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LIVE REEF FISH

The live reef fish export and aquarium trade

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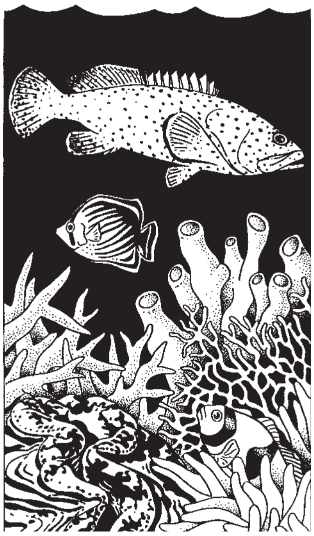
INFORMATION BULLETIN



Editor and group coordinator: Bob (R.E.) Johannes, 8 Tyndall Court, Bonnet Hill, Tasmania 7053, Australia. [In Australia: phone: 03 62298064 - fax: 03 62298066. From overseas: phone: +61 3 62298064 - fax: +61 3 62298066. E-mail: bobjoh@netspace.net.au] **Production:** Information Section, Marine Resources Division, SPC, B.P. D5, 98848 Noumea Cedex, New Caledonia. [Fax: +687 263818; e-mail: cfpinfo@spc.org.nc; Website: http://www.spc.org.nc]. **Printed with financial assistance from France.**

Editor's mutters

Steering, not stopping

Once I was on a fast train that was heading straight off a high precipice. There was no way of stopping it, and it appeared that I was doomed. But, at the last moment, I discovered that by sheer mental effort I was able to shift the tracks. The train began to change direction and narrowly skirted the cliff edge. I awoke greatly relieved.

Aquaculture is like that train. It is unstoppable, just as the evolution from hunting and gathering to farming was unstoppable. But we can try to ensure that it doesn't take us off the environmental and socio-economic cliffs towards which it sometimes heads. It is easier to shift the tracks in dreams than in reality, but we must try.

In the last issue of the SPC *Live Reef Fish Information Bulletin*, Yvonnne Sadovy and Jos Pet cited research on fish whose pelagic larvae settle in coral reef communities that suggests that most of their natural mortality occurs before and soon after settlement. Fishing for juvenile groupers to supply aquaculture may therefore, they said, be unsustainable because it adds, perhaps substantially, to natural mortality. This view is shared by other biologists (see also McAllister, this issue, p. 47, for example).

Leaving aside the fact that recent literature indicates that post-settlement mortality of coral reef fish can be prolonged and significant, the two species of groupers that supply the great majority of wild-caught juveniles for aquaculture (*Epinephelus coioides* and *E. malabaricus*) do not settle into coral reefs. They settle into mangroves and estuaries—habitats with very different characteristics from coral reefs and where post-settlement mortality trends may also be different.

Inside this issue

It is into these same habitats that milkfish larvae also settle. Milkfish have been farmed in the Philippines for centuries, with milkfish farmers depending entirely, until recently, on wild seed.

In recent decades the numbers of milkfish fry collected annually from the wild in the Philippines is estimated to be greater than one billion. Is there a resulting shortage of wild milkfish fry today, as some writers claim? Bagarinao states, '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' (Bagarinao, T. l998. Milkfish 'fry' supply from the wild. SEAFDEC Asian Aquaculture 20(2): p. 26).

A recent study in the Philippines by Nephe Ogburn and me (to be summarised in the next issue) revealed that precisely the same statement could be made about grouper fry fisheries.

Both Bagarino, and Sadovy and Pet, point out the need for research on aquaculture-support fisheries. But in the meantime it is futile to try to stop them. Effective enforcement would be not only very unpopular (fisheries for the fry of milkfish and groupers support several hundred thousand poor Filipinos directly and thousands of fish farmers indirectly), it would also be prohibitively costly. Moreover, if such a ban did somehow succeed, it would add to the demand for wild-caught adult groupers for the live fish trade—an industry that readers of this publication will know has wreaked marine environmental havoc in the Philippines and elsewhere. This, in turn, could encourage displaced fry fishermen to enter the live reef fishery.

In this light, the Philippines government's inclusion of the micro-reefs built in estuaries by grouper fry fishers in its ban on the construction of artificial reefs (Administrative Order No. 97-01. Setting of Moratorium on the Deployment of Artificial Reef Nationwide) although well intentioned, can be seen to be misdirected. It is also futile; it is being ignored by grouper fry fishers and grouper farmers because the government does not begin to have the resources to force it upon them.

By all means, let us do the research needed to determine if there are cliffs ahead for aquaculture-support fisheries and try to steer away from them. Research will probably show, for example, that some collecting methods are less environmentally sound than others. If so, then incentives and educational efforts might be designed to steer fishers towards the sounder methods. The Philippines has an exceptional number of NGOs that are dedicated to improving coastal zone management and skilled in village-based environmental education. They could assist with such efforts, whereas they cannot so easily help with law enforcement.

Eventually (although it may take many years at the current depressing rate of progress) research will bring about the phasing out of aquaculture-support fisheries as hatchery-bred fry become cheaper than wild-caught ones. But prejudging the issue and trying to halt these fisheries prematurely constitutes a misdirection of conservation effort. It won't work in developing countries. And if it did, it would have socially and environmentally undesirable consequences.

Cyanide substitute?

In this issue Mark Erdmann (p. 4) describes clove oil as an anaesthetic that may have the potential to replace cyanide in the live reef fish trade. It is cheap, and the collateral environmental damage attending its use may be less than that caused by cyanide. The use of any foreign chemical in the marine environment is bound to make some people nervous. If further research shows that clove oil is, indeed, a lesser evil than cyanide, is this sufficient justification for promoting its use? I'd like to hear from our readers on this.

Targeting spawning aggregations

In this issue researchers working in three different countries independently note the upsurge in the targeting of grouper spawning aggregations by the live reef food fish trade. Erdmann and Pet (p. 22) note, for example, that 'divers interviewed here (in East Kalimentan) were all aware of the phenomenon of grouper spawning aggregations, and actively targeted them. They all mentioned how much easier it was to collect fish during these aggregations. They furthermore report that Napoleon wrasse were also known to aggregate in several of the same areas as the groupers, though at different times.' Once again this underscores the urgent need to protect spawning aggregations in the region, which I described in an article in issue #3 of this publication.

New aquaculture section

In this issue we introduce a new aquaculture section (p. 36), including a grouper aquaculture section coordinated by Mike Rimmer, head of grouper aquaculture research at the Department of Primary Industries, Northern Fisheries Centre, in Cairns, Queensland. You can send relevant LRF Information Bulletin contributions to Mike at <RimmerM@prose.dpi.qld.gov>.

In addition, we carry an article by Don McAllister (p. 47)—editor of the marine environmental newsletter *Sea Wind*, and long-time crusader against cyanide fishing —criticising aquaculture as a means of combating the excesses of the live reef food fish trade.

We encourage informed debate, including further comment on this issue. It can be in the form of either an article or a letter to the editor.

Industry perspective

We are pleased to be able to include in this issue an article submitted by a representative of the live reef food fish trade (p. 17). We welcome more such input.

Silly heading

In the last issue I wrote a brief article about a German woman, Inge Sterk, who, in her frustration over the live reef fish trade, cut the nets of holding pens in Indonesia to release the fish. The heading of the article was 'Ecotourist turned Ecoterrorist.' Ms Sterk protested, pointing out that (as the article stated) she reported her actions to the authorities and awaited their response. Ms Sterk, moreover, has a long history of commitment to non-violent action in connection with various human and environmental injustices. Her complaint is fully justified, the heading was indeed ill-chosen, and I apologise unreservedly.

Bob Johannes

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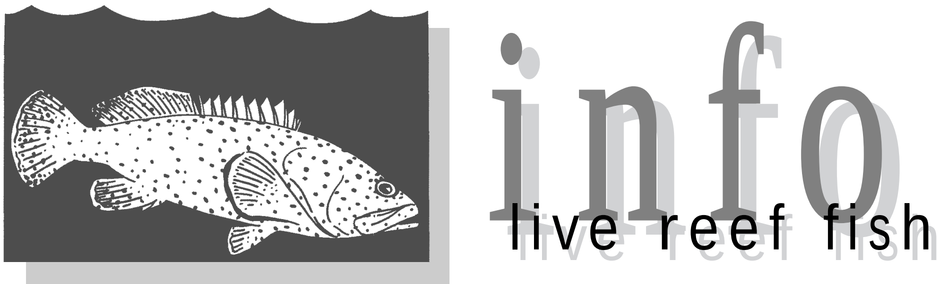

Clove oil: an 'eco-friendly' alternative to cyanide use in the live reef fish industry?

by Mark V. Erdmann[1]

Introduction

As mentioned by Erdmann and Pet (this issue), an interesting new development in the aquarium fish trade in Indonesia is the reported use of clove oil as an 'eco-friendly' alternative to cyanide solution to stun and capture ornamental fishes *in situ*. While the accuracy of this claim obviously requires substantiation, this is certainly an interesting idea worthy of further investigation.

Clove oil, distilled from the crushed stems, buds and leaves of the clove tree *Eugenia caryophyllata*, has been used for centuries as a topical anaesthetic for humans in Indonesia (Soto & Burhanuddin, 1995). The primary active ingredient in clove oil is the phenolic compound eugenol, which commonly comprises 70–90 per cent of commercially sold clove oil in Indonesia (Hernani & Tangendjaja, 1988).

I first became aware of the use of clove oil as an anaesthetic for capturing marine organisms several months ago when a colleague suggested that I use a clove oil/ethanol solution to immobilise and capture stomatopod crustaceans in their cavities within the reef. This solution was extremely effective and greatly increased my capture success.

Several months later, when I encountered the report of clove oil used in the aquarium fish trade in Ambon, I tracked down the original reference from whence my colleague had suggested clove oil use (Munday & Wilson, 1997).

Subsequent discussions with Philip Munday and several aquaculture researchers from the University of Guelph (Cristina Soto, David Noakes and Richard Moccia) suggested that clove oil is a highly desirable, if underutilised, fish anaesthetic that may have a place in the live reef fish trade.

A superior fish anaesthetic?

Though clove oil (eugenol) has been used as a fish anaesthetic for at least the last quarter-century (Endo et al., 1972; Hikasa et al., 1986), it has recently been the focus of research aimed at establishing its effectiveness and safety as an anaesthetic for use in both aquaculture and in wild-capture and laboratory research on coral reef fishes (Soto & Burhanuddin, 1995; Munday & Wilson, 1997;

1. University of California, Berkeley and Indonesian Institute of Sciences

Keene *et al.*, 1998). Anaesthetics such as quinaldine and MS-222 are used widely by both aquaculturists and fish biologists for the purpose of minimising stress and injury during capturing, handling, sorting, and transporting wild-caught and cultured fishes (Munday & Wilson, 1997; Keene *et al.*, 1998).

However, not only are these chemicals expensive and often difficult to obtain in developing countries, they may also have potential harmful side effects on humans—especially in the situation where the anaesthetic is squirted by a diver attempting to capture wild fishes (Munday & Wilson, 1997). Clove oil is both inexpensive and non-harmful to humans, making it attractive as a possible alternative anaesthetic.

While their techniques, dosages and target species differed widely, both Munday and Wilson (1997) and Keene *et al.* (1998) found clove oil to be on the whole a superior anaesthetic compared to a number of other chemicals, including MS-222, quinaldine, and benzocaine.

Without attempting a thorough review of those studies, their results suggested that clove oil was an excellent alternative for the following reasons:

1) Clove oil is highly effective even at low doses. Keene *et al.* (1998) report that it induced anaesthesia faster and at lower concentrations than MS-222, while Munday and Wilson (1997) found clove oil only marginally less effective than quinaldine and more effective than 3 other chemicals, except at high doses.

2) Clove oil provides a much calmer induction to anaesthesia than the other chemicals.

3) Recovery time after clove oil anaesthesia is substantially longer than recovery time from other anaesthetics.

4) Clove oil is much less expensive than other chemicals. For example, Keene *et al.* (1998) showed clove oil to be less than 1/15 the price of MS-222 when preparing solutions of each capable of inducing stage 5 anaesthesia in less than 3 minutes in rainbow trout.

Both of these studies found that dissolving clove oil in ethanol first was preferable, as this kept the clove oil evenly suspended in solution and induced anaesthesia more quickly.

The two groups use very different concentrations: Keene *et al.* (1998) suggest a concentration of 40–60 ppm, dissolving the clove oil first in a small amount of ethanol and then diluting with water; while Munday (pers. comm.) uses 100 ml clove oil dissolved in 400 ml of ethanol only (250 ppt). The large difference is easily accounted for as a difference in requirements; Keene *et al.* (1998) used clove oil as an anaesthetic for cultured juvenile trout, while Munday uses the stronger solution to capture small reef fishes *in situ*. In the latter case, a much higher concentration is required in order to counter the effects of instant dilution upon squirting the solution into the ocean and to achieve a faster induction to anaesthesia.

Possible uses in the live reef fish trade

All of the above mentioned researchers are highly enthusiastic about clove oil's potential as a fish anaesthetic. I can imagine at least three possible uses for clove oil within the live reef fish trade, especially as it is practised in developing countries such as Indonesia.

1) Anaesthetic for wild capture

While the use of cyanide to capture live reef food fish seems to be declining in Indonesia, it is still very widespread, and is still used in the majority of ornamental fish capture operations observed. While organisations such as the International Marinelife Alliance and the Haribon Foundation have done important work to promote a 'drug-free' tradition for aquarium fishers in particular, I believe that any chemical which can be shown to be otherwise reef-friendly should be considered for promotion in the live reef fish trade as a cyanide replacement.

The fact remains that some highly sought-after ornamental and food fish are difficult to target with barrier nets or hook and line, and more to the point, many of the fishermen are not concerned if corals are killed or the collected fish die later in an aquarium or cage—they have already been paid. Given these considerations, I believe it would be worthwhile to further investigate the potential for clove oil as a replacement for cyanide in wild capture of live reef fish.

In order to receive widespread support from both fishermen and environmentalists for clove oil use in the capture of reef fish, at least two conditions must be met.

First, clove oil solution must be shown to be as effective as cyanide in stunning reef fishes. Clove oil compares highly favourably to other (legal) fish anaesthetics, but cyanide was not included in the above mentioned test comparisons for obvious reasons! Munday (pers. comm.) has found clove oil to be highly effective in capture of damselfishes on the Great Barrier Reef. Munday and Wilson (1997) make the point that the ability of clove oil to induce anaesthesia even at low doses is extremely valuable for use in the field, where instant dilution is a major problem.

I have personally used clove oil in ethanol solution to collect stomatopod crustaceans from cavities in live and dead coralline algae, and found it extremely effective. I can only imagine it would have a similar efficacy on spiny lobster (*Panulirus* spp.), which are currently collected by using cyanide solution in Indonesia. Whether clove oil would be an effective anaesthetic for larger grouper or Napoleon wrasse for the live reef food fish trade is unknown; however, I believe this would be a worthy avenue of research.

Secondly, clove oil solution must be shown to be harmless to non-target reef organisms (including corals) in the concentrations which would be used to stun reef fishes. My initial experience with clove oil/ethanol solution showed that coralline algae would frequently bleach soon after contact with my solution, though it invariably recovered within a week's time. Munday (pers. comm.) and Soto (pers. comm.) suggested this might be more a result of the ethanol than the clove oil. Further anecdotal experiments of squirting clove oil and water solution on *Pocillopora* spp. and *Acropora* spp. coral colonies *in situ* showed no observable ill effects.

Obviously, before clove oil can be promoted for widespread use, it would need to be tested thoroughly for its effects (both with and without ethanol) on corals and other invertebrates, preferably in both the field and in a laboratory setting. The rigorous experiments of Jones (1997) on cyanide effects on corals in the laboratory could serve as a template for clove oil tests.

Even if these two conditions are met, there is one further consideration which may negate any potential advantages of clove oil. In the standard scenario of divers using cyanide to capture live reef food fish, the diver chases the fish into a hole, squirts enough cyanide solution into the hole to stun the fish, and then proceeds to break away all of the surrounding coral in order to access the stunned fish. Under such a scenario, the fact that the chemical used is benign is irrelevant; the main damage to the reef is caused by the diver breaking away the coral (Pet, pers. comm.).

My personal view is that the extent to which this coral breakage happens is exaggerated; in the several cyanide fishing episodes I have witnessed underwater, the fish invariably fled from the hole after being squirted with cyanide, soon thereafter losing its balance, and was easily collected. This is an important consideration, but one which is less applicable to the collection of ornamental fish, where the potential for extensive collateral environmental damage from cyanide use is actually much greater than in the live reef food fish trade (Erdmann & Pet-Soede, 1996).

2) Anaesthetic for handling

Wild-caught grouper and Napoleon wrasse often receive rough handling at the collection cages in Indonesia, where they may be stored for up to several months before transport to importing countries like Hong Kong.

In my experience in Indonesia, when these fish are sorted or moved between cages, they are typically given either no anaesthesia or, worse still, may be hit with another dose of cyanide to 'calm' them. Surely it would not be difficult to adapt the clove oil dosages reported by Keene *et al.* (1998) for handling rainbow trout to those required for coral trout, Napoleon wrasse, and even ornamental fishes.

Clove oil use during handling could significantly reduce cage mortality of live reef fish (still a problem in Indonesia), and is much cheaper than alternatives such as MS-222. The latter point should make clove oil attractive even to live fish dealers in countries like Australia where anaesthetic use is common.

