and are collected by *bubo* (see below), *sugong* or other devices.

In some provinces, *sudsod* are illegal (e.g. Davao and Bohol) because of their destructive effect on benthic habitat. Areas scraped by *sudsods* for several months are denuded of the grasses, molluscs and other benthic organisms. Although grouper seed collection may continue in these places, fishers say their catches gradually decrease.

Figure 6. **Scissors net or *sudsod***

Other minor methods

The *Sabay* is similar to a very small beach seine and is sometimes used for catching grouper seed in the Bohol area.

Bungsod, or fish corrals, are used mainly for catching milkfish and prawns. Grouper fingerlings caught incidentally by this device, are not always in good condition because they get gashes from the bamboo fencing.

Kawil, or hook and line, is sometimes used to collect grouper fry and fingerlings. It use for this purpose is widespread but probably does not account for large percentages of the catch in most areas. Catch per unit effort is probably relatively low, although in Roxas City, Capiz, up to 2,000 grouper fingerlings have been caught in a day at peak season by hook and line fishers collectively.

Sigpaw or *sadyap* are scoop nets used by children and fishers for collecting groupers as well as other kinds of fish. In Tubod, Lanao del Norte, they are used to collect bigger grouper fry and fingerlings while diving with a compressor or hookah gear because strong currents can destroy other devices. The method is often limited to fishers who can get their diving gear from grouper traders because it is not often affordable by ordinary fishers. This method can also be observed in good coral reef areas serving tourists where diving gear can be rented.

Bubo, or fish traps, although used mainly for catching bigger food fish, are sometimes used for catching grouper seed. In Bohol, *bubos* are modified using finer-mesh and a smaller aperture so only fry and fingerlings can get in. Like *sabay*, this is not a commonly-used method.

Other survey information

The grouper ball jackpot

In the deeper areas, approximately 7–10 fathoms, of a bay in Mindoro Oriental, fishers have reported seeing what have come to be described as 'grouper ball jackpots'. The balls are actually a membranous material that look, at first glance, like drifting plastic bags. In one instance, a fisherman scooped up one of these balls thinking it was waste and discovered when it burst that there were many thousands of tiny green groupers inside. Since the coral reef areas where groupers spawn is still much farther out, the tiny groupers enroute to nursery grounds may seek shelter in these membranous sacs. Their origin and composition is unknown.

Grouper seasons

The seasons for green grouper tinies, fry and fingerlings in the Philippines vary widely according to provinces and towns and the associated weather and geography of each. In general, the peak grouper seed season is associated with the relatively wetter months of the year. An exception is found in places where it is always rainy and heavier rainfall lowers grouper catch, as in Tagabuli Bay, Davao del Sur. Interannual variation in grouper season and abundance is observed by all fishers. They generally agree that it depends on the relative wetness of a year and on which months the rains are heavier. The worst grouper seasons are associated with El Nino years or when there is a drought. The number of seasons per year is usually higher in places where there is a relatively uniform or evenly distributed rainfall throughout the year, like Pagadian City and Davao del Sur.

It is noteworthy that, in several areas, grouper seed collectors told us that their best catches were associated with windy weather. This corresponds to a number of recent descriptions by researchers of recruitment pulses of settlement-stage reef fish, including groupers, that accompanied windy weather that apparently transported the fish shoreward (e.g. Shenker *et al.*, l993; Dixon *et al.*, l999).

Evaluating grouper seed collection methods

Is the collection of grouper seed from the wild for aquaculture sustainable in the Philippines? The detailed information needed to make a clear-cut judgment is lacking. However, it is evident from the information gathered in this preliminary study that some grouper collection methods are more problematic than others. Clearly destrucive are methods that result in high mortality of by-catch, are damaging to fish habitat and/or result in monopolisation of the local fishery by a few individuals. As already mentioned, two of these destructive devices, scissors net (*sudsod*) and fyke net (*sangab*) have already been banned in some towns.

Of the eleven major grouper seed collection devices, eight do not possess the above drawbacks; namely, fish nests, miracle holes, fish shelters with and without a boat, lift nets, hook and line, bamboo shelters and scoop net. However, if catches are not handled properly, significant destruction of by-catch as well as high mortalities of grouper seed are possible *after* the fish are harvested. The last three methods listed above are the least worrisome in this regard, but are not among the more important methods used in the Philippines.