3) Anaesthetic for transport

This is perhaps the most important area where clove oil promotion could have positive effects in a country like Indonesia. Even here, anaesthesia is commonly used in transport of live reef fish. Unfortunately, this presents the largest loophole in efforts to prevent cyanide fishing in Indonesia; cyanide is considered legal for use as an anaesthetic for fish transport. This makes it nearly impossible to prosecute vessels with cyanide on board or even those with cyanide-tainted fish; the fishermen can always claim that the cyanide was used as an anaesthetic for transporting the fish, which were otherwise captured legally. It is only illegal to actually capture the fish with cyanide, and this is exceedingly difficult to prove.

While I have not seen an official explanation of why cyanide is legal as a transport anaesthetic, one can easily imagine the economic arguments that would be used by politicians. Cyanide is relatively cheap and readily available, and it would not be fair to require poor fishermen to purchase expensive imported chemicals such as quinaldine or MS–222. However, at roughly Rp 6000 (US$ 0.60) per 100 ml bottle, clove oil surely compares with cyanide for cost effectiveness.

Furthermore, in Indonesia, clove oil is a local product, an important political consideration in promoting its use.

If policy-makers in Indonesia could be persuaded that clove oil is an effective, inexpensive and benign substitute for cyanide as a transport anaesthetic, it should be possible to ban the use of cyanide outright, thereby closing the gaping legal loophole that now exists. This, I believe, is the strongest argument for the promotion of clove oil use in the live reef fish trade in Indonesia.

Conclusion

Recent research has shown that clove oil is a highly effective, cost-efficient and safe fish anaesthetic for use in aquaculture and laboratory research settings. Further research must be conducted in order to verify the 'eco-friendliness' of clove oil for use in wild capture of reef fishes, but its potential to replace cyanide use in the live reef fish industry seems promising. I urge those involved or concerned with the live reef fish trade to consider this potential and openly debate its merits and drawbacks.

Acknowledgments

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The life reef food fish trade in the Solomon Islands

by Robert E. Johannes[1] and Michelle Lam[2]

Introduction

The Solomon Islands lie in the south-west Pacific, to the east and south of Papua New Guinea. The country consists of two roughly parallel island chains with six major island groups. There are some 992 islands with a collective land area of nearly 30 000 km^2 distributed over 1 280 000 km^2 of ocean. The Solomon Islands group is the second largest archipelago in the South Pacific.

The reliance of Solomon Islanders on marine resources is reflected by one of the highest per capita seafood consumption rates in the world. A survey conducted by the Japan International Cooperation Agency estimated per capita consumption of fish in Honiara at 47.9 kg in 1992. A family of 6.5 persons consumes 2.5 kg of fish per meal, four times a week. It is likely that rural fish consumption is even higher.

Inshore marine resources play a significant role in the lives of Solomon Islanders and are critical to the economy of the country. However, few management controls are in place to ensure that harvests remain at sustainable levels. The following is a condensed version of a report of a brief investigation of the dynamics of the live reef food fish trade in Western Province, Solomon Islands and the need for management.

Dynamics of the trade in Western Province

In Western Province the Live Reef Food (LRF) fishery started out in Vella La Vella Lagoon in 1994, and was pursued year-round by a company called IKA Holdings. Insufficient fish were obtained this way according to the company. So pulse fishing, targeting seasonal grouper spawning aggregations, was begun, first in Marovo Lagoon, then in Roviana Lagoon.

The primary targets of this fishery were three species of grouper: the flowery grouper, *Epinephelus fuscoguttatus*[3], the camouflage grouper, *E. polyphekadion* , and the coral trout, *Plectropomus areolatus*. All three aggregate to spawn in the same locations and during the same seasons and moon phases.

Humphead (Maori) wrasse *Cheilinus undulatus* were also caught[4]. Although this species fetches much higher prices in Hong Kong, fishers were paid the same price for it as for the grouper species (SI$ 5/kg[5] to the fisher plus 50 c/kg to the community). *E. fuscoguttatus* and *E. polyphekadion* are rather similar in appearance and fishers do not always distinguish between them, some believing the latter to be small individuals of the former species. Consequently *E. polyphekadion* did not loom as large in fishers' accounts of their catches as they do in official export statistics (see Table 1, next page).

Much lower prices were paid for the occasional *Epinephelus oligocanthus* and the snapper *Lutjanus rivulatus.*

Conveniently, the spawning season of the three species is roughly from October through January in Roviana lagoon and from February through June in Marovo lagoon. The beginning and end of the spawning season varies by about a month from one year to another. The spawning season is different again in Ontong Java, which has been the third focus of the LRF fishery in the Solomon Islands (not studied here), and where there are two spawning seasons per year.

The above species were caught primarily by local villagers (men, women and children) with hook and line. The line, plus special hooks designed to minimise deep hooking were both supplied by the company. Canoes with special salt-water holding pens were also provided by the company in some cases.

When a fish is brought up from deep water (greater than about 18 m), the gas bladder expands and makes the fish so buoyant it floats helplessly at the

1. R.E. Johannes Pty Ltd. 8 Tyndall Court, Bonnet Hill, Tasmania 7053, Australia. E-mail: bobjoh@netspace.net.au
2. Fisheries Division, Honiara, Solomon Islands.
3. Sometimes misleadingly referred to as the 'giant grouper' in the Solomon Islands. Elsewhere the term 'giant grouper' is reserved for *Epinephelus lanceolatus*, which is called 'rava' in the New Georgia area.
4. This is one more piece of evidence that disproves the widely-used argument in the LRF industry in Southeast Asia that cyanide must be used to catch humphead wrasse because these fish cannot be caught with hook and line.
5. Equivalent to about U$ 1.10. For comparison, Indonesian fishermen received from US$ 6 to US$ 10 for live coral trout after the Asian economic meltdown. Before then, in 1997, they were receiving roughly twice this amount (Erdmann & Pet, l999).

Table 1: Total live reef fish exports in 1997 (Fisheries Division, unpublished)

Commonname[1] *Scientific name* [1]	Date exported/Amount exported (kg) 2 March	24 May	7 Sept.	10 Sept.	Total
Flowery grouper *Epinephelus fuscoguttatus*	6500	5700	3000	2500	17700
Camouflage grouper *Epinephelus polyphekadion*	2000	3000	500	2000	7500
Coral trout *Plectropomus* spp.[2]	2000	2500	400	2000	6900
Maori (humphead) wrasse *Cheilinus undulatus*	500	300	100	0	900
Total	11000	11500	4000	6500	33000

1. Common and scientific names given by exporters have been corrected.
2. Mainly *P. areolatus*

surface. The pressure must be released to save the fish. The company taught some fishermen to puncture the swim bladder by inserting a hypodermic needle in it. For cod the needle was inserted under the pectoral fin. This is the generally approved insertion point and avoids puncturing the gut. In coral trout however, the fishermen were taught to puncture the fish near the anus. (This seems a peculiar practice, although fishermen in PNG are taught to puncture coral trout, unlike cod, at the same spot. We cannot see how puncturing in this manner would avoid puncturing the gut, thus allowing infectious micro-organisms into the body cavity, as well as puncturing the gonads and promoting the spontaneous release of eggs. Can any reader supply us with the rationale for this practice?)

The prescribed practice was not always carried out, however. One reliable observer states that he remembers company officials complaining of high mortality within the Sasavele holding pen. In Sasavele the captured grouper usually had a greatly inflated swim bladder, so an official would grab it, and stick a rusty nail into its swim bladder in order to deflate it.'

The fish were transferred from the fishing canoes to floating holding pens. The pens were usually, but not always, owned by the company, and usually overseen by a local villager hired for the purpose by the company. About twice a month during the fishing season the company vessel, the *John Franklin*, would tour the lagoon and pick up the fish.

The fish were then transported to and stored in holding pens at company facilities at Liapari, Vella La Vella. There they were fed bonito rejected by the nearby tuna cannery in Noro Port. (This, once again, seems like a peculiar practice insofar as experience elsewhere has been that the *Epinephelus* spp. do not readily accept bonito flesh and coral trout usually reject it outright (Squire, pers. comm.).

The fish were held at Liapari until a sufficient quantity (typically 15 tonnes) was available to justify ordering a large, live reef fish transport vessel from Hong Kong to pick them up and take them back to Hong Kong. There they were sold to restaurants or transhipped to other coastal Chinese cities such as Guangzhou.

The fishery had ceased by the time of our visit, so we were unable to make first-hand observations. But interviews with fishers and with industry personnel revealed that very high mortalities of fish often occurred. Causes mentioned were foul-hooking, rough handling of fish by fishers prior their delivery to the cages, poor placement of village-based cages (i.e. in areas where water circulation was inadequate), failure to provide shade (sunburn can otherwise occur), overcrowding of fish, lack of feed, and failure to quarantine sick fish[6]. High mortalities sometimes also occurred while the fish were being held by the company at Liapari. In one case, according to a company representative, out of 15 tonnes of fish awaiting pickup by the Hong

6. One company representative actually volunteered that fish that die in the cages are sometimes fed to other caged fish!

Kong vessel, only 5 tonnes remained alive by the time the ship arrived.

We obtained no hard evidence that cyanide was being used, although one suspicious practice was reported. A company vessel was said to be equipped with a hookah compressor with long hoses. The gear was claimed to be used only at night, by the crew, in order to obtain 'kitchen fish' [7]. Villagers seemed well aware of the problems created by using cyanide and it seems unlikely that they ever used it, especially since they own their traditional fishing grounds (see below) and thus have a vested interest in protecting them.

Customary marine tenure

Traditionally, Solomon Island lineages own not only their land but also their coastal waters. The latter is generally referred to as customary marine tenure (CMT) (Hviding, 1996). The traditional ownership, or perhaps more correctly guardianship of these resources, and the associated right to decide who has access to them and under what conditions, is described in detail for Marovo Lagoon by Hviding[8], and is fully recognised by both provincial and national governments. Outside resource users, such as LRF companies, are bound by law to obtain the permission of CMT owners before exploiting an area.

Within the CMT system there are the primary rights owners, who can dictate who may exploit their coastal resources and how. Secondary rights owners are those who, by virtue of intermarriage or other relationships to the primary rights owners are sanctioned to exploit resources in the waters controlled by the former. Their right to do so for subsistence purposes is generally taken for granted. To do so for commercial purposes often requires a formal request to be made to the primary rights owners—which may not always be granted.

Because CMT confers upon primary rights owners a vested interest in protecting their resources, various conservation measures were and are implemented when stocks of exploited species are seen to be overfished. As Johannes (1978) pointed out, all the basic conservation measures for marine fisheries that textbooks suggest were invented by Europeans at the turn of the last century, were, in fact, in operation in Oceania (including the Solomon Islands) centuries earlier. More recently Hviding (1996) lists among the recent methods used by Marovo Lagoon CMT holders to protect their stocks, the following:

1. limiting entry to the fishing grounds;
2. banning dynamiting everywhere in the lagoon;
3. banning the use of gillnets in some areas;
4. banning spear-fishing in some areas;
5. banning the use of traditional fish poisons in some areas; and
6. temporary closure of fishing grounds to let populations rebuild.

This somewhat lengthy discussion is aimed at establishing firmly in the readers' mind that primary CMT owners in Marovo Lagoon possess: 1) the incentive to control exploitation of their marine resources, 2) a general awareness of the need to do so, and 3) the legal as well as traditional rights necessary to implement and enforce (with government assistance when necessary) appropriate measures.

This is not to say that they are all dedicated conservationists, any more than are people in Australia or the U.S. In the Solomon Islands, as elsewhere, the lure of short-term benefits may override issues of long-term sustainability of natural resources.

Although the people of Roviana Lagoon also possess traditional rights over their fishing grounds, Aswani (1998, p. 217) states, 'people do not feel responsible for either limiting their own catch rates or enforcing their property rights against interlopers.' Nevertheless, 'marine tenure institutions have been successful in fending off the threat of large-scale fishery development in the inner lagoon.' Aswani (1997) also notes that chiefs periodically close shells beds to permit recovery from overexploitation and sometimes enforce gear restrictions.

It is well documented throughout the Pacific Islands that as the value of nearshore resources increases, so do disputes among traditional owners. This is clearly the case in Marovo and Roviana lagoons in connection with the LRF fishery. Several villages in Marovo are involved in disputes over primary rights to spawning aggregation sites. In addition, certain groups claim that their leaders have misappropriated the 50 c/kg fee the company pays, which is supposed to go to the village as a whole.

It is also clear from various comments we heard during our interviews that foreign companies do not always understand the traditional marine tenure system, and that it necessitates direct negotiations with traditional reef owners in order to exploit their marine resources. Some companies try to get provincial or national government authorities

7. A man who worked for this company in l995 claimed that the crew poached giant clams at night.

8. I rely heavily on Hviding's work for my description here of the general workings of CMT in the Solomon Islands.

Table 2: **Perceptions of villagers concerning the impact of fishing for the LRF trade on grouper spawning aggregations.**

Village	Passage fished	Fish numbers decreasing	Fish sizes decreasing	Number of years fished for LRF trade
Marovo Lagoon				
Telina	Lumalihe	yes	yes	4
Rukutu*	Lumalihe	yes	yes	4
Chumbikopi*	Lumalihe	yes	yes	4
Sasaghana	Charapoanna	no opinion	no opinion	4
	Lumalihe	no opinion	no opinion	
Chea	Charapoanna	yes	yes	3
Michi*	Charopoanna	yes	yes	2
Vacambo	Monggo	yes	?	?
Ramata*	Veravera Entr.	too soon to judge	too soon to judge	1
Roviana Lagoon				
Hapai	Saikile	too soon to judge	too soon to judge	1
Saikile*	Saikile	too soon to judge	too soon to judge	1
Nusahope*	Nusahope	too soon to judge	too soon to judge	1
Sasavele*	Honiavasa	yes	no	2
	Kosianae Pt.**	yes	no	2
Nusambanga	Honiavasa	yes	yes	2

* Primary owners of the fishing grounds that encompass the spawning aggregation sites they fished

** This is the only aggregation site reported to be fished for the LRF trade that is not located in or near a reef passage. An employee of a recreational diving company in Munda reported discovering another spawning aggregation site at a location outside the lagoon . This site seems to be unknown to village fishers and supports REJ's opinion that in the Solomon Islands as in other Pacific Island countries fishermen's knowledge of the location of spawning aggregation sites for groupers, while often exceptionally valuable, will, nevertheless, not usually be complete. We refrain from identifying the site here.

to sanction their activities. Others have a vague understanding of the traditional system, but negotiate with the wrong villagers, i.e. ones who are not the primary owners of the fish grounds in question.

This apparently happened in Marovo Lagoon in connection with a LRF operation, and is the cause of a court dispute between Telina and Rukutu villages. For all foreign business with interests in Solomon Islands nearshore resources the Fisheries Division should consider providing a brochure describing the relevant laws and customs and the steps that need to be taken to observe them[9].

Villagers' perceptions of the LRF fishery

What, then, is the status of the awareness of fishing communities in Marovo and Roviana Lagoons of the impacts of the LRF trade and its focus on spawning aggregations? Where more than two-year's fishing had been done for the LRF trade, four out of five communities interviewed reported a decline in catch per unit of fishing effort and a decline in average size of the fish caught in grouper spawning aggregations (Table 2). (Sasaghana villagers were non-committal about the subject.) In two passages, Charapoanna and Lumalihe, these declines were seen to be very substantial. All four villages where, for two years, LRF fishing had occurred, reported a decline in catch per unit of effort, while two of them reported a decline in mean fish size.

Primary reef owners, as might be expected, tended to be more vocal about depletion than secondary owners, especially in Marovo Lagoon. Michi villagers, the primary owners of Charapoanna Passage, declared, for example, that due to the heavy depletion of grouper spawning aggregations perceived to have been brought about by the LRF trade, they were going to close the passage to all commercial fishing immediately. Furthermore, they hoped to be able to work with a nearby resort at Uepi to make the passage and the area around it

9. Indeed such a brochure would be useful for many Pacific Island countries, since the principles are similar for many island groups.

into a protected marine area. Similarly the villagers of Rukutu, primary owners of Lumalihe Passage said they intend to close this passage to commercial fishing for the same reason.

The people of Ramata are primary owners of three passages in which grouper spawning aggregations occur; Veravera Entrance (= Ramata Passage), as well as Lolomo and Pipa passages. In 1998 they opened Ramata Passage to LRF fishing. Out of a desire to protect their aggregations from overfishing, they are considering in future years to open two out of the three passes for one year, then only one the following year, then two again, and so on. It is questionable, however, whether the LRF fishery will be pursued at all in Western Province in 1999 (see below).

The people of Vacambo said that the state of the resource was their first priority and prices received were their second concern. They said they would like to be able to monitor their spawning aggregations if the government could advise them on how best to do it[10].

One concern voiced by many fishers was the wastage of non-target species caught adventitiously. Since the company would not buy them, and since there were often too many of them to be consumed by the villagers, they went to waste. In some cases whole families would stay on the fishing grounds for a week at a time. There was thus no opportunity to return to their villages to distribute the non-target species they caught.

Some Marovo fishermen, primarily secondary owners of fishing grounds, justified their continued fishing by echoing the sentiments of one Telina man, who said, 'we know it's destructive, but the government gives us no alternative to make money from our fish.' (Several government and church schemes to provide a commercial outlet for iced fish in the area over the years have failed. Logistics in this remote area are a major obstacle, as they have consistently proven to be in remote areas throughout the Pacific Islands.