To combat this harvest/post-harvest handling problem, education of fishers has been carried out successfully in at least two instances: i.e., in Banacon Island of Jetafe, Bohol (Yao & Bohos, Jr., 1988) and in ARTFIN Farm, Medellin, Cebu (Ogburn & Ogburn, 1995). In the former instance, Bohol fishers were taught by the Integrated Social Forestry Program to harvest catches from *gangos* and miracles holes (collectively referred to as *amatong*) using nets of a mesh size that allows smaller fish to escape. In Medellin, farm suppliers of grouper seed were trained rigorously in fish handling and treatment of weak/sick fish and were discouraged from taking in non-target species, except those that are normally utilised by the fishers as food. Such education could easily be introduced elsewhere and integrated with existing village-based coastal management programs.

Grouper seed collection from the wild using non-destructive methods not only provides employment to fishers, middlemen and fish farmers, but can also have certain environmental benefits. The farmed fish arising from this fishery help reduce the demand for wild-caught adults and thus the use of cyanide and dynamite, as well as the decimation of spawning aggregations by collectors of adult groupers for the live reef food fish trade. In addition, provided the fish are grown out locally, the use of wild fry reduces the risks of alterating gene pools or of tranporting disease (e.g. Munro & Bell, 1997).

Fishers for juvenile groupers actively patrol their fishing areas, believing that the use of cyanide anywhere in such areas will affect their catches. Some *gango* fishers volunteered that they, themselves, were cyanide-users before they discovered the advantages of *gangos*. Fishing using cyanide or explosives are among the few options readily available to poor fishers in the region, and they are more lucrative, and thus more attractive, than is sometimes realised (Galvez *et al.*, 1989; Pet-Soede & Erdmann, 1998).

Fisheries for juvenile groupers in one area have even been described as assisting mangrove reforestation efforts. During community-based mangrove replanting projects organised by the Integrated Social Forestry Program in the Central Visayas, coastal villagers were encouraged to construct *gangos* and miracle holes to obtain cash while waiting for returns from their mangrove stands (Yao & Bohos Jr., 1988).

Sadovy and Pet (1998) noted that the removal of grouper seed from the wild by any method might reduce subsequent adult populations. The seriousness of this threat is unknown, but it would seem to be less where tinies are targeted rather than fry or fingerlings. The first few days of the demersal existence of coral reef fish appear to be a period of high mortality (e.g. Beets, l997 and references therein).

Fishers and researchers in the region agree that they see tinies in much greater numbers than grouper fry or fingerlings. This suggests that, as with the reef fish discussed above, there is considerable natural mortality among the tinies. If true, this indicates that the harvesting of tinies is less likely to have an impact on future adult populations than the harvesting of fry or fingerlings.

If recruitment of estuarine grouper seed is habitat-limited, then increasing the harvest of wild grouper seed by means of fish nests (*gangos*) and miracle holes may not deplete wild stock. Sadovy and Pet (1998) pointed out that 'the critical question here is whether natural mortality is reduced by artificial habitats such that the 'excess' survivors, i.e. the juveniles that would otherwise have perished, can be harvested, or, alternatively, whether artificial habitats attract significant numbers of juveniles that would otherwise settle successfully in natural habitat, thereby increasing total mortality.'

The value of suitable shelter for recruiting reef fish has been demonstrated by various researchers (e.g. Brock & Kam, 1994; Beets, 1989; Shulman, 1984). Shelter such as that provided by the six major attractant devices described above, provides not only protection from predation, but also attracts food organisms. In addition, it reduces currents, thus reducing energy expenditure of fish in maintaining their positions. Teng & Chua (1979) demonstrated that the placing of shelter such as PVC piping in net cages with small estuarine grouper, *E. salmoides* (an old name for *E. malabaricus*) more than doubled both optimum stocking densities and net production.

It is worth noting in this connection that the natural habitat for *E. coioides* and *E. malabaricus* fry and fingerlings has been greatly reduced in recent decades. Juveniles of these species commonly inhabit mangrove estuaries (e.g. Sheaves, l995). The destruction of hundreds of thousands of hectares of mangroves in Southeast Asia in this century—an estimated 40–50% of the total mangrove area in the region and 80–90% of the mangroves in the Philippines (see the various papers in the Mangrove Forests section of Wilkinson, 1994) has greatly reduced the shelter available to these fish, as well as to other mangrove dwellers. Creating artificial shelters on featureless estuarine mud bottoms, especially in areas where mangroves have been destroyed, may therefore increase the survival of grouper and recruits as well as that of the other species they attract.

None of this proves, however, that these or other methods for harvesting grouper juveniles do not deplete adult stocks. The question clearly needs research. Fortuitously, the many of the artificial grouper shelter/attractant devices described above offer exceptional opportunities for well-controlled field research to answer this question. They constitute discrete, easily replicated units of artificial habitat that are ideal for experimental manipulation.

Many authors have stated that there is a 'shortage' of wild grouper fry, and some have concluded that they are therefore being overfished. The conclusion does not follow from the observation. Milkfish fry, of which about one billion are harvested annually for aquaculture in the Philippines, offer an instructive parallel. Bagarinao (1998) states that, 'the seasonality of milkfish reproduction has serious effects on the fry industry—fry are abundant and low-priced during the peak months, but scarce and highly priced during lean months. The problem of mismatched timing between fry availability, low prices and pond stocking is commonly perceived as 'fry shortage'.' This same scenario pertains to fisheries for grouper seed in the Philippines.

Most *gango* operators interviewed perceived no decrease in their catches per *gango* over the years, even though the numbers of *gangos* in their waters had increased. When asked how they felt about new entrants to their fishery they almost invariably had no objection. 'There's enough for everyone' was a common reply.

The only areas where catches per *gango* were said by their users to be decreasing noticeably were in bays known to be seriously affected in recent years by sedimentation and/or pollution, and where fishing in general has declined markedly. Thus, although grouper seed catches were decreasing in these bays, overfishing does not appear to be the main cause.

Significant declines in some other species of groupers harvested as juveniles in other countries have been reported. The most often mentioned decline is that of *Epinephelus akaara* along the south China coast, including the waters around Hong Kong. Is this reported decline a result of misperception due to harvest/demand mismatch, or is it real? If it is real, is it due to overfishing of juveniles, to overfishing of adults, to pollution and/or to habitat degradation? In the mid-1990s almost half of the world's dredges were at work in Hong Kong waters in support of land 'reclamation' (Patten, 1998). The feverish pace of development in adjacent coastal regions of the Chinese mainland in recent years is well known. In addition, the pollution of coastal waters in the region due to sewage and industrial waste is notorious (e.g. Morton, 1998). It seems unlikely that juvenile *E. akaara* in their shallow nearshore habitats have wholly escaped this onslaught.

There are some ecological risks associated with any harvest. But focusing on these alone in connection with fisheries for grouper seed ignores not only the socioeconomic but also the conservation benefits. Whatever the arguments in support of fishing for wild grouper seed, however, it should be stressed that these fisheries yield only certain species of the genus *Epinephelus* in significant quantities[3]. They do not yield many of the most highly-priced groupers, i.e. the highfin grouper (*Cromileptes altivelis*), or plectropomid groupers, i.e., coral trout (*Plectropomus* spp.). (During our study, plausible accounts were given in two areas, however, of post-larval coral trout being caught in significant numbers; this deserves investigation.)

Nor do they provide seed of the most expensive of all live reef food fish—humphead wrasse. In at least some cases this is because the juveniles of these species do not do not aggregate in large numbers (e.g. Doherty *et al.*, 1994; Colin *et al.*, l997). Solving the problems of economic hatchery production of these species thus seems to be the only way to substitute farmed for wild-caught adult fish.

The biological, social and economic features of fisheries for grouper seed are thus complex and not easily reduced to a balance sheet of plusses and minuses, especially in the absence of quantitative data on key questions. We have learned enough about the plusses, however, so that we do not recommend banning wild grouper seed fisheries in the absence of persuasive evidence that it is unsustainable[4]. We have also learned enough about the minuses to be critical of certain collection devices that are, or appear to be, environmentally damaging or socially inequitable. For these reasons the collection of grouper seed using lift nets, scissors nets, mangrove nets or fyke nets should not, in our opinion, be encouraged.

Education of fishers to reduce wastage of by-catch or harvests should be promoted. This would probably not be difficult to build into the many coastal resource management projects carried out by NGOs in fishing villages in the region. As already noted, this has already been done in the Central Visayas.

Methods that target post-larvae are less likely to deplete stocks than methods that target fry and fingerlings (e.g. Bell et al., this issue). But research is needed before it can be determined if either type of fishery threatens stocks. It is somewhat reassuring that fishers interviewed during our surveys do not perceive such a threat in the Philippines. Their catches per unit effort, they say, have not decreased except in areas of pronounced habitat degradation. But to get a definitive answer to this question, definitive long-term research would be needed.