The most recent effort in Marovo Lagoon paid fishers similar prices for their iced fish to what the LRF company did for live ones. The problem was that the collection centre, situated at the only commercial airfield in the area, was far from the main fishing grounds and required that fishers have outboard motors (most of them don't) and make long trips.

Roviana fishers tended to be less concerned about depletion than Marovo fishers. In part, at least, this may be because the LRF fishery had not been operating for as long in Roviana as in Marovo and depletion was thus less obvious. In Roviana the low prices fishers received for their fish was their biggest complaint about the fishery. (This came second, after depletion, among the concerns expressed by Marovo fishers). Fishers from both areas also complained that any fish larger than 8 kg fetched only the price of an 8 kg fish. Fishers in both areas were well aware that the prices received in Hong Kong for their fish were several tens of times higher than the price they got. In Roviana they also complained about non-local crew of the company boat causing dissension in their villages.

The company announced that it would not be returning in 1999 to Roviana Lagoon. Fishers assumed this was because of their demands for higher prices. However, there may have been additional factors involved, such as the rumoured collapse of the parent company in Hong Kong.

In response to the cessation of the LRF fishery in their waters, Roviana fishers, judging by REJ's limited interviews, seemed unperturbed. In part this is probably because of a fish-buying facility, a village market and some demand for fish from tourist facilities at Munda, more conveniently located than the fish facility in Marovo Lagoon. They thus have a more practical alternative outlet for their catch. In addition, the price differential between live and dead fish was not great when taking into account loss of fish due to mortality in the live reef fishery.

The company has since gone out of business entirely. A new company is planning to set up in Western Province, but various setbacks it has experienced suggest that its plans for a new LRF operation may not succeed.

Figures provided by villagers and by IKA Holdings indicate that single aggregations yielded between 4 and 12 tonnes of fish per year, declining with time.

Companies' perspective of the LRF trade

In response to fisher complaints about the low prices they receive, company representatives point out, quite rightly, that the cost of shipping the fish back to Hong Kong is very great, much greater than it is to ship them from the Philippines or

10. Underwater visual census has already been taught to some fishermen in Marovo Lagoon and to some Fisheries Division personnel. If funds could be found, this training could be extended to Vacambo, but it would be expensive. With the need to provide SCUBA facilities in such a remote area, the costs would almost undoubtedly outweigh the benefits in terms of promoting a sustainable local fishery worth to the villagers, at most, only SI$ 2–3000 annually.

Indonesia where fishers receive higher prices for them. They also point out that losses due to dying fish are very substantial. This is true, but we wonder if more could not have been done by the company to develop better holding practices. As it is, judging by what we were told, they were often very poor.

One reason that such high mortalities were experienced is that female fish are more susceptible to stress when they are ready to spawn and therefore they do not survive handling and caging as well as at other times. This is the main reason why the commercial live reef fishermen of Queensland, Australia have asked the government to ban LRF fishing during the grouper spawning season.

When we challenged the wisdom of targeting spawning aggregations because of their great vulnerability to depletion or complete obliteration we were given the following arguments.

1. The company can't operate at a profit without the efficiencies afforded by targeting spawning aggregations when transportation costs are as great as they are from the Solomon Islands to Hong Kong.

This argument is plausible only in the short term. If spawning aggregations disappear as a consequence of the LRF fishery, as has happened in other countries, this argument will sound very hollow.

2. The fish still spawn in the holding pens in which they are held.

This may be true or it may be that the females are just spontaneously releasing their eggs (e.g. see Fewings & Squire, this issue). In any event, the environment where spawning occurs is vital to the survival of the eggs, and holding pens are definitely not the right environment.

3. Fish do not bite when they are ready to spawn.

This argument is simply not true (see for example Johannes *et al.*, 1999). Moreover, it conflicts with the previous argument.

Management issues

The difficulties of managing LRF operations in the Solomon Islands include poor communication between national and provincial governments and between Ministries (e.g. the Foreign Investment Board issuing investment licenses but the Fisheries Division not knowing who is investing). It also includes inadequate communication within the Fisheries Division. The Research staff find recording fish caught difficult when licensing officers sign export permits or issue licenses without proper checking. Also in one case an officer was placed on board an LRF vessel as an observer, only to be removed by another higher-ranking officer after company personnel had talked with him.

In the original report a lengthy section follows giving recommendations for government management and suggested LRF license requirements which are extensions of the general recommendations given by Johannes and Riepen (1995) and Smith (1997).

Satellite tracking

A live reef fish vessel travelling from Hong Kong to the Solomon Islands and back takes more than 40 days. As mentioned above, one company official said only 5 tonnes were shipped out on one occasion. On another occasion 4 tonnes of fish were reported as being shipped out (*Solomon Star* No. 832 8/9/95). It would not be economical for such a vessel (which typically has a capacity of 20 tonnes of live fish) to return with only 4–5 tonnes of fish. Therefore the vessel presumably picked up more fish on the way to or from Hong Kong.

Although it may have obtained additional fish from other countries en route, the possibility cannot be discounted that it fished for them illegally in uninhabited reefs in Solomon Islands Exclusive Economic Zone (EEZ). Such locations include Ricardo reef (located near Ontong Java), Edward Bank outside Isabel, Alite Reef off Malaita and Indispensable Reef off Rennel-Belona.

The targeting of remote reefs by the LRF trade is well known in Southeast Asia. As one Southeast Asian live fish dealer told REJ, 'we prefer the remoter areas because they are away from prying eyes.' And as Erdmann and Pet Soede (1998, p. 33) remarked concerning Indonesia, 'the most remote reefs in Indonesia are the most destroyed.' The existence in the Solomon Islands of these tempting reefs makes it important to keep tabs on LRF transport vessels as long as they are in the Solomon Islands EEZ. This might most easily be accomplished by requiring any live reef fish vessel entering these waters to carry a transponder enabling its movements to be monitored using FFA's satellite-based vessel monitoring system (VMS).

FFA member countries, including the Solomon Islands, are now able to track in their EEZs, the position, speed and direction of fishing vessels by means of this technology (see Richards, this issue, p. 15). A vessel's position can be pinpointed, then relayed to a monitoring station on-shore. The system may be pre-set to determine a vessel's position on a regular basis, or set to 'poll' a vessel thought to be acting suspiciously. A dedicated computer based at the FFA Secretariat headquarters in Honiara identifies those vessel position reports which violate a set of rules stored in the computer.

Although the system was developed for tracking tuna fishing vessels, it could easily be applied to tracking other vessels, such as those that transport live reef fish from the Solomon Islands to Hong Kong. This would enable fisheries officers to determine whether such vessels travelled directly out of the EEZ from the port where they cleared customs, or whether they stopped off en-route at remote, uninhabited reefs (see above), perhaps illegally to take on board extra live reef fish. Pillaging of uninhabited reefs in the Pacific for various resources, such as giant clams and beche-de-mer, has been going on for decades and there is no reason to assume that the live reef fish trade is any more fastidious about the law than other foreign fishing operations. Indeed its record in some other countries is extremely poor.

Banning the LRF fishery

The effective control of the live reef food fish trade in the Solomon Islands would be expensive and time consuming. Moreover the income generated by it has been limited. An article in the *Solomons Voice*, dated 15 June l995, quoted a spokesman for the Division of the Ministry of Commerce, Industries and Employment as saying that the live reef fish export could generate SI$ 10 million per annum. So far, using company purchasing figures, and presuming that fishers are the prime local beneficiaries of the industry, it has generated, at best a *gross* income of an average of less than 3% of that, or SI$ 260 000 (roughly US$ 60–70 000[11]) annually over the past three years.

Moreover, the LRF fishery has reportedly reduced the sizes of spawning aggregations, sometimes very markedly, in the areas where it has been operating for two or more years according to fishers. It has also stimulated disputes among traditional owners of the fishing grounds involved and resulted in the complete wastage of many tonnes of fish.

Johannes and Riepen (1995) point out that the live reef food fish trade, if properly managed, could be a sustainable, value-added type operation. The 'value-added' element in the Solomon Islands is debatable, however. Fishers get only a little more for live fish than for dead fish, and the industry says it can't afford to pay more. If the costs of all the dead fish that are wasted in the LRF operation are factored in, the LRF fishery may, in fact, be a 'value-subtracted' industry.

Taking all the above circumstances into consideration, the Solomon Islands Government may wish to consider whether the live reef food fish fishery is worth all the trouble that would be involved in regulating it effectively, or whether it should simply be banned outright from the country.

Acknowledgments

The fishers in the villages mentioned above were unfailingly helpful and generous with their time, and I thank them all. We would particularly like to thank Peter Ramohia of the Fisheries Division, who accompanied REJ during his fieldwork and who was exceptionally effective in facilitating this work, as well as being fine company. Lyle Squire, Richard Hamilton and Shankar Aswani made many good suggestions for improving the first draft of this report. We also thank Uepi Lodge for their generous support. This report was funded and supported by The Nature Conservancy and the Solomon Islands Fisheries Division.

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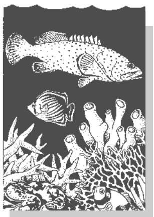
Addendum

Note added in press: Contrary to what we expected based on the fieldwork we did in early December, the reformed LRF company began to operate again in Marovo Lagoon. In early 1999, they once again focussed on spawning aggregations, including the one at Charapoana where two tonnes of fish were caught in January. The traditional ownership of Charapoana has not yet been finalised as we had been led to believe, and the dispute will go to the High Court. (Christian Nielsen, pers. comm.).



Application of the FFA member countries' Fishing Vessel Monitoring System to track live reef fish transport vessels

by Andrew Richards [1]

Introduction

FFA member countries now have the capability of tracking in their Exclusive Economic Zones (EEZs), the position, speed and direction of distant water fishing nation (DWFN) fishing vessels by means of a satellite-based vessel monitoring system (FFA VMS). Increasingly, government fisheries organisations worldwide are adopting such systems to assist in the management of their fisheries resources. In the Pacific, VMSs have been successfully introduced for domestic fishery management in Australia, New Zealand and Hawaii. Other countries, which have recently set up national VMS, include Argentina and Morocco.

Tools with which to achieve compliance

Several compliance measures are already in place in the western and central Pacific, notably air and sea surveillance, observer programmes, the Regional Register of Foreign Fishing Vessels and agreements on cooperation in surveillance between the FFA member countries. The FFA VMS provides a cost-effective tool to enhance these existing compliance measures.

What is a VMS?

A VMS is a technical system, which enables a vessel's position to be reported to a monitoring station, without that station being on board the vessel. Modern VMS use satellite technology to pinpoint a vessel's position and then relay that information to the monitoring station on-shore. The system may be pre-set to determine a vessel's position on a regular basis, or set to 'poll' a vessel thought to be acting suspiciously.

Capabilities of the FFA VMS

The FFA VMS offers a range of capabilities that cannot be readily achieved by other means. The baseline form of the FFA VMS, in accordance with the stated preference of FFA member countries, will enhance the effectiveness of several other measures being implemented to assist with the sustainable development and management of the tuna resources of the western and central Pacific.

The VMS will assist with monitoring the position, speed and direction of DWFN vessels that are fitted with Automatic Location Communicator (ALC) devices.

The VMS is capable of simultaneously monitoring the position, speed and direction of up to 1000 fishing vessels at any one time with the potential to monitor up to 2000 vessels. A computer based at the FFA Secretariat headquarters in Honiara, Solomon Islands, known as the 'VMS Decision Engine' identifies those vessel position reports

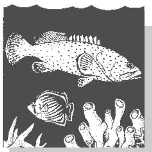
1. Forum Fisheries Agency, Honiara, Solomon Islands

which violate a set of rules stored in the computer. Exception and alert reports are generated accordingly by the computer and sent to the FFA member country in whose EEZ the vessels are operating.

The FFA Secretariat and each FFA member country is equipped with a graphical monitoring facility to view the exception and alert reports and other position data against a display of the member country's defined geographical areas. It is also capable of securely transferring vessel positions to each FFA member country, as required, enabling individual FFA member countries to track the movements of vessels in their EEZs.

Application of the FFA VMS to tracking of live reef fish carrier vessels

Although the FFA VMS was developed for the purpose of tracking tuna fishing vessels, it could easily be applied to tracking other vessels, such as those that transport live reef fish from the western and central Pacific to markets in Hong Kong. This would enable MCS officers in FFA member countries to determine whether such vessels travelled directly from the port where they cleared customs out of the EEZ or whether they stopped off en-route at remote locations, perhaps to illegally take on board extra live reef fish (see Johannes & Lam, this issue, page 8).



Live reef fish operations in Kiribati

by William Sommerville [1] & Derrick Pendle [2]

Negotiations for setting up a live fish venture in Kiribati, selling to Hong Kong, started in early 1996. Since Kiribati is in the middle of nowhere, far from any international port, it is extremely difficult to export marine products that will 1) give a reasonable return to the exporter and 2) give a price to the harvester/fisherman which makes the venture worthwhile.

Many ventures have been started by local and overseas businessmen which have soon foundered with nobody benefiting as a result. The only way to make a profit is from high-value products such as shark fin, and sea cucumber. Exporting live or chilled products usually costs more for the transport than the value of the product on the world market.

Despite the fact that it takes 50 days sailing on a round trip from Hong Kong to Kiribati, plus loading time for fourteen tonnes, because of the relatively high value of live fish, all parties involved in the operation can realise a profit. After looking at potentials and drawbacks for exporting live fish we initiated a small trial, the aims being:

1. To see if the required species of fish were present in Kiribati.
2. To find out if the local fishermen, using their traditional methods, could catch and keep the fish alive.
3. To find out if we could keep the fish alive for two months after we purchased them.

We began the trial in March 1996, and took it through to August 1996. After a few teething problems we discovered that we could keep alive 100 kg of cods, coral trout and wrasse for two months. We soon learnt that the old fishermen remembered that Chinese traders had kept fish in cages for their own consumption prior to World War II and this idea was not new to them.

We reckon that to start our live fish business cost close to AU$ 150 000 including the cost for the first ten tonnes of fish and somewhat more than that before it becomes profitable. We did not have this sort of cash at the time so we tried banks, aid project funds, and venture capitalists. Banks thought it was too risky, aid donors thought it was too environmentally sensitive and venture capitalists wanted too great a share of the profit. We decided, in conjunction with our marketing agents (Asil Group Ltd in New Zealand) to start it alone.

On a wing and a prayer and very short of capital we started in Tab North Island in the Gilbert Group. Apart from the small trial we had no other experience but were forced to start up earlier than originally planned as we found that a Chinese fishing company had just been given a licence to start the same business. Having had ten years experience of Chinese traders in the Pacific, we knew that we had to start before them to prove that such an operation could be environmentally friendly and give a fair return to the fishermen.

1. ASIL Group Ltd., 72 Friend Street, Karori, Wellington 6005, New Zealand
E-mail: asil@ihug.co.nz; Phone: +64 4 476 3888; Fax: +64 4 476 7555.
2. Managing Director of Marine Products Kiribati (MPK).

Kiribati had very limited hardware and fishing equipment available on the main island of Tarawa, and nothing on the island for the proposed development. We therefore had to build the first fish cages with chain link fencing. This resulted in the first cages breaking up and sinking as they were towed out to the site. We managed to salvage and repair the cages and began buying fish three days later. The local fishermen had all attended the workshops we had run to show them the species we wanted and the techniques used to handle the fish, including catching, use of a decompression needle (if required), holding and transportation of the fish. The fishermen were extremely keen and had already arrived at the cages with fish to sell before the cages had been anchored into position.

The average income for an 'I Kiribati' on an outer island is AU$ 40 per week. We now offered them the possibility of AU$ 250 per week, which most have reached and a few surpassed. This is only fishing for one full tide approximately 8–9 hours per day. The fish that we were targeting, especially 'cods', are not species traditionally targeted by the local people. Fishermen move away from an area if they can only catch cods, and they traditionally fish at night for the snapper species that they like to eat. The technique used by the local fishermen is hook and line fishing from a canoe, or from the surface while floating with a mask and snorkel. Usually there are two people floating in the water, with a third in the canoe. The fishermen guide the hooked bait to the fish they wish to catch and, once the fish is hooked, hand the line to the fishermen in the canoe to pull it in. At present these are the only methods used, and they have been very successful with our first two shipments of fish exported and the third, which is currently being harvested.

MPK does not own any fishing boats nor employ any fishermen, only station workers to buy and care for the fish. Fishermen bring their catches to the station in their own boats. The fish that are accepted are weighed and the fishermen are paid the same day. The majority of fishermen use sailing canoes which are less expensive to run than canoes with engines. There are only three middlemen from the fishermen to the customer in the restaurant: the exporter, the importer, and the restaurant owner.