Fishing for juvenile groupers to supply fish farmers occurs in almost every country with a coastline from south China through Southeast Asia at least as far west as Sri Lanka. To clarify this issue then, research must be carried out in selected areas throughout the region on a variety of harvest methods and for a variety of species.

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3. It is the two Indo-Pacific Epinephelid species that spend their first demersal year or so in estuarine waters that are most easily cultured. This is probably no coincidence. Species that can tolerate the large variations in salinity, temperature, turbidity, nutrients and organic loads characteristic of estuarines are more likely to be able to tolerate the environmental insults to which they are typically subjected in ponds and cages.
4. The recent ban on construction of artifical reefs in the Philippines includes devices such as gangos and miracle holes, suggesting that a premature judgement has been made about their effects. However, since the ban is not enforced, it has had no practical impact on grouper seed collection as far as we have been able to determine (Johannes, 1999).

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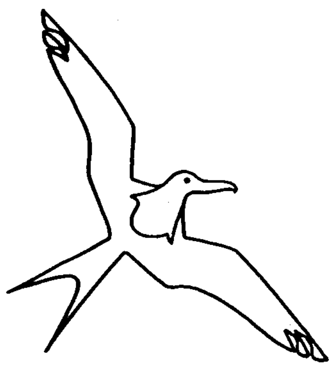

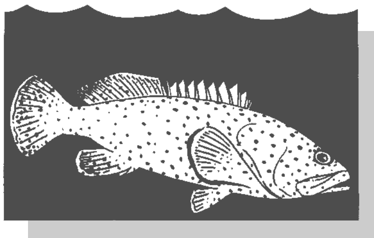

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Trai, N. van & J.B. Hambrey (1998). Grouper culture in Kanh Hoa Province, Vietnam. INFOFISH International 4/98: 30–35.

Watson, D., P. Hart, J. Gallagher & D. O'Sullivan (1999). Bali success with Barramundi cod. Austasia Aquaculture. June/July: 50–51.

Cromileptes altivelus, also known as panther grouper, highfin grouper and barramundi cod, is one of two highest-priced species in the live reef food fish trade. Their sustained commercial hatchery production has eluded aquaculturists for years. The Gondol Research Station in Bali, Indonesia, has apparently overcome the problems. Although survival to post-metamorphosis has never been more than 10%, the profit margin is so high, the authors state, that farming this species is proving more profitable than farming milkfish. 'The farmer only needs one success out of three production cycles to be profitable.' The station is also experimenting with the culture of Maori wrasse (*Cheilinus undulatus*), which, the authors state, eat coral in the wild. [This is incorrect. The similar-looking but only distantly related humphead parrotfish, *Bolbometapon muricatus*, eats coral. Maori wrasse eat a large variety of reef invertebrates and will accept many (but not all) species of fish in captivity–. Editor]

JOHANNES, R.E., L. SQUIRE, T. GRAHAM, Y. SADOVY & H. RENGUUL. (1999). Spawning Aggregations of Groupers (Serranidae) in Palau. Marine Conservation Research Series Publ.#1, The Nature Conservancy. 144 p.

Three species of groupers, *Epinephelus fuscoguttatus, E. polyphekadion* and *Plectropomus areolatus* aggregate to spawn at overlapping locations and during overlapping seasons in Palau, Micronesia. A number of such aggregations were eliminated by overfishing, including fishing to supply the live reef food fish trade. The government therefore wanted advice concerning how best to protect remaining aggregations. In response, spawning aggregations of all three species were censused at each of three sites for 2–3 years. The best days of the lunar month and best months of the year were determined for monitoring these aggregations in order to provide truly comparative data. It was found that:

1. The timing of spawning aggregations of each species varied somewhat between aggregation sites in terms of months of the year and days of the lunar month. The size distributions and sex ratios of *P. areolatus* also varied significantly between aggregation sites. There was considerable intermonthly and interannual variation in peak spawning aggregation size that was evidently independent of fishing pressure, management measures or recruitment. Such background variability makes it difficult to detect changes in aggregation size due to changes in fishing pressure quickly enough to adjust management measures effectively in response.
2. At least 57 other species of reef food fish also spawned in or near the grouper aggregation study sites, including a number of important food fish. Protecting such sites from fishing can therefore relieve fishing pressure on these species as well as on groupers.

Management of groupers and other reef fish to achieve optimum yields or stock sizes is not feasible. Management with the less precise but feasible goal of protecting spawning stock biomass from serious depletion or local extinction, is a practical alternative. Temporal and / or spatial closures designed to reduce fishing on spawning aggregations can be a cost-effective way of implementing such management. Marine resource managers in the tropics should avail themselves of this opportunity much more widely–especially in the Indo-Pacific where the protection of spawning aggregations is at least a decade behind the western tropical Atlantic.

Broodstock (especially males) of various groupers species, is hard to come by in Asia. Broodstock of some favored grouper species could easily be obtained at known times and locations in various Pacific Island countries.

‘Best Practice’ manual does not live up to its title

by L. Squire & R.E. Johannes

ISO Best Practice Manual: Storage and Delivery of Live Reef Fish. 1997. Commonweath of Australia

(Requests for copies should be directed to: Assistant Secretary, Resource Processing Industries Branch, Department of Industry Science and Tourism, Canberra ACT 2601, fax +61 (0)2 6213 7619.)

This manual does not deliver what it promises. In fact, it falls so far short of adequately describing good (let alone ‘best’) practices in the live reef fish industry that we wonder why it was ever published. Its shortcomings include the following.

On page 7, one of the two ‘acceptable’ ways of depressurising fish is described as: a ‘syringe’ (what is meant, in fact, is a *hypodermic* syringe *needle*—and the needle gauge should have been specified) is ‘enterred (sic) near anus to deflate swim bladder.’ This practice should, in fact, be strictly avoided because it introduces bacteria into the body cavity, thereby increasing the chances of internal infection—the same process that makes a ruptured appendix potentially fatal. The needle should be inserted so that it does not penetrate the gut before entering the swim bladder. The other method the manual recommends accomplishes this.

The manual recommends that fish be held without causing damage or removing scales, but little information is given on how this should be done. For example, no mention is made of the desirability of internal baffles in the holding tanks to reduce the sloshing around of the fish with possible attendant damage, as well as to reduce the sea sickness, to which fish are, in fact, prone in holding tanks during rough weather.

Although knotless nets are recommended for shifting the fish in order to minimise abrasion, no mention is made of the fact that these nets should also be of fine mesh in order to minimise snagging of the fish by their teeth or fin rays. Also in this connection, no mention is made of the need to handle fish with wet hands or gloves so as to minimise removal of scales and of the fishes' protective mucus.

The recommendation that 'Weighing of individual fish must be replaced by payment on size and number of pieces' is a good one, but the reasoning behind it is not given (i.e. weighing individual fish involves extra handling and time out of water, thus increasing chances of damage).

It is stated that, 'in closed systems the aeration and scrubbing systems must maintain a suitable environment for survival'. But the criteria for a suitable environment are not given, and 'scrubbing' is not defined.

Although cleaning of holding tanks is described, nothing is said concerning the disposal of used cleaning fluids. (In Australia there are suitable storage containers provided at many docks where commercial fishers operate.) Also, no mention is made of the need to flush pipes and pumps routinely with a good disinfectant so as to avoid buildup of pathogenic organisms that can infect fish.

Some of the terms used are not only unknown to fishermen outside Queensland, they are even unknown to some experienced commercial Great Barrier Reef fishermen, suggesting that they are of very localised usage. For example, the vessel is described as anchoring at a pressure point on the reef. What, we ask, is a pressure point in this context? And what are 'pound boards'?

No reasons are given for some of the recommendations. For example, it is recommended that fish be brought to the surface as quickly as possible. Why? To reduce chances of shark attack? To minimise struggle and the depletion of the fish's energy reserves?

The operation of the fishing dories is not adequately decribed. For example, there is no indication of how it is that, when a dory is travelling, 'a venturi [term not defined] aerates the storage tank'. The venturis are said to introduce turbulence. Of what value is turbulence in this connection? Do the authors mean oxygen?

We suspect that the bilge pump in the dory, which is described as recirculating the water, is not recirculating it, as stated, but rather replenishing it. Of what value would recirculation be?

While important information is often absent in this report, unimportant information is present, e.g. in statements like 'crew unload the freezer by handing up cartons on the deck of the vessel'. The six pages devoted to filleting and freezing of fish seem excessive. In addition, why this subject is even relevant to the live reef fish industry (i.e. so as not to waste injured or non-target fish) is poorly explained.

This manual reflects badly on Australia's reputation for high standards in connection with the live reef fish industry. It is also of limited value to people in other countries who look to Australia for guidance in these matters. We are not suggesting that practices in the Australian industry are substandard. This manual, however, certainly is.

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