For the first two months of the operation, the fish purchased experienced 50–60 per cent mortality (we had been advised that the norm would be about 10 per cent). Much discussion and hair loss resulted, as we wondered why we were losing so many fish. We tried imported treatment chemicals and started bathing every fish in these, which succeeded in reducing the loss by only 1%. We therefore thought the species in Kiribati were too fragile and we considered giving up this business. After more discussion with the fishermen and all concerned, we went out with the fishermen to see if they were doing anything wrong, as the fish looked perfectly healthy when they arrived at the station, but died 2–4 days later. Traditionally, once a fish is landed on the boat, it is held firmly by inserting the fingers into the gills, or by a very strong grasp of the fish body. Then, the hook is removed and the fish is thrown into the bottom of the boat and left there until reaching the beach for consumption. We immediately stopped all the above pactice and explained that this was the way to kill fish, not to keep them alive. The problem was simply that the fish did not have enough water and oxygen whilst in the boat; in addition the water got very hot in the sun. The water needed to be changed every 30 minutes. By drilling holes in the bottom of the canoes the problems were fixed but it was extremely difficult to convince the fishermen to do this. Once we had fixed this problem the mortality fell to less than 10 per cent overnight.

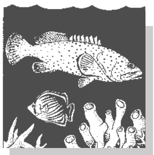
It is our experience that bad handling is the single biggest cause of fish death. The only treatment that we give the fish now is a 5- to 20-minute (depending on size) bath in fresh water. Decompressing the fish is another source of fish death, as fishermen take time to gain experience in piercing the fish. The mortality now is between 3 and 10 per cent constantly and it is our belief that the chemicals are a waste of time and money, treating only the symptoms and not the cause. The single most critical factor is education of the fishermen.

MPK works closely with the Kiribati Fisheries Department, so that we can monitor catch rates and sustainability. We are building a very large database on fish numbers, which is shared with the Department. As in most fisheries departments in the Pacific there is little or no information on the three species (coral trout, grouper, and wrasse) that we are targeting. Everybody needs this information if this type of export is to remain viable.

In May of 1998 our Hong Kong buyer, Brightfuture Industries Ltd. invited Gerry Reyes of The International Marinelife Alliance (IMA), Philippines, to travel with us on our second shipment to look at what we were doing and give us advice on any reef damage and fish stocks. The initial view from IMA was that there was no reef damage caused by our fishing techniques and that the reef area was wide enough for a live fish operation to successfully continue, with many of the target species being observed during stock assessments. Meanwhile the Chinese operation—which had brought its own Indonesian fishermen who used a compressor and the usual Indonesian fishing techniques—had its fishing licence revoked by the Fisheries Department and the Kiribati Government.

In order to meet our target of 14 tonnes per shipment we have set up three bases on three separate islands to minimise the impact on the resources in any one location.

We are happy to share our experience in more detail, and possibly co-operate to some extent commercially with ventures in other parts of the Pacific. In the first instance contact should be made with our marketing associates (their contact number are given, bottom page 16).



Cyanide fisheries: Where did they start?

by Don E. McAllister[1], *Prof. Ning Labbish Caho*[2] *& Prof. C.-T. Shih*[3]

Ornamental fishes and cyanide

The marine aquarium or ornamental industry began in 1957 when Earl Kennedy began exporting fishes from the Philippines (Fleras, 1984). Fishes were caught with cotton nets and traps placed on coral reefs. In 1962, a little-known fish collector named Gonzales began to spray sodium cyanide on reefs to stun ornamental fishes, making them easy to capture (Rubec, 1988). That approximate date is supported by Ireland and Robertson (1974) who reported that Graham F. Cox (pers. comm., 1973) had stated that cyanide collecting had been used in the Philippines for the last 10 years. Ireland and Robertson (1974) also suggest that the widespread and virtually uncontrolled use of cyanide to eliminate unwanted fishes in milkfish ponds led to the application of this chemical in coral fish capture and cited a 1970 FAO review (Lennon *et al*., 1971). When one of us (D.E.M.) was in the Philippines in 1986, it was reported that cyanide was still being used to clean milkfish ponds of unwanted fish before restocking. Cyanide was also used later as a fish eradicant to get rid of undesirable exotic fishes in lakes in Canada (Leduc *et al*., 1973), but its use was discontinued.

The stunning of aquarium fishes with cyanide spread through the Philippines and its usage grew up to at least 150 000 kg per year (McAllister, 1988), and spread from there to Indonesia. The use of poisons, including cyanide, to capture fishes is illegal in the Philippines and Indonesia, as it is in most countries. For more information on the ornamental cyanide fishery and measures to introduce alternatives, consult reports of Ocean Voice International, the Haribon Foundation for Conservation of Natural Resources, International Marinelife Alliance (IMA), and publications in the bibliography on cyanide toxicity to fishes and corals (McAllister, 1998).

Live food fishery and cyanide

While the use of cyanide in the ornamental fishery has been an open secret, little had been reported on the use of cyanide in the live food fish trade until the report by Johannes and Riepen (1995) and subsequent publicity by The Nature Conservancy and IMA. However, there were earlier reports. A fisheries and law enforcement report by Lt. Col. Rodante Joya mentioned the cyanide ornamental and live food fishery and was released at the 1987 Baguio Fisheries Conference in the Philippines. The first issue of the first volume of *Sea Wind*, published in 1987, showed photos of a seized ship and its live wells used to transport cyanided fish for the live food trade from the Philippines to Hong Kong. Steve Robinson prepared a manuscript report on the live reef food fish trade in 1986. Johannes and Riepen (1995) document the spread of the use of cyanide in this trade through Indonesia and elsewhere in Southeast Asian waters.

Origins of cyanide fishing

The reader will have noticed that the early records reported for cyanide use in ornamental and live food industries were in the Philippines. This might suggest that cyanide fisheries began in the Philippines as early as 1962 and spread out from there. Galvez *et al.* (1989) suggested that plant poisons were used for fishing in the Lingayan Gulf area of the southern Philippines, before the introduction and use of sodium cyanide. Cyanide was subsequently introduced there by two immigrant fishers from the Visayas, but who both learned the

1. Ocean Voice International, Box 37026, 3332 McCarthy Road, Ottawa, ON KIV OWO, Canada
2. Universidade to Amazonas, Bio-Amazonia Conservation International, Manaus, Brazil
3. Department of Zoology, National Taiwan University, Taipei, Taiwan 106

technique in Mauban, Quezon. It has been suggested (Steve Robinson in Rubec, 1986), that a marine fish collector named Gonzales learned about the 1958 work of Bridges in Illinois, U.S.A. Bridges was seeking a fish toxicant (poison), and found that fish were apparently able to recover from low doses. That hypothesis suggests that a Filipino fish collector read a special scientific report of the US Fish and Wildlife Service and learned to apply the technique to capture ornamentals on reefs. Alternatively, a collector might have learned the technique from those who used cyanide to eradicate undesirable fishes from milkfish ponds in the Philippines.

But there is another possible origin of cyanide fishing in the Philippines. One of us (C.-T.S.) heard of cyanide fishing in Taiwan as an undergraduate student from 1954 to 1957. That is at least 5 years before cyanide fishing was used in the Philippines and one year before Bridges' study. Cyanide fishing is now illegal in Taiwan, but some divers still use it. Another of us (N.L.C.), as a student, was asked by his professor to buy potassium cyanide at the local chemical store, and to use it for a fish collecting project. The cyanide was sold to the student without any questions. Four or five of the potassium cyanide tablets, the thickness of round crackers and about 5 cm in diameter, were wrapped in cheese cloth and tied to the tip of a 2-m pole. The tip of the pole was then waved around coral heads or poked into crevices. Specimens of butterflyfishes (Chaetodontidae) were collected in this manner for an undergraduate thesis in the summer of 1965. At that time cyanide fishing was probably the easiest way for local fishers to catch reef anchovies which were dried for food.

A search of records in the Fisheries Bureau of Taiwan showed that the first prosecution for cyanide use occurred 22 December 1990, with nine additional cases up until the last one, 7 February 1994. Most of these cases were in the southern waters of Taiwan. So cyanide was apparently in fairly common use in Taiwan before the Philippines. This suggests the cyanide fishing technology might have been transferred from Taiwan to the Philippines. According to the Fisheries Act of Taiwan (last amended 1 February 1991), Chapter 3, Article 48, the use of poisonous materials is not permitted in collecting (including fishing) aquatic plants and animals. We have not been able to locate scientific papers on the use of cyanide for fishing in Taiwan.

It is highly probable that cyanide was used for capture of food fishes in Taiwan, not for marine aquarium fishes; the commerce in marine aquarium fish had not even begun in the early 1950s. Where did the cyanide come from? The most likely source was from mining activities. Gold is found near Sincheng (Shinjo) on the east coast, and alluvial gold is washed out in the Keelung and Zuiho rivers (Encyclopaedia Britannica, 1957, 9: 521).

Which cyanide? Choose your poison

A number of authors refer to the poison simply as cyanide. But there appears to be two distinct cyanide chemicals in use, sodium cyanide ($NaCN$) and potassium cyanide (KCN).

Sodium cyanide is the form in common use in the Philippines, and potassium cyanide seems to be the one in use in Taiwan. Johannes and Riepen (1995) mention the use of sodium cyanide in the live reef fish trade in Asia and the western Pacific, though most of the time specifying simply cyanide. Cesar (1996) for Indonesia and Barber and Pratt (1997) for Southeast Asia, mention the use of both sodium and potassium cyanide, while Nokome Bently, in a report in press on exploitation and trade in live reef fish in Southeast Asia mentions only sodium cyanide.

It is not certain why a user applies one of the two different forms of cyanide. It may be a question of availability. It is possible that it may be a question of price; one reference suggests that sodium cyanide is cheaper. While most authors fail to specify size (weight) of the tablets used, some do.

Ocean Voice International recommends that observers specify which kind of cyanide is in use and how many tablets there are per kg, as well as the price, when this is possible. Knowing brand names or photographing original containers, if this can be found out without risk, would also be desirable. This information would help track down sources of the chemicals. Enforcement officials should be advised that either form might be in use.

As far as the fish are concerned, both chemicals are potent toxins. Stunning capacity may not differ significantly, given the variable in the application—diminishing size of tablets as they dissolve in the squirt bottle and differing wave action or currents, and differing lengths of stay in the vicinity of a cloud of cyanide solution.

Possible conclusions

Firstly, we cannot be sure where the technology originated from, either the U.S., Philippines, or Taiwan. However, on the basis of geographic proximity and the chronological sequence, the Taiwanese origin seems more likely. On the basis of political connections the American origin is possible. But is should not be overlooked that there might be an older origin and source for the technology in an other country. We would appreciate any input from readers.

Secondly, the evidence in hand suggests that it is likely that the technique of fishing with cyanide began with food fisheries, rather than with marine aquarium fisheries, rather than the other way around.

But whatever the origins of cyanide fishing, the results were sad. They included:

- Useless death of desired target species of food and aquarium fishes from reef customer;
- Loss of employment for fishers and income for coastal communities;
- Loss of economic sources of protein, minerals and vitamins for coastal and inland communities, fostering malnutrition;
- Loss of coral reef habitat, leading to secondary loss of target species and biodiversity;
- Degradation of coral reefs, lowered attractiveness of reefs to tourists, reduced beach sand generation, and lessened protection of coasts from storm waves. This adds to the degradation caused by sedimentation, use of explosives for fishing, eutrophication and other forms of pollution, extraction, and more;
- Exposure of fish harvesters and their families to cyanide skin rashes and other afflictions, and occasional deaths;
- Growth of aquarium industry using unsustainable harvest methods;
- Lowered profits of collectors, fish buyers, exporters, importers, dealers—dead fish don't sell well in the ornamental and live food fish trade; and
- Lowered reputation and market potential with stressed fish; dissatisfaction of ornamental fish hobbyists and live fish trade consumers; and lack of customer confidence in the industries.

These demerits can be reversed, if new resources and effort are put into solving the problem. As indicated elsewhere, an integrated approach is required, one which involves participation by the harvesters. The simple solutions often proposed just don't work. Just regulation obviously doesn't work. Preaching doesn't work. Organising the community, using former cyanide fisherfolk as trainers in the community, helping provide alternatives, in-depth education involving all causes of reef destruction, making available appropriate educational tools, and providing incentives for conversion, seem to work the best. Assisting communities to establish marine protected areas helps involve them in decision making about their own future. All of this takes time, and patience, a rare commodity amongst people of industrialised countries, who seek a quick technical fix.

Fisherfolk, often marginalised, would like a better life. Opportunities in coastal villages are often few. The reef, if its health is sustained, is the biggest resource villagers have.

The bigger challenge has been to catalyse the industries and governments involved. It has taken two decades for NGOs to increase awareness of the issues and to mobilise significant resources.

But governments and the enlightened sectors of the ornamental fish industry are now on board. Ornamental Fish International, Rolf C. Hagen, Segrest, and the American Marinelife Dealers Association are amongst those who have joined the challenging task of finding an alternative to cyanide fishing.

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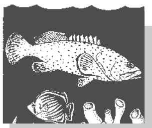

A note on cyanide fishing in Indonesia

by Jos S. Pet[1] *& Lida Pet-Soede*[2]

In Indonesia reef fish stocks are declining as a result of over-fishing and destruction of habitats. The latter is caused by the dying of corals from cyanide and by the breaking of corals around holes where fish are hiding. In the capture of a single grouper, more than a square meter of corals is destroyed when the fish is removed from its hiding place. In areas where cyanide fishing has been practised intensively, the reef is mostly dead, overgrown with algae, and has only very few animals still living on it. The target fish species in the cyanide fisheries are all species which aggregate at specific sites to spawn. Groupers and Napoleon wrasse migrate many miles each season to aggregate at the sites where they reproduce. Spawning aggregation sites are extremely vulnerable since experienced cyanide divers are skilled in locating them. Wiping out the fish in one aggregation site equals the elimination of top predators from several square miles of reef. Spawning aggregation sites of grouper and Napoleon wrasse therefore need to be protected wherever possible.

There are several types of cyanide fishing operations in Indonesia: large-scale operations working mostly in remote and pristine areas, and small- and medium-scale operations working in more densely populated and exploited reef areas. The large-scale operations use motherships with skiffs, and have crews of some 20 persons. These boats make one-month trips after which the catches are transferred to floating cages or to concrete basins on shore. The fish from the cages are transported by Live Fish Transport Vessel (LFTV) to Hong Kong. The fish from the concrete basins are air-freighted out. The medium-scale operations employ 5 crew of which a minimum of two dive with hookah gear. They make three-day trips. The small-scale operators, with only a single fisherman, free-dive from outrigger canoes and are thus confined to shallow reefs. Small- and medium-scale operations sell their fish from floating live fish cages.

When a large-scale cyanide mothership with working boats enters a pristine coral reef area the operators are only targeting prime species such as Napoleon wrasse, barramundi cod, coral trout and large groupers. The divers are especially keen to spot a grouper spawning aggregation. By the time a mobile large-scale operation has taken its quarry from a reef, local fishermen have learned the practice and start fishing with cyanide. This continued poisoning prevents new coral recruits from successfully settling on the dead reefs.

1. The Nature Conservancy, Indonesia Program
2. Dept. of Fish Culture and Fisheries, Wageningen Agricultural University, The Netherlands

Cyanide is cheap and easy to obtain. The costs per 0.5 l solution are about Rp 5000. Small-scale operations use 2 bottles per diver per day-trip, medium-scale divers use 15 bottles per 3-day trip and the large-scale operations use some 750 bottles per 1-month trip. Catches of large-scale cyanide operations average around 2500 kg per trip. A regular medium-scale dive operation catches around 20 kg of live groupers per trip. Small-scale operations average 1 kg per trip. The cyanide fishermen in Indonesia receive prices ranging from US$ 5.00 to US$ 35.00 per kg, depending on species, size and quality. The net profits per boat-owner per month in the cyanide fishery are US$ 100 for the small-scale operations (owner = crew), US$ 413 for medium-scale operations and no less than US$ 35 000 for large-scale operations. Crew members on average earn incomes per month of US$ 100 in small-scale operations, US$ 252 in medium-scale operations and US$ 400 in large-scale operations.

The profits and incomes are higher than in any type of conventional fishery. The large financial rewards (although short-term) lure many fishermen into the practice, even when they are aware that the resources will eventually cease to provide them and future generations with employment, income and food. It is more a matter of greed than a matter of need (Pet-Soede & Erdmann, 1998). Even if fishermen have other options to make a living at sea, in many cases they deliberately choose this lucrative practice. Cyanide fishing is also a profitable enterprise for investors and boat owners.

The Fisheries Law No. 9, signed on 19/6/1985 by the President of Indonesia, includes a specific prohibition of the use of destructive fishing techniques such as explosives and poison. The penalties are up to 10 years of jail and/or 100 million Rp. fine. The marine police and navy, together with the fisheries service, are responsible for law enforcement. Profit margins in the cyanide fisheries and live reef fish trade are large enough, however, to allow for very large bribes. Corruption therefore makes the eradication of this illegal and destructive fishing method extremely difficult. Very few cases of cyanide fishing are brought to court, and usually the offenders are released after payment of a 'fine'.

Corruption at the lower government levels is almost inevitable, considering the large bribes paid and the low salaries for government officials. This combined with a lack of funds and facilities for enforcement, lack of knowledge and awareness with the authorities, and lack of political will at all levels, means that the cyanide fishing still continues largely unhindered.

The biggest problem is finding support at higher levels for banning destructive practices. Most authorities seem disinterested. Political will has to be developed through increased awareness of macro-economical problems caused by destructive fishing such as its impacts on tourism and fishing.

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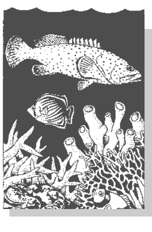

Krismon & DFP: some observations on the effects of the Asian financial crisis on destructive fishing practices in Indonesia

by Mark V. Erdmann[1] *& Jos S. Pet*[2]

Primary effect of the crisis: Increasing export fisheries

In recent months, various marine scientists and concerned environmentalists have approached us for information on the effects of the current Asian financial crisis (known as 'krisis moneter,' or 'krismon' in Indonesia) on destructive fishing practices (DFP) here. Specifically, we have often been asked to confirm if blast fishing has increased as the Indonesian rupiah devalued precipitously and prices within the country soared. Our combined observations in the regions of South and North Sulawesi, Komodo, East Kalimantan and Maluku suggest that krismon has indeed had major effects on DFP in Indonesia, though different fisheries have been affected differently. In particular, fisheries targeting species for export (such as the live reef fish trade and lobster, shark fin, and tuna fisheries)

1. University of California, Berkeley and Indonesian Institute of Sciences
2. The Nature Conservancy, Indonesia Program

have intensified, while those providing products for local consumption (such as blast fishing) have actually decreased. This phenomenon is rather easily explained by three interrelated factors:

1. Prices paid to the fishermen

Because exported fisheries products are generally valued (very loosely) in US dollar terms, rupiah prices for these products have risen as the rupiah devalues. On the other hand, the prices for fish in local Indonesian markets have risen only slightly (if at all) due to the perishable nature of the products. This discrepancy in prices seems to have influenced even more fishermen to abandon traditional, domestic fisheries in order to enter export-oriented fisheries. In the case of blast fishing, which also supplies local markets, this trend is enforced by the increasing cost of imported fertiliser, an ingredient in most home-made bombs.

2. Prices paid by the exporter

Although the prices paid to fishermen for export products have increased in rupiah terms, these prices have actually decreased in US dollar terms (see 'trends in prices' below). This has meant that exporters who sell their products overseas in US dollars have actually seen profit margins increase during the financial crisis. This seems to have spurred them into even more aggressive campaigns to source these products from local fishermen.

3. Decreased enforcement

Export-oriented fisheries using illegal capture techniques have even less to fear from enforcement agencies during the krismon period than previously. Not only are local enforcement agencies strapped for funding for patrols and other enforcement activities, but also, they are even more prone to accepting bribes as officials struggle to feed their families. Blast fishermen, on the other hand, have even less profit to divert to bribery.

These three factors have resulted in many fishermen giving up blast-fishing and other traditional fisheries (at least temporarily) in order to enter export fisheries.[3,4] Without question, the live reef fish trade has shown a definite intensification during this period.

Unfortunately this has come at a time when grouper and Napoleon wrasse stocks were already being pushed to the point of collapse in Indonesia (Pet-Soede & Erdmann, 1998). Below, we discuss in more detail some of the trends we have observed over the past year of the financial crisis, as well as some new observations on the live reef food fish trade.

Trends in prices

As mentioned above, rupiah prices for many fisheries export products have risen considerably as the rupiah devalued from roughly Rp 3200/US$ in October 1997 to a low of Rp 17 000/US$ during the Jakarta riots in June 1998. However, these price increases have hardly kept pace with the devaluation; while rupiah prices paid to fishermen have roughly doubled since October 1997, the rupiah's value against the dollar has averaged 1/3 to 1/4 of its value at that date. Although the actual prices offered to fishermen vary greatly throughout the archipelago, the trend is similar everywhere. For instance, fishermen in South Sulawesi received on average Rp 60 000/kg (US$ 18.75/kg) for live *Plectropomus leopardus* in October 1997, while in April 1998 they received up to Rp 100 000/kg (US$ 10/kg). By comparison, fishermen in the Komodo area who used to receive Rp 30 000/kg (US$ 12/kg) in mid-1997 for coral trout now receive Rp 60 000/kg (US$ 6/kg). Similar trends are evident in prices for both *Cromileptes altivelis* and *Cheilinus undulatus*. With this situation, both fishers and exporters have even stronger incentives to enter or remain in this fishery.

Trends in prices paid to fishermen for other export fisheries followed similar patterns: live spiny lobsters (*Panulirus* species) and dried shark fin have roughly doubled in rupiah price throughout the archipelago, while high quality trepang has quadrupled in price (thereby maintaining a stable dollar price). Interviews with fishermen in South Sulawesi revealed that they were very aware (and quite angry) that the exporters and middlemen were now making a much larger profit, but felt quite helpless to do anything about it. Although price increases were gradual during devaluation of the rupiah, exporters almost immediately dropped the prices paid to fishermen when the rupiah subsequently strengthened against the dollar.

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3. In North Sulawesi and Maluku, where many fishermen are also land-owners with small clove, nutmeg or coconut (copra) plantations, a related trend has been for these fishermen to devote more and more time to their plantations, as these export commodities now command handsome prices as well.
4. Also in North Sulawesi, tuna fishermen are altering their behaviour to maximise export-related profit. While they used to keep a certain proportion of their catch for personal consumption and sale within their villages, they now feel pressured to sell almost all of their catch to the local, export-oriented cannery, which pays them much higher prices for their fish than villagers can afford. Within the Bunnan National Marine Park, the unfortunate result is that many villagers, including some of the tuna fishers, are now illegally spear-fishing and gill-netting for small reef fish for their own consumption.

One exception to the above-mentioned trend is the price paid to South Sulawesi fishermen for Napoleon wrasse, *C. undulatus*. When we first noted declining prices for *C. undulatus* (Pet-Soede & Erdmann, 1998), it was explained to us as being a direct result of the governmental ban on export of adult Napoleon wrasse. The middlemen to whom the majority of these fishermen sell their fish claimed that the associated risks of storing the illegal fish justified the lower prices being paid. The trend has continued; in April 1998, fishermen there reported receiving only Rp 10 000/kg for larger specimens (less than US$ 1.50/kg). However, this is clearly a case of dishonesty among middlemen; not only are Napoleon prices much higher in other areas of Indonesia, but one fisherman who 'freelances' and sells his fish directly to the exporters in South Sulawesi confided that he received Rp 320 000/kg for large specimens.

Trends in techniques

As described in Pet-Soede and Erdmann (1998), the live reef food fish trade in Indonesia is a very dynamic fishery, repeatedly undergoing wholesale changes in technique. As large-scale cyanide fishing boats become unprofitable in areas where grouper stocks dwindle, they are replaced by smaller-scale fishermen using hook and line and trap fishing to catch those grouper which remain. Now, in the Komodo region, another form of medium-to-small scale grouper fishing technique has become widespread in the past 6 months. 'Kedo-kedo', small, motorised outrigger canoes from which fishermen troll using steel wire with a feather and plastic fish lure, now dominate the coral trout fishery within Komodo National Park. Several fleets of up to 14 kedo-kedo and one mothership have been actively operating in the area since at least August 1998, though recent enforcement activities seem to be working in driving these operations outside of park boundaries.

Unfortunately, these fishermen are no longer limited to *Plectropomus* species; both *Cephalopholis argus* and *C. miniata* are now actively targeted. Even more alarming, these fishermen are clearly targeting spawning aggregations of coral trout throughout the park.

Another fishery which seems to be intensifying is the capture of live aquarium fish for export. In recent months in the Komodo National Park, a number of boats from Java have been arrested with large quantities of cyanide, crowbars, ornamental fishes, and army or ex-army 'guardians' on board. In Ambon, capital of the Maluku province, several new ornamental fish operations have reportedly begun operating. According to a local hotelier, one of these operations is run by an European who openly admits to cyanide use, claiming it is the only economical way to capture aquarium fishes.

Another company is avoiding censure by claiming to use clove oil as an alternative, 'natural' fish anaesthetic. This is a most interesting development, as clove oil (or eugenol in its purified form) is a moderately well-known anaesthetic for small fishes and crustaceans (e.g., Munday & Wilson, 1997; Soto & Burhanuddin, 1995). Recent research has shown clove oil to be a highly cost-effective and safer alternative to standard anaesthetics used in aquaculture such as quinaldine and MS-222 (Keene *et al.*, 1998; see also Erdmann, page 4, this issue). However, we are not aware of any research on clove oil's potential for collateral environmental damage to corals and other non-target reef organisms.

The first author's experience in using an ethanol/clove oil mixture to extract stomatopod crustaceans from coralline algae nodules suggests that coralline algae bleaches almost immediately upon contact with this mixture. According to Philip Munday (pers. comm.), this effect may be attributable more to the ethanol carrier than to the clove oil, and subsequent anecdotal experiments with pure clove oil squirted on *Pocillopora* spp. and *Acropora* spp. coral colonies in situ showed no observable ill effects. Additional research on its effects on corals especially would be most welcome in order to establish if this truly is a less environmentally damaging technique for catching aquarium fishes.

A final trend that we have noticed in Komodo National Park is a dramatic increase in long-lining for sharks (for shark fin) and large groupers, which are sold fresh-chilled for export. Prices for both of these products have increased dramatically in the past several months. This is most saddening, as Komodo National Park was one of the few areas in Indonesia where sharks and large grouper were regularly encountered by divers.

Different strokes... The East Kalimantan live reef food fish trade

One fascinating aspect of the live reef food fish trade in Indonesia is the range of techniques encountered throughout the archipelago for catching, storing, and trading fishes. A recent visit to East Kalimantan revealed a live reef fish trade with practices that were quite different from anything we have reported before from Indonesia—primarily driven by the remoteness of the area. Large river deltas along the eastern coast of Kalimantan have prevented extensive reef development here, with some notable exceptions such as the reef complex including Derawan and Sangalaki islands. The live reef fish trade in this area is controlled exclusively by one businessman, who made his first fortune by dominating the trade in turtle eggs there (which he still does). By completely controlling the trade, this businessman keeps prices paid to fishermen at a minimum. For example, fishermen received Rp 15 000/kg (US$ 1.50/kg) for *Plectropomus* spp. in April 1998, compared to the Rp 100 000/kg (US$ 10/kg) paid to South Sulawesi fishermen at the same time.

Not surprisingly, the fishermen have little loyalty to this 'boss' and actively cheat him in one of the few ways they can. When the live fish transfer vessels (no airfreight in this region) arrive to collect shipments from this businessman, fishermen attempt to rendezvous with the vessels before they dock in order to sell fish directly to the vessel. In this manner, they can receive US$ 40/kg (in dollars) for Napoleon wrasse, which would otherwise fetch Rp 25 000/kg (US$ 8/kg) from the businessman.

Divers here do not use SCUBA or hookah to collect grouper and Napoleon wrasse. While they do use cyanide in large quantities, they free-dive to 20–30 m depth to collect the fish. Free diving to these depths is commonly reported for pearl divers in the south Pacific, but this is the first time we have encountered such practices in Indonesia. Given the amount of time it can take chasing a large grouper or Napoleon wrasse before it seeks shelter in an area where it can be collected with cyanide, this is impressive indeed. Divers interviewed here were all aware of the phenomenon of grouper spawning aggregations, and actively targeted them. They all mentioned how much easier it was to collect fish during these aggregations. They furthermore report that Napoleon wrasse were also known to aggregate in several of the same areas as the groupers, though at different times.[5]

Whatever happened to the large cyanide catcher vessels?

Recently we reported that the large-scale cyanide fishing boats which used to be common in South Sulawesi have become unprofitable in that region and have moved operations to more remote areas of eastern Indonesia where the grouper stocks are decimated (Pet-Soede & Erdmann, 1998). In April 1998, one of us (MVE) had the opportunity to talk at length with Mr. Muddin, a diver who has been working for one of these operations since 1994. As Muddin had provided us with extensive information on the practices of large-scale cyanide vessels in the past (see Erdmann & Pet-Soede, 1996), we were interested to receive an update on these practices.

According to Muddin, many of the large boats which used to operate in South Sulawesi are now operating in south-east Sulawesi (Tukang Besi archipelago and surroundings) and remote areas in the Banda Sea. His mothership carries 12 fiberglass dinghies, each of which is manned by a crew of four (two hookah divers, one dive tender, one driver). They typically go to sea for one-month fishing periods, during which time they dive every day. Each of the dinghy teams cooperate in a highly professional manner; the boat owners keep salaries relatively low (Rp 250 000–300 000 per month, or US$ 25–30 per month in April) and use a bonus system to motivate the teams. Teams receive a bonus of Rp 500–1000 per fish (split amongst themselves). Additionally, each team has a monthly goal of 500 kg of fish, and those who achieve the goal are given an extra Rp 1000/kg to split. Muddin reported that the base salaries have not been raised during the krismon period, but the bonuses have been roughly doubled from those of mid-1997.

Under this bonus system, the diving teams have become very efficient in their task. The two divers coordinate in chasing and cornering grouper and Napoleon wrasse as the boat driver deftly manoeuvres the dinghy above them and the tender keeps hookah lines untangled. Muddin said that all of these teams are aware of and skilled at locating spawning aggregations. Even cyanide use is more efficient than in years past: cyanide solution is now mixed in a ratio of one tablet of sodium cyanide to 15 l of water, and Muddin reports greatly reduced mortality from cyanide overdose. He said that some boats have resorted to diluting cyanide solution with soap solution in an attempt to even further reduce costs (see Pet & Djohani, 1998), but his bosses have strictly forbidden this due to supposed harmful effects on the fish.[6]

5. Editor's note: Our research in Palau supports this observation (R.E. Johannes, L. Squire, T. Graham, Y. Sadovy, and H. Renguul. (in press). Spawning Aggregations of Groupers (Serranidae) in Palau. The Nature Conservancy and the Forum Fisheries Agency).
6. Interestingly, Munday and Wilson (1997) mention that mixing detergent with commonly used fish anaesthetics often increases efficacy of the anaesthetic. Munday (pers. comm.) suggested that the detergent, acting as a surfactant, may keep many anaesthetic powders or oils well-dissolved in water, and may assist with transport of the anaesthetic across the gills. He commented that detergent is commonly added for this reason to rotenone as well. Munday and Wilson did not test cyanide solution among their anaesthetics, but this may be the answer to the 'detergent dilemma' posed by Pet and Djohani, (1998). This would correspond to Pet and Djohani 'reason #1 and #2: detergent is added to increase solubility and efficacy of the cyanide. On the other hand, Peter Rube (pers. comm.) informed us that his experience dictates that detergent is likely added for Pet and Djohani's 'reason #3': to increase visibility of the squirted cyanide solution. He reported incidents of divers in the Philippines and Indonesia adding milk, kerosene or gasoline to cyanide squirt bottles specifically to increase the visibility of the cyanide plume, and suggests that soap could be used for the same purpose.

But this heightened efficiency has not been able to prevent the inevitable. While Muddin's mothership can hold up to 8 tons of live fish, they have not collected more than 3 tons per month for the past year. His team now catches no more than 4–5 fish per day of diving, and occasionally they go home empty-handed. Even with the krismon-adjusted bonuses, Muddin now only makes Rp 400 000–500 000 per month, compared with the Rp 700 000 he used to make in years past. He reports that many of his co-workers are now looking for work elsewhere, and with good reason: his bosses (from Hong Kong) have openly declared that they will shut down operations and leave Indonesia by mid-1999, as they can no longer reap the profits they require. A year late, perhaps, but Johannes and Riepen's 1995 prediction of a collapse in the live reef food fish trade in Indonesia within three years seems dangerously close to being fulfilled.

Conclusions

The above discussion illustrates again the extremely dynamic nature of destructive fishing practices in Indonesia. Far from being set in their ways, Indonesian fishermen respond quickly to changing market forces and can rapidly adopt new fishing techniques as they become profitable.

In general, the Asian financial crisis has affected Indonesian DFP in a most logical manner: export-oriented fisheries, with much higher prices offered, have intensified, while fisheries that provide domestic product have stagnated or declined. While Indonesia has always relied heavily on exports of its vast timber, oil, mineral and fisheries resources, the financial crisis seems to have resulted in government and businesses 'selling off' these resources at an even more alarming rate in order to generate desperately needed foreign capital.

A further example comes from Ambon, where local fishermen report a dramatic increase in foreign fishing vessels (mainly tuna fishers) during the krismon period. While no one can deny Indonesia the right to call upon its vast natural resources to help extract itself from the current financial crisis, there is a grave danger of government officials and private businessmen greatly undervaluing these resources and selling them off in a rushed and unwise manner. Most of these resources, including the fisheries discussed above, are of very high-value and have the potential to sustain the country and fuel its development in the future if carefully managed. Unfortunately, if Indonesia continues to undervalue these resources and export them in a desperate bid for foreign currency, it may emerge from the financial crisis only to find itself plunged even deeper into environmental crisis.

Acknowledgments

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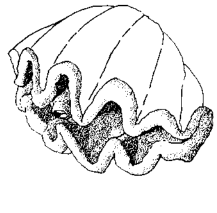

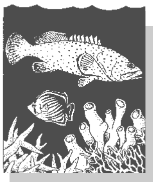

Recent developments in combating cyanide fishing: Much talk but little action on the ground

by Charles Barber [1]

It has been at least three years since the live reef fish trade (LRFT) and its widespread use of cyanide began to receive extensive media attention. Since that time it has been discussed at a host of international meetings and become a legitimate funding priority for a number of bilateral, multilateral, and private funding agencies. But much of the media-generated buzz has died down since 1997, and there seems to be a growing public belief that the 'experts' are handling the problem. How could they not be handling it, after it had been on CNN and in *Time* magazine? Haven't major donors committed themselves to solving the problem? Haven't major environmental groups launched initiatives to deal with it?

The situation is reminiscent of the great flurry of concern in the U.S. and Europe about the Amazon rainforests in the late 1980s. Cover stories, TV documentaries, petitions on the counter at the Body Shop, rock star benefits and a slew of other factors led to a 'Save-the-Amazon' boomlet, even the creation of a special international fund. By the mid-1990s, however, the celebrities moved on to other causes and the media followed them. Ordinary Americans and Europeans were by then surprised to hear that the Amazon was still being hacked and burned even faster than in the late-1980s. 'Didn't Sting fix that?'

The LRFT has not yet been subject to this ultimately counterproductive boom-and-bust cycle, and no celebrity the likes of Sting has emerged as the champion of the napoleon wrasse. But the dialogue about the LRFT has been characterised by the emergence of a series of partial quick-fix solutions, including grouper aquaculture, certification of live reef fish imports in consumer countries, and attempts to develop a test for the presence of cyanide in fish, simpler than the methods currently available. These are all parts of the solution, but miss some of the main elements discussed below.

More worrisome is the apparent belief by some that a little publicity by itself will make the problem go away. A recent edition of *Asian Divers* 'Ecowatch' feature, for example, announced that 'the Toloka Foundation has managed to stop the live reef fish trade in the Togian Islands, off Sulawesi' in Indonesia. Indeed, on its website, the Toloka Foundation announced in September 1998 that 'since publicising the live reef fish trade in the magazine *Asian Diver*, Toloka have successfully raised this issue with the Indonesian authorities and this activity seems to have ceased altogether in the Togian Islands.'[2]

Unfortunately, nothing could be farther from the truth. A team of experienced investigators from the International Marinelife Alliance (IMA) carried out an assessment of the live reef fish trade in early September 1998—the very month in which Toloka was proclaiming victory—and found a pervasive and widespread live reef fish trade in which cyanide was being widely used.[3] A follow-up IMA team is currently in the field working with local government agencies to develop and implement a programme to train cyanide fishermen in cyanide-free capture techniques, and the government is considering a ban on live fish exports from all operators whose fishermen have not undergone training.

Cooperation and hard work 'based on a realistic assessment of the problem' can reduce the use of cyanide and other destructive effects of an unregulated LRFT in the Togians and elsewhere, but declaring premature victory in the face of a real-life situation to the contrary solves nothing, and discourages donors and other partners from addressing the problem.

Concerted and comprehensive action can reduce cyanide fishing in places where it is already well established, and prevent it in places where the LRFT is just getting started. Furthermore, working with government agencies and NGOs on this issue provides a strategic entry point for addressing broader concerns about the sustainability of the LRFT, and other coral reef threats such as blast fish-

1. Charles Barber, Biological Resources Program, World Resources Institute, 14 Cabbage Street, Valle Verde 5, Pasig, Metro Manila, Philippines. E-mail: cbarber@mnl.sequel.net
2. Campaign to Halt the Live Reef Fish Trade. STOP PRESS September 98…,VICTORY FOR TOLOKA, <http://members.aol.com/toglovers/campaign.htm> downloaded 29 October 1998.
3. Cruz, F. (1998). Assessment of the Live Reef Fish Trade in the Togian Islands, Southeast Sulawesi Province, Indonesia. Manila: International Marinelife Alliance. October, 1998.

ing and the over-harvest of reef invertebrates and other reef organisms.

This article discusses the Indo-Pacific Destructive Fishing Reform Initiative, launched by IMA and the World Resources Institute (WRI) in early 1998. The article's purpose is to seek the comments and collaboration of the many groups and individuals working to ensure that the incomparable coral reefs of the Indo-Pacific, the 'Amazon of the Oceans' survive and prosper well into the coming millennium.

A model for regional action: The Philippines Destructive Fishing Reform Program

The Philippines, 'birthplace of cyanide fishing', is also the birthplace of an effective strategy for combating the spread of the practice and establishing sustainable live reef fisheries. The Philippines' experience serves as the model for the Indo-Pacific Destructive Fishing Reform Initiative discussed in the next section, and is therefore worth reviewing briefly, although it has been discussed in detail elsewhere.[4]

Beginning in the late 1980s, IMA—the NGO that had first exposed cyanide fishing through an international publicity campaign earlier in the decade—began working with the government's Bureau of Fisheries and Aquatic Resources (BFAR) to develop a strategy to combat cyanide fishing and other forms of destructive fishing. This has evolved into a durable partnership between IMA, BFAR, and numerous local communities and local government units around the country, as well as donors including USAID and the Asian Development Bank. Elements include:

- Cyanide Detection Test (CDT) laboratories at six key locations around the country to test samples from export shipments and either certify or seize them, backed up by additional Monitoring and Inspection Stations (MIS), all operated by IMA under contract to the government;

- Training programmes to convert fishermen (some 2000 so far) to cyanide-free capture techniques, help them obtain a better price for their catch, and assist them in developing other livelihood enhancement activities;

- Development of new government policies and procedures to more effectively regulate the live reef fish trade and the distribution and use of cyanide;

- Intensive public awareness campaigns with the media and in the educational system to promote marine conservation and raise awareness of the effects of cyanide fishing, explosive fishing, and other destructive practices;

- Collaboration with environmentally concerned live fish importers in the USA (through the Marine Aquarium Council, a newly established certification body, see Holthus, page 34, this issue) and in Hong Kong, to build consumer and importer support for a more sustainable live reef fish trade.

While the primary focus of the Philippines' programme has been on eradicating the use of cyanide in the live reef fish trade, the strategies employed have also proven helpful in converting fishermen from other destructive reef fishing practices such as the use of explosives and harvest of sea turtles.

In 1997, IMA and the World Resources Institute (WRI) together published and widely distributed *'Sullied Seas: Strategies for Combating Cyanide Fishing in Southeast Asia and Beyond'*. This report highlighted the threat and spread of cyanide fishing, analysed the Philippines' response, and set out recommendations for action in neighbouring countries.

The response to *Sullied Seas* from government agencies and non-governmental organisations (NGOs) in the region was immediate and very clear: 'We have a large (or rapidly expanding) live reef fish trade and we suspect (or in some cases, are certain) that the operators are using cyanide. We have read your report. Please come and help us!'

The Indo-Pacific Destructive Fishing Reform Initiative (DRFI)

In early 1998, in response to these numerous requests for advice and assistance, IMA and WRI launched the Indo-Pacific Destructive Fishing Reform Initiative (DRFI), a five-year campaign designed to ensure that the last, best reefs of the Indo-Pacific region do not fall prey to the destruction that the cyanide-based live reef fishery has already brought to many areas of the Philippines and Indonesia. The objectives of the DRFI are:

- Consolidate, expand, and further institutionalise the gains in combating cyanide fishing and pro-

4. For detailed analysis of the Philippines' Destructive Fishing Reform Program, see C.V. Barber and V.R. Pratt, 'Sullied Seas: Strategies for Combating Cyanide Fishing in Southeast Asia and Beyond' (WRI and IMA); and C.V. Barber and V.R. Pratt, 'Policy Reform and Community-Based Programs to Combat Cyanide Fishing in the Asia-Pacific Region' in M.E. Hatziolos, A.J. Hooten, and M. Fodor, eds., Coral Reefs: Challenges and Opportunities for Sustainable Management, Washington DC. World Bank, 1998.

moting sustainable coral reef management already made in the Philippines over the last decade under the joint government-IMA Destructive Fishing Reform Program;

- Conduct systematic assessments of the status of live reef fisheries and associated threats to coral reefs—and related policy, legal, economic, and institutional issues—in eastern Indonesia, Papua New Guinea, Sabah (Malaysia), Thailand, the Solomon Islands, the Federated States of Micronesia, the Republic of the Marshall Islands, the Republic of Kiribati, the Andaman and Nicobar Islands (India), and selected countries of the western Indian Ocean.

- Work with the governments of the target countries to develop Action Plans to combat destructive fishing practices and build local capacity for coral reef conservation and sustainable live reef fisheries management;

- Work with buyers of live reef fish in major markets (the United States, Europe, Hong Kong) to establish market standards and practices that discourage destructive reef fishing practices and provide market incentives for sustainable uses of reef fish and other resources;

- Conduct strategically targeted scientific research to fill existing gaps in knowledge about the biology and behaviour of the grouper species that are the prime target of the live reef food fish trade—information needed to provide a sounder scientific basis for policy and fisheries management decisions;

- Systematically document and publish the findings and recommendations from all work carried out under the project in order to evaluate its impact, influence policymakers, and inform the general public.

The work in each country will necessarily vary with the nature of the local LRFT and the cultural, institutional, and policy conditions. In broad outline, however, each local programme will include similar elements, as follows:

Field and Policy-Institutional Assessments in Target Countries.

Teams assembled by IMA and WRI have already undertaken field assessments of the live reef fish trade in four areas of eastern Indonesia[5]; Kiribati[6]; Papua New Guinea[7]; and India's Andaman Islands[8]. Preliminary assessments have also been carried out in Sabah (a key live-fish trans-shipment point for the Philippines and Indonesia) and the Marshall Islands. In the first part of 1999, assessment teams are also being sent to the Solomon Islands, the Federated States of Micronesia (FSM), and countries of the western Indian Ocean, and more extensive follow-up assessments in some of the countries will be carried out, particularly with respect to policy, legal, and institutional issues.

These assessments are undertaken in collaboration with relevant government agencies in each country. Other collaborators have included the World Wide Fund for Nature (WWF) Indonesia Program, The Nature Conservancy (in the Pacific and Indonesia), Conservation International (in Papua New Guinea), and a variety of local NGOs, especially in eastern Indonesia.

Results of the field and policy assessments will form the basis for dialogue with government agencies and other actors, leading to agreement on live reef fish trade national action plans to be carried out under the initiative by key government agencies in collaboration with IMA, WRI, and a variety of NGOs and other technical and policy specialists.

Monitoring, Inspection and Sampling (MIS)

Government fisheries agencies cannot hope to regulate the LRFT without adequate capacities to monitor the trade, inspect facilities and vessels, and systematically sample the catch for cyanide testing and other purposes. The DFRI therefore stresses training for local Fishery agents in the monitoring and inspection of fish shipments, and in the collection of statistical data on exports and volumes of live fish passing through the markets, airports and piers.

5. C.V. Barber & F.P. Cruz, 'Turning the Poison Tide: The International Marinelife Alliance's Cyanide Fishing Reform Program in Indonesia,' SPC Live Reef Fish Information Bulletin No. 4, April 1998 (discusses results of an assessment in North Sulawesi); F. Cruz, Assessment of the Live Reef Fish Trade in the Kei Islands, Maluku Province, Indonesia. Manila: International Marinelife Alliance. September, 1998; Ferdinand Cruz, Assessment of the Live Reef Fish Trade in the Togian Islands, Southeast Sulawesi Province, Indonesia. Manila: International Marinelife Alliance. October, 1998. (The report of an assessment in the Luang island area of southwest Maluku Province, carried out in collaboration with Telapak Indonesia, an Indonesian NGO, is forthcoming.)
6. G. Reyes, Rapid Assessment of the Live Reef Fish Trade in Kiribati. Manila: International Marinelife Alliance. May, 1998.
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Cyanide Detection Testing (CDT)

Cyanide Detection Testing (CDT) is not a panacea, but it is the best technical tool currently available to identify cyanide-tainted fish and provide hard evidence with which to prosecute violators. Countries that are serious about stopping cyanide fishing must be serious about developing their capacities to systematically test live fish intended for export. To that end, the DFRI will provide technical assistance to target countries that want to establish their own CDT laboratories.

Until such time when target countries can establish their own labs—or in countries where it makes more sense to contract out this function, such as some small island nations—samples will be sent for testing at the CDT laboratories in the Philippines, as is already being done with fish from Indonesia and as will be done in early 1999 with fish from the Marshall Islands and Kiribati.

Information, Education and Communication (IEC) campaign

Public awareness and education in the schools are key tools in mobilising public opinion against destructive fishing practices. To that end, the DFRI will assist the target host governments in developing information, education and communication (IEC) campaigns to increase the level of people's awareness on the diversity and wealth of their marine resources and to alert the people to the problems of destructive fishing. Building on IMA's extensive programmes with the Philippine public school system, the DFRI will also work with local Education Departments to develop curriculum-enhancement programmes.

Skills Training Programme (STP)

When fishermen are presented with effective cyanide-free technologies for capturing live food and aquarium fish—and given greater awareness about the legal, health, and ecological risks of cyanide fishing—many choose to convert to cyanide-free techniques. Skills training in barrier-net collection (for aquarium fish) and hook-and-line decompression collection (for live food fish) thus lies at the core of an effective strategy for reducing cyanide fishing.

The DFRI therefore places particular importance on developing such programmes with host governments and NGOs in target countries. In addition, training is often needed in post-harvest handling of fish to reduce mortality. In the Andaman Islands, for example, cyanide use is unknown but mortality rates are extremely high due to poor fish handling techniques.

Community Enterprise Development (CED)

Once a community is using cyanide-free capture techniques and capable of good post-harvest handling, it needs assistance in linking with buyers willing to pay a premium for high-quality live fish caught in environmentally sustainable ways. The DFRI will therefore assist such communities with marketing matters, to ensure that their fishery is profitable as well as environmentally sustainable, and has already done so in North Sulawesi, Indonesia, as well as throughout the Philippines.

Grouper aggregation, aging, and breeding

Scientific knowledge about grouper biology and behaviour is inadequate for effective management. To help remedy this gap, the DFRI will both strengthen IMA's ongoing research on grouper aging and breeding in the Philippines, and help partner government agencies and local universities to build their own capacity in this regard, particularly with respect to better understanding local group aggregation behaviour and identifying aggregation sites.

Policy reform and institutional capacity building

This will involve policymakers and government fisheries management agencies in target countries. Parallel with the programme elements noted above, the DFRI will work with senior policymakers, government fisheries and marine conservation agencies, and other stakeholders to define and implement the policy reforms and institutional strengthening measures necessary to effectively implement all other elements of the programme. The Initiative will also work with governments to act as a catalyst for attracting bilateral and multilateral Official Development Assistance to countries for these purposes.

Moving live fish markets towards sustainability

Incentives for LRFT source countries to move their live reef fisheries toward sustainability will be considerably bolstered if importers and consumers in importing countries require that live reef fish come only from cyanide-free and otherwise environmentally friendly sources. To that end, the DFRI is working with the Marine Aquarium Council (MAC) in the United States—a new consortium of live reef fish importers and NGOs working towards a certification system for aquarium fish imports in the United States (see article by Holthus on MAC in this issue)—and the Chamber of Seafood Importers—a new body with the potential to perform the same function for live food fish imports into Hong Kong—to establish market incentives for both importers and exporters to take steps necessary to ensure a transformation to a sustainable, cyanide-free live reef fish trade.

Indeed, without a great deal of work such as that being carried out under the DFRI, there will be no Indo-Pacific reef fish on the market able to be certified as cyanide-free and otherwise sustainably caught and handled.

Documentation and evaluation

Finally, IMA and WRI believe it is important that experiences from the field, both good and bad, need to be widely shared and evaluated. To that end, the DFRI places strong emphasis on documenting its work and resulting data and lessons learned into high quality, readable publications and other media for wide dissemination to policymakers, fisheries and marine conservation managers, donor agencies, NGOs, and the general public.

Conclusions and a request for feedback and partnership

WRI and IMA are well aware that this ambitious initiative is well beyond the scope of our two organisations working on our own. As a result, the DFRI will only work in countries and communities where there is strong support from local government units, fisheries agencies, local and national NGOs, and the communities where field activities are carried out. And we are already working with, or in the process of developing relationships with, a range of international institutions, including the World Bank, Asian Development Bank, U.S. Agency for International Development, The Nature Conservancy, the World Wide Fund for Nature (WWF), and Conservation International.

While we are convinced that the DFRI's approach is essentially sound, doubtless there are many improvements and refinements that could be made. We therefore urge readers to send us comments and recommendations and, above all, we invite collaboration with any and all organisations that share our commitment to conserving the reefs of the Indo-Pacific into the next millennium.

Contacts

Vaughan R. Pratt, President
International Marinelife Alliance
#17 San Jose Street, Kapitolyo
Pasig City, Metro Manila, Philippines
E-mail: imaphil@mnl.sequel.net
Tel: +632 631 4993
Fax: +632 637 7174
http://www.imamarinelife.org/

Charles V. Barber, Senior Associate
World Resources Institute
14 Cabbage Street, Valle Verde 5
Pasig City, Metro Manila, Philippines
E-mail: cbarber@mnl.sequel.net
Tel: +632 631 0421
Fax: +632 631 0406
http://www.wri.org/wri

Notes on reproduction in the estuarine stonefish *Synanceia horrida*

D.G. Fewings[1] *& L.C. Squire*[1]

The estuarine stonefish, *Synanceia horrida* is a benthic ambush predator with a distribution ranging from India to Australia and north to China (Randall, Allen & Steene, 1990). The species typically inhabits coastal foreshores, in waters that are subject to salinity fluctuations and often carry a high sediment load (Grant, 1987). These conditions provide a muddy substrate, which the estuarine stonefish use to camouflage themselves from predators and potential prey by burying themselves in the silt or sand, with only their mouth slit protruding (Grant, 1987). We observe that these fish can be tracked from one sunken ambush site to another by following impressions left in the mud by the fish hopping across the bottom on its pectoral fins

Stonefish are an important fisheries resource in the live fish trade. After capture, the fish are maintained alive, then transported, usually by air, to Hong Kong where they are considered a delicacy. (Fifteen-inch Stonefish, *Synanceia veruccosa,* averaging about 38 cm in length, were selling live for $US 34.10 per kg live weight in the Hong Kong market in February 1999 (Y. Sadovy, pers. comm.)).

To date, stonefish have been collected from several sources, including the Philippines, Indonesia and Papua New Guinea. Stonefish stocks have been recorded as fished out of prime areas in Papua New Guinea, where previously large numbers were collected for anti-venom production (Brown

1. P.O. Box 5N. Cairns Post Office, Cairns 4870, Australia

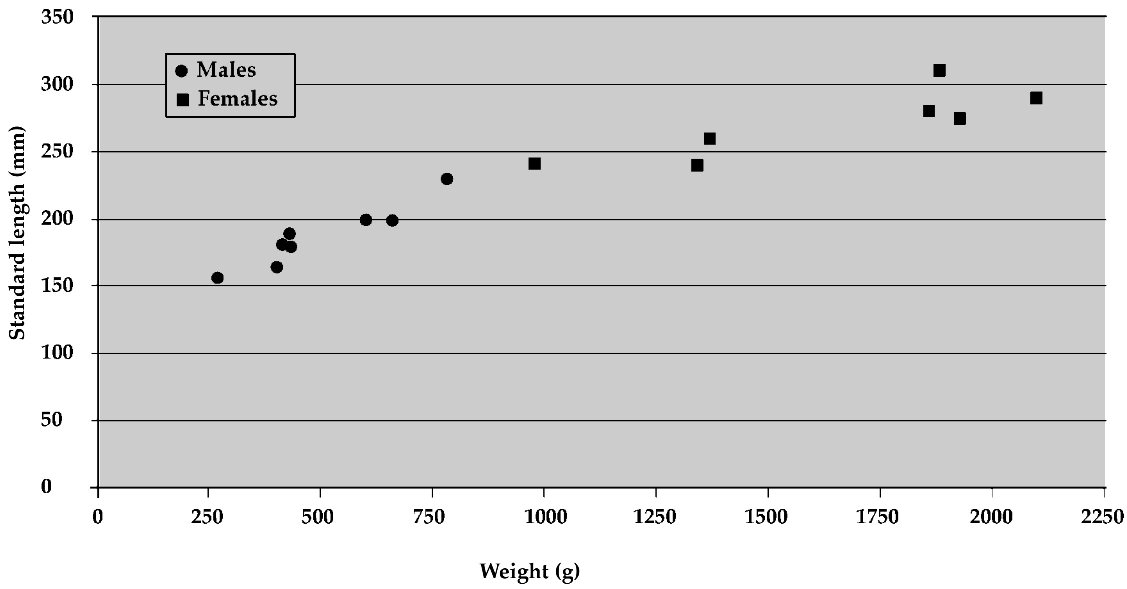

Figure 1: **Size distribution of estuarine stonefish (*Synanceia horrida*) specimens**

& Fielder, 1991). The loss of stonefish in this area was perhaps the first documented depletion resulting from overfishing of any marine fish in Papua New Guinea and emphasises the importance of stonefish to the live fish trade.

The demand for stonefish suggests that an investigation into the potential use of *S. horrida* for future aquaculture ventures may be warranted. It would therefore be valuable to have a detailed knowledge of the stonefish reproductive cycle. This paper reports on the authors' observations of a spawning aggregation of *S. horrida* in Queensland, Australia, and the subsequent egg release by females of specimens in captivity.

The spawning aggregation, observed on 21 October 1997, was located at the end lead markers for the dredged channel leading into a harbour, on the east coast of north Queensland, Australia. The layout of this site consists of three pylons spaced 8 metres apart at the bottom, in the shape of an equilateral triangle. The minimum depth of the site is 8.5 metres. The tidal range for the month varied from mean sea level of 0.88 metres at low tide, to a mean sea level of 2.34 metres at high tide. The surrounding substrate consists of a soft, silty, mud layer on a hard-packed mud bottom. There is an accumulation of rubbish around the pylons in the form of ladders and old batteries from the lead marker lights.

S. horrida specimens were being targeted at the time for public aquarium displays. At this site they are normally found as solitary individuals, either sitting up off the bottom, camouflaged on the marker pylons, or completely buried in the mud, with only their eyes and mouth slit protruding. On the documented occasion, however, between 25 and 30 *S. horrida* specimens were seen concentrated in an area of bottom of about 16 m^2**.** All but one were sitting up on top of the substrate where the fish were much more conspicuous that the few which had been seen at the site previously.

Sixteen stonefish were collected. Sexual dimorphism was apparent, with a distinct size difference between male and female fish (Fig. 1). All small specimens collected were males, with females having standard lengths of up to 80mm greater than the largest male. Females were noticeably broader in proportion to their lengths, had swollen abdomens and a mean weight of about 50 per cent greater than that of the male specimens (Fig. 1).

The *S. horrida* specimens were collected at high tide, at about 2 pm, and placed in a holding facility during the late afternoon. The four largest fish, all females, were placed in a glass fish tank measuring 900 mm x 450 mm x 450 mm. The remaining fish were divided between two identical tanks. One male and one female died during the acclimatisation period. This might have been the result of an inability to cope with capture stress when in such an advanced reproductive state.

Overnight the four female *S. horrida* released their eggs, producing a layer of eggs, 60 mm thick in a gelatinous mass on the bottom of the tank. We do not know if the nature or buoyancy of the eggs would have changed with fertilisation. The unfertilised eggs had a mean diameter of 1.55 mm ± 0.02. The eggs in the dead female fish were hydrated and the dead male was running ripe with free flowing milt being released during its handling.

For aquaculture it is preferable to have closed the reproductive cycle of a species rather than rely on wild-caught specimens for grow out or broodstock (McCormack, 1989). Accomplishing this requires understanding the natural breeding conditions of the animal in question and replicating them as closely as is practical. Our observations may thus be useful to anyone planning a stonefish breeding programme.

S. horrida has several characteristics that suggest that it may be suitable for farming. With a diameter of 1.55 mm, its eggs are relatively large for marine fish. Larvae that hatch from large eggs tend to be well developed, to be strong swimmers and to feed usually within 24 hours. Such larvae are generally easier to feed and grow out than marine fish which have less well-developed larvae at hatching.

The cost of transporting a product to its destined market can be an important factor when deciding the viability of an aquaculture operation. *S. horrida* specimens require only small volumes of water. Ratios of 1:1 water to product weight have been demonstrated as sufficient for at least 24 hours—enough time to pack and airfreight the fish from northern Australia to Hong Kong. This factor greatly reduces the shipment costs of the fish and enhances its viability as a live food commodity. As their common name suggests adult estuarine stonefish also tolerate a large range of salinities (personal observations).

Larvae of *S. horrida* were not observed during this study and no assumption can be made as to whether they are pelagic or demersal. Species from the related family, Scorpaenidae, produce a floating, gelatinous egg mass, while species from other related families exhibit both demersal and pelagic spawning (Thresher, 1984).

In many Asian areas, shrimp farms have failed due to disease outbreaks and poor water quality. Shrimp culture ponds often experience considerable salinity fluctuation and develop sludge layers on the bottom (McCormack, 1989). Fish candidates are being investigated to use in these vacated ponds. However, many species require higher water quality than these ponds provide. The estuarine stonefish typically inhabits areas with similar characteristics, however, and might prove suitable for farming there.

Acknowledgments

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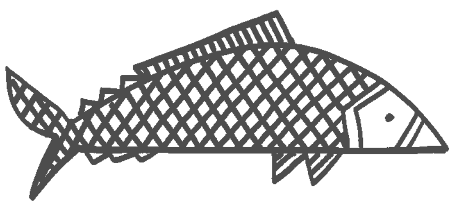


The Marine Aquarium Council, certifying quality and sustainability in the marine aquarium industry

by Paul Holthus

Why was the Marine Aquarium Council established?

Market forces are the most useful means to encourage and support quality 'products' and sustainable practices in the marine ornamentals industry. The demand from informed consumers for such products and practices creates an incentive for industry to adopt and adhere to standards for quality and for the management of the organisms, habitat, and industry practices—and thereby to provide quality-assured, higher-value marine organisms.

The corollary is that marine aquarium organisms of poor quality and/or resulting from unsustainable practices will be less acceptable to the market. In turn, destructive and substandard practices (e.g. use of sodium cyanide, lack of water quality control, high levels of mortality) will decrease as these operators either improve their practices to comply with the standards, or lose the support of the market.

To allow these market forces to work, a certification system is needed to:

- Establish standards for quality products and practices;
- Provide a mechanism to certify compliance with these standards;
- Label the results of certification for quality assurance; and
- Create consumer demand and confidence for certified and labelled organisms, practices and industry participants.

Because the trade in marine ornamentals is worldwide, an international institution which is independent, and which involves all relevant stakeholders, is required to develop and control such a certification system. In particular, it is essential to work with the entire 'Chain of Custody' of the industry—i.e. from collectors to exporters to importers/wholesalers to retailers and the consumer. The Marine Aquarium Council (MAC) has been established for this purpose.

The Marine Aquarium Council offers those with a stake in the future of marine aquarium organisms, habitat and the industry the opportunity to:

- Participate in developing and implementing standards for quality, and a certification and labelling system;
- Exercise greater control and management over the organisms and habitat upon which the industry is based;
- Provide a quality-controlled, value-added product to the consumer;
- Benefit from a programme to create consumer demand for organisms supplied through MAC-certified practices; and
- Be a part of a forum for the industry and its partners to address the opportunities and future of a quality-based, sustainable industry.

Background and mission of the Marine Aquarium Council

The Marine Aquarium Council (MAC) is a non-profit organisation composed of representatives of the aquarium industry, hobbyists, conservation organisations, government agencies, and public aquariums - all with a shared interest in the future of the marine aquarium industry, the marine organisms it is based on, and the habitat that supports them. Participation in the Marine Aquarium Council continues to be open to those ready to collaborate and contribute to a constructive dialogue and the development of a certification system to achieve the goals of MAC.

The foundations for MAC (initially called the Marine Aquarium Fish Council) emerged from the meetings of a cross section of these stakeholders and their common aims of:

• Addressing concerns about the effects of destructive fishing and poor handling practices on coral reef fish and habitat;

• Developing a market for marine aquarium organisms which are supplied through certified sustainable practices based on consumer demand and where organisms which are certified have a higher value;

• Maintaining livelihoods and income-earning ability of rural fishermen by ensuring the marine aquarium fishery, and hence industry, is sustainable; and

• Increasing marine conservation awareness and action within the industry and among marine aquarium hobbyists and the general public.

The goal of MAC is to ensure a sustainable future for the marine aquarium industry, organisms and habitat through market incentives that encourage and support high quality and sustainable practices.

MAC will accomplish this by establishing standards for 'best practices', developing an independent system to certify compliance with these standards, and creating consumer demand and confidence for MAC certified organisms, practices and industry participants.

From the broad coalition—or network—that constitutes MAC, an Interim Board was created to provide for more consistent, focused action toward realising the MAC goals. The Interim Board is currently composed of representatives of: American Marinelife Dealers Association, American Zoo and Aquarium Association, International Marinelife Alliance–Philippines, Ornamental Aquatic Trade Association, Pet Industry Joint Advisory Council, Philippine Tropical Fish Exporters Association, Quality Marine Inc., The Nature Conservancy, and World Wildlife Fund. The Interim Board formed a series of technical committees to begin work on issues such as standards, monitoring, and education; hired an Executive Director as of June 1 1998; and has incorporated MAC as a non-profit organisation.

The importance of what MAC is working to achieve, its innovative basis in market mechanisms, and the broad base of participation has led to the active interest and initial support of several funding organisations for the initial development of the certification system in pilot areas. In Hawaii, an initial prototype set of collecting and handling guidelines has been developed through a series of multi-stakeholder workshops. Similar efforts are underway in the Philippines and soon will begin in a South Pacific pilot area. MAC will continue a phased process of multi-stakeholder consultations to finalise the initial standards, test them in collection-to-retailer operations in pilot areas, and launch the certification/labelling system in 1999.

It is envisaged that the MAC organisation and process, when fully established and mature, will evolve into a largely self-financed system based on the improved economic return from certified marine aquarium organisms. In the meantime, external funds continue to be sought for the initial stages of establishing MAC—e.g. to support the development and testing of the certification system, to train fishermen in sustainable collecting and handling methods, and to conduct awareness raising among the consumers and industry.

How to 'join' the Marine Aquarium Council

MAC is a global network of those interested in ensuring a sustainable future for the marine aquarium industry—and the organisms and habitat it is based on—through a certification system that encourages and supports quality products and sustainable practices.

Organisations, companies, associations, government agencies, other groups, and individuals who are ready to collaborate and contribute constructively to achieving the goals of MAC are invited to join the MAC Network by completing and submitting the form on the MAC Website.

http://www.aquariumcouncil.org

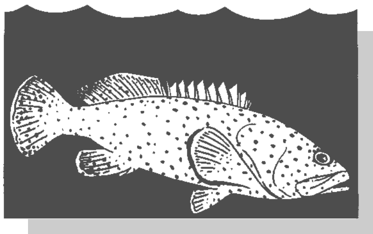
General MAC information bulletins and updates will be posted at the MAC Update Bulletin location of the Website. More specific 'mailings' will be made to Network Working Groups through fax and e-mail List Serves. The List Serves will initially be used to develop and consolidate geographic MAC Working Groups, especially in source areas (e.g. Philippines, Hawaii). As MAC efforts progress, calls for participation in cross-cutting Technical Working Groups on specific topics (e.g. water quality standards) will be made and List Serves developed for these groups.

Where to contact the Marine Aquarium Council

MAC welcomes your comments, input and, especially, your involvement. For more information (and if you do not have access to the MAC Website) contact:

Paul Holthus
Executive Director, Marine Aquarium Council
3035 Hibiscus Dr.
Honolulu, Hawaii
USA 96815

Phone: (+1 808) 923 3254
Fax: (+1 808) 923 6023
E-mail: info@aquariumcouncil.org
MAC Website: http://www.aquariumcouncil.org



aquaculture
live reef fish

Regional cooperation in grouper aquaculture research moves forward - A new research network formed

by M.A. Rimmer, K.C. Williams, M.J. Phillips & H. Kongkeo

Introduction

The groupers (Family Serranidae) are an economically important group of marine fishes widely distributed in tropical and subtropical areas throughout the world. There is increasing interest in grouper aquaculture throughout the world, but particularly in the Asia-Pacific region, because of the high demand for groupers in local and export markets, and the high value that groupers bring in these markets. Currently, much of the supply is provided by capture fisheries, but in some areas this has been associated with environmentally damaging techniques, particularly the use of cyanide to capture fishes for the high-value live markets in Hong Kong and China. There is considerable potential for aquaculture production of groupers to replace wild-caught product, and to assist in alleviating environmental damage and overfishing.

The development of sustainable commercial grouper aquaculture has been constrained by a range of factors, but principally by the limited availability of seed (fry or fingerlings). Throughout most of the Asia-Pacific region, grouper culture is highly dependent on the capture of juvenile fish from the wild to supply seed stock for aquaculture. At the Regional Workshop on Sustainable Aquaculture of Grouper and Coral Reef Fishes organised by the Department of Fisheries, Sabah, Malaysia and the Network of Aquaculture Centres in Asia-Pacific (NACA) and held in Sabah, Malaysia, in December 1996, the Working Group on Technical Aquaculture Issues examined the status of aquaculture technology for a range of high-value reef fish species. There was widespread recognition from workshop participants that further research is necessary to develop reliable culture techniques for grouper. Moreover, it was clear that research progress was constrained by the lack of effective communication of research results among the various research groups involved in grouper aquaculture.

Specific recommendations from the Working Group in Sabah were:

1. Similar workshops should be held in the future to allow follow-up and examination of research progress achieved.

2. Research coordination at national and international levels should be strengthened to fill gaps in knowledge in need-based areas.

3. The system of exchange and dissemination of information should be improved. It was generally agreed that NACA was in a position to undertake this role.

The last of these recommendations has been addressed by the development of a World Wide Web site by NACA and AIT, which is dedicated to grouper aquaculture:

http://www.agri-aqua.ait. ac.th/grouper/

In response to the other two recommendations, the Australian Centre for International Agricultural Research (ACIAR) has agreed to fund a research project to develop improved grouper aquaculture techniques in conjunction with the Queensland Department of Primary Industries (QDPI), the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and NACA. A central component of this project will be the facilitation of improved collaboration and coordination of grouper aquaculture research within the Asia-Pacific region. The initial activity associated with this project was the Grouper Aquaculture Workshop held in Bangkok on 7–8 April 1998, which was attended by researchers from Australia, Hong Kong, Indonesia, Israel, Malaysia, the Philippines, and Thailand.

The objectives of the Bangkok workshop were to:

1. Identify constraints to the successful development of grouper production technology.

2. Identify research in progress in the region and how improved collaboration and information exchange can enhance the progress of this research.

3. Establish a mechanism to foster cooperative research and to facilitate information exchange among grouper aquaculture researchers in the Asia-Pacific region.

These objectives were achieved over the two days of the workshop, and further details will be provided in the workshop proceedings to be published later this year. This is an important achievement, and it is entirely due to the enthusiastic cooperation of all the workshop participants.

The workshop showed that there is a large research effort being undertaken in the Asia-Pacific region on the development of aquaculture technology for groupers, and that progress will likely be obtained more rapidly if duplication of research is reduced and a wider collaborative approach to research is undertaken.

Expansion of grouper aquaculture in the Asia-Pacific region would provide increased employment opportunities for local people in the aquaculture industry, as production of groupers increases to meet the growing demand for live and fresh-chilled product in the region. In addition, increased employment opportunities could be created in associated industry sectors, such as feed and equipment manufacturing and distribution. Provision of greater quantities of aquacultured grouper product would also help reduce the exploitation of wild grouper stocks.

The targeting of spawning aggregations by commercial fishers contributes strongly to the unsustainable nature of much of the wild fishery for groupers in the Asia-Pacific region. Similarly, the use of cyanide and dynamite for capturing coral reef fish species, particularly the highly valued groupers, has caused widespread damage to coral reefs in the region as emphasised at several recent meetings, including the recent APEC workshop in Hong Kong on the Impacts of Destructive Fishing Practices on the Marine Environment.

Workshop recommendations

During the final session of the grouper research workshop, there was considerable discussion on how to progress grouper aquaculture research and development in the region, and how to facilitate the continued development of an Asia-Pacific Grouper Network. The following recommendations were agreed upon by workshop participants:

1. There is a need for further research to address the constraints to grouper aquaculture technology. Research is needed to address specific topics, under the following general headings:

   - broodstock management and nutrition,
   - improved larviculture technology,
   - definition of nutritional requirements for grow-out diets,
   - development of low-pollution grow-out diets,
   - disease and health issues.

The outcomes of this research should where possible be incorporated into 'best practice' guidelines for grouper aquaculture and efforts should be given to incorporating such guidelines into practical aquaculture extension activities.

Grouper diseases already cause substantial economic losses during grow-out. The regional capacity for marine fish disease control should be improved, and development of a regional diagnostic centre, particularly for viral diseases, is considered a high priority.

2. There is a need to establish a coordinated grouper research programme in the Asia-Pacific region. This could be facilitated by:

   - establishment of a research programme comprising institutional or collaborative projects to address the key issues identified in this workshop - facilitated by NACA in cooperation with other organisations and institutes such as APEC, AIT, and SEAFDEC,
   - agreements by institutions to participate in a regional coordinated research programme on grouper aquaculture technology development, and
   - additional training opportunities, for example through staff exchanges and short-term attachments at participating institutions.

3. There is a need for improved exchange and dissemination of grouper research findings. This could be facilitated by:

   - institutional support for researchers to attend grouper aquaculture sessions at

regional conferences and workshops,
- focussed technical workshops on aspects of grouper aquaculture such as breeding and larviculture, grow-out diet development, and fish health issues,
- reporting of research findings in regional aquaculture magazines (*Asian Aquaculture* and *Aquaculture Asia*) and journals, and on the NACA grouper web site.

4. Implementation

- NACA in cooperation with other institutes will prepare a cooperative grouper aquaculture research and development programme based on the above recommendations and specific research needs detailed in this workshop,
- the research programme will be circulated to respective institutes seeking institutional support and commitment,
- seeking of funding support for specific projects under the grouper aquaculture research and development programme.

Where to now?

To be successful, this Asia-Pacific Grouper Network will rely heavily on the active cooperation of all participants. While NACA will continue to coordinate activities within the network, the active participation of researchers and research institutes will be vital to the research network achieving its objectives. Already this collaborative approach has generated a lot of interest, and further research cooperation is being planned, with ACIAR and APEC.

Anyone involved in, or interested in, grouper aquaculture is invited to contact the people below and participate in its activities—or alternatively log on to:

http://www.agri-aqua.ait.ac.th/grouper/

Further information

For further information on the Asia-Pacific Grouper Network, contact:

Dr Mike Rimmer
Queensland Department of Primary Industries
Northern Fisheries Centre, PO Box 5396, Cairns
Queensland 4870, Australia

Phone: +61 (07) 4035 0109
Fax: +61 (07) 4035 1401
E-mail: rimmerm@dpi.qld.gov.au

Dr Kevin Williams
CSIRO Division of Marine Research, PO Box 120
Cleveland, Queensland 4163, Australia

Phone: +61 (07) 3826 7284
Fax: +61 (07) 3826 7222
E-mail: kevin.williams@marine.csiro.au

Hassanai Kongkeo and Dr Michael Phillips
Network of Aquaculture Centres in Asia-Pacific
Kasetsart University Campus, PO Box 1040,
Kasetsart Post Office , Bangkok 10903, Thailand

Phone: +66 2 561 1728; 561 3022
Fax: +66 2 561 1727
E-mail: naca@mozart.inet.co.th

Grouper aquaculture news and abstracts

As one of the initiatives of the Asia-Pacific Grouper Network (see article above), current news and research outcomes on the development of aquaculture technology for groupers and other high-value reef fish species will be published in a number of regional magazines and bulletins, including the *SPC Live Reef Fish Bulletin*. Any contributions to this section would be greatly appreciated. Contact Mike Rimmer (see contact in previous article) for further details.

Research outcomes

The following abstracts on various aspects of grouper culture are from papers and posters presented at the Fifth Asian Fisheries Forum—International Conference on Fisheries and Food Security Beyond the Year 2000—held in Chiang Mai, Thailand, from 11–14 November 1998.

The status and potential of grouper culture in Asia

Cristina Rowena S. Dato-Cajegas, Nguyen Van Trai & John B. Hambrey

Agricultural and Aquatic Systems Program, School of Environment, Resources and Development, Asian Institute of Technology, PO Box 4, Klong Luang, Pathumthani, 12120, Thailand.

This article reviews the current status of grouper culture in Asia, and discusses the state of the art in terms of species grown, seed supply, breeding and spawning, larval rearing, nursing, grow-out and marketing. Results of a case study on Khanh Hoa, a central province in Vietnam, are discussed to highlight some of the issues. Cross-cutting technical issues such as those concerning disease and nutrition are also addressed. Current technical problems and the various technical and economic constraints to the further development of the industry are identified, and future prospects discussed.

The most commonly cultured species include *Cromileptes altivelis, Epinephelus akaara, E. amblycephalus, E. areolatus, E. awoara, E. bleekeri, E. coioides, E. fuscoguttatus, E. lanceolatus* and *E. malabaricus. E. tauvina* may also have been cultured, but there has been some misidentification and confusion of this species with *E. malabaricus* and others. Most commercial production is based on the use of wild seed. Commercial hatchery production is restricted to Taiwan, although there are several experimental hatcheries operating in the region.

Breeding and spawning, both natural and hormonally induced, are relatively straightforward and have been achieved for many species. The large size of the male is sometimes problematic, but may be overcome through hormonally induced sex reversal. Early rearing of larvae is difficult, and survival rates from commercial and experimental hatcheries rarely exceed 15 per cent.

The problem of rearing is related mainly to the timing, size, and nutritional quality of feed in the early larval stages, to sensitivity to disturbance, and physical damage, in the later larval stages, and to cannibalism at metamorphosis and during nursing. Although hatchery survival rates between 5 and 15 per cent may be financially acceptable given the very high value of the seed produced, risks remain high, and this fact, coupled with the technical difficulties, has hindered further development of a hatchery sector in most parts of the region.

The relative success in Taiwan Province is probably related to the levels of skill, and the structure of the industry where small operators are engaged in specialised work in different aspects of the hatchery process, allowing for rapid turnover of investment, minimal working capital and lower risk. It is concluded that the current constraints are as much institutional and developmental as technical, and this must be recognised if the industry is to develop.

Variation of plasma sex steroid levels in the Giant Grouper, *Epinephelus lanceolatus*

Renu Yashiro, Vichai Vattanakul[1], Jeanjit Kongkumnerd[1], Prakong Tangpraprutkul[2] & Soranuth Sirisuay[1]

1. National Institute of Coastal Aquaculture, Kao-sean Soi 1, Songkhla, Thailand 90000
2. Faculty of Sciences, Chulalongkorn University, Payathai Road, Bangkok 10330

Study on the variation of sex steroids in the Giant Grouper, *Epinephelus lanceolatus* by RIA method: Average and individual plasma levels of sex steroids were recorded for 18 months in fish with an average weight of 14.4–24.4kg. Results showed that the monthly average level of estradiol-17 (E2) and testosterone (T) were significantly different ($P<0.05$). E2 level peaked during January to March 1996 (464.3–514.3 pmol/l). The lowest level (143.8 pmol/l) was recorded in November 1996. However, although T level peaked during January to February 1997 (1375–945 pmol/l) these levels were not significantly different ($P>0.05$) from the levels of August and September 1996.

The lowest level of T recorded during this study was also in November 1996 (195 pmol/l). A growth of 535 g/month (17.8 g/day) in body weight was recorded. Results from individual checking of these hormone levels revealed that the natural spawning season of these fish may have 2 peaks, from August to October 1996 and from January to March 1997. Histological study from gonad samples in February and August 1996 showed various stages of oocytes including the vitellogenic stage.

11-Ketotestosteron affects sex reversal in Honeycomb Grouper, *Epinephelus merra*

Young Don Lee[1], Sum Rho[1], Akihiro Takemura[2] & Kazunori Takano[2]

1. Marine Research Institute, Cheju National University, 3288 Hamduk-ri, Chochon-eup, cheju-do 695-810, Korea
2. Sesoko Station, Tropical Biosphere Research Center, University of the Ryukyus, 3422 Sesoko, Motobu, Okinawa 905-0227, Japan

Fishes belonging to the genus *Epinephelus* are protogynous hermaphrodites. Several hormones, including steroids are thought to participate in their sex reversal. In the present study, we examined the effect of a single injection of 11-ketotestosteron (11-KT) on histological changes in the gonad of *Epinephelus merra*.

Samples of *E. merra* species were collected from around Sesoko Island, Okinawa, Japan, using hook and line in November 1997. The experiment was carried out from December to January, when some gonads naturally undergo sex reversal from female to male. The fish were anaesthetised with MS-222, and one half of the gonad was surgically taken from the abdominal cavity. 11-KT was dissolved in peanut oil and injected intramuscularly at a concentration of 1 or 10 µg/g of body weight. The fish were reared in one-metric ton tanks with running seawater for 15 or 30 days after hormonal treatment and the rest of the gonad was sampled at the end of experiment. The gonads were fixed in Bouin's solution, embedded in paraffin, sectioned at 6 µm, and then stained with Mayer's haematoxylin-eosin.

Out of 12 individuals examined, 7 had bisexual gonads. Initially, the previtellogenic ooctyes at the early and the late peri-nucleolus stages, were observed in the ovarian lamellae of these gonads. A small number of gonia cells and spermatocytes were also confirmed in the lamellae epithelium. There were no histological changes in the gonads of control fish (#7 and 8) before and after the experiment. However, 11-KT at both doses increased the number and the area occupied by spermatocytes and spermatid in the gonads (#9, 10, 11 and 12). Few changes occurred histologically in the gonad of functional males, but the number of spermatocytes and sperm tended to decrease after 11-KT injection. The present results reveal that 11-KT increases male characteristics such as spermatocytes and spermatid in the gonad of female fish. We conclude that 11-KT may be playing a role, at least partially, in the sex reversal of this species.

Natural spawning and larval rearing of barramundi cod *Cromileptes altivelis* in tank

Ketut Sugama, Tridjoko, Wardoyo, Jhon H. Hutapea, H. Matsuda and S. Kumagai

Gondol Research Station for Coastal Fisheries, PO Box 140, Singaraja, 81101 Bali, Indonesia

The first natural spawning of barramundi cod, *Cromileptes altivelis* in captivity was recorded in May 1996 at the Gondol Research Station for Coastal Fisheries, Bali. Wild broodstock of *C. altivelis* were captured in Kangean Island in January 1996 by means of fish traps. Twenty-four females (BW(body weight): 0.9–2.4 kg) and 3 males (BW: 3.0–3.2 kg) were stocked in a 100-ton circular concrete tank with flow-through, with a 300% turnover of natural seawater per day. The tank was aerated and maintained with a natural photoperiod. Water temperature and salinity were relatively constant at 26.8–27.4°C and 34.8–35.2 ppt respectively. Fish were fed ad-libitum with trash fish composed of sardine and squid. Floating eggs from natural spawnings were collected by means of an overflow outlet in the broodstock tank. Natural spawning took place monthly from the 4th day before new moon and continued for five to eight consecutive days.

The fish usually spawned in the early morning; the number of eggs released in each spawning period were estimated at 0.2–4.2 million. It seems that fish spawn throughout the year with a peak in September to January. The fertilisation rate and hatching rate of floating eggs were 80–90% and 20.6–85.9% respectively. At ambient temperature, the incubation period was about 15 to 17 hours. Larval rearing trials were concurrently conducted and a few thousand juveniles were produced. Green water and SS or screened S-type rotifers were used to feed the larvae from Day 2 to Day 15 after hatching. Artificial feed and enriched artemia were used from Day 15 until Day 35 and then the larvae were trained on dry pellet only from Day 36. Trials using 10-ton larval-rearing tanks with initial stocking density of 10 ind./l, with larvae harvested on Day 51, resulted in a survival rate of 1.8% with the body length of juveniles ranging from 22.7–35.4 mm (average 27.9 ± 5.5 mm).

About 40% of the larvae died before Day 6 after the start of the first feeding on Day 3. The second-highest mortality was observed daily from Day 11 to Day 26, perhaps due to nutritional requirements. At this stage the survival rate was estimated at 20%. However, a gradual loss due to cannibalism was recorded daily, during and after metamorphosis, from Day 31 to Day 51.

Feeding ecology of selected marine fish larvae

Riza S. Ordonio-Aguilar[1] and Atsushi Ohno[2]

1. College of Fisheries, Univ. of the Philippines in the Visayas, Miagao, Iloilo, Philippines 5023
2. Tokyo University of Fisheries, Konan, Minato-ku, Tokyo, Japan 108

The feeding ecology of the larvae of *Chanos chanos, Lates calcarifer, Siganus guttatus, Epinephelus coioides* and *Lutjanus argentimaculatus* was observed during the transition period from endogenous to exogenous feeding. The larvae were reared in the hatchery facilities of SEAFDEC-AQD at Iloilo, Philippines, and fed with *Nannochloropsis* spp. and *Brachionus plicatilis* given prior to expected time of initial mouth opening.

Observations on gut content, gut fullness, number and lorica length of rotifer and feeding incidence were made on 2387 larvae. The feeding preferences of all the larvae were assessed using Ivlev's Electivity index, while the daily food ration was estimated for all five species on the third day of mouth opening.

Results show that feeding success in first-feeding larvae is dependent on several factors including mouth size at opening (*Chanos chanos*), functional development of structures related to feeding (*Lates calcarifer*) and larval size. In the case of *Siganus guttatus,* feeding success is attributed to its persistent feeding behaviour observed throughout the daylight hours as opposed to the peaks and lows observed in the other species.

Results of the study show that rotifer quantity, and not size, is the main consideration in the feeding of *Chanos chanos* and *Lates calcarifer* due to their voracious feeding habits. In the case of *Siganus guttatus* and *Lutjanus argentimaculatus,* the larvae may survive well on rotifer alone provided small-sized rotifer are given. As for *Epinephelus coioides,* there is a need to look for alternative food organisms such as *Acartia* or for a semi-intensive feeding scheme to be adopted.

Osmotic regulation and Na^+, K^+–ATPase activity in grouper *Epinephelus coioides* larvae and juveniles

Nora B. Caberoy & Gerald F. Quinitio

Aquaculture Department, Southeast Asian Fisheries Development Center, 5021 Tigbauan, Iloilo, Philippines

The osmotic response and changes in Na^+, K^+–ATPase activity in grouper juveniles abruptly transferred from an ambient rearing condition (32 ppt, 26.5–30°C) to different salinity (8, 18, 32, 40 ppt) and temperature (25, 30°C) combinations were determined. In addition, changes in Na^+, K^+–ATPase activity in grouper larvae were determined under the same test conditions. Grouper juveniles (Day 60: 2.33 ± 0.89 g, 31.89 ± 1.50 mm) quickly adapted to the experimental conditions by maintaining or decreasing their plasma osmotic concentrations. Regardless of temperature, juveniles transferred to the test salinities reached equilibrium state from 6 to 24 h after exposure. The plasma osmotic concentrations at equilibrium state ranged from 426.25 to 456.78 mOsm. Changes in Na^+, K^+–ATPase activity in whole body samples of Day 20 larvae (0.090 ± 0.004 g, 7.32 ± 0.27 mm) did not vary ($P>0.05$) at salinities 8–32 ppt (1.09–4.16 µmol Pi.mg $protein^{-1}$ hr^{-1}). However, enzyme activity significantly ($P<0.01$) decreased from 6 (2.0 µmol Pi.mg $protein^{-1}$ hr^{-1}) to 12 h (0.02 µmol Pi.mg $protein^{-1}$ hr^{-1}) after exposure to 40 ppt. Survival at this stage was markedly reduced to 3%. Na^+, K^+–ATPase activity in gills of Day 40 juveniles (0.20 ± 0.01 g, 21.35 ± 0.43 mm) were also similar (17.03–49.21 µmol Pi.mg $protein^{-1}$ hr^{-1}), except for fish exposed to 40 ppt at 30°C, wherein a significant increase ($P<0.05$) in enzyme activity was observed 12 h after transfer (from 19.91 to 66 µmol Pi.mg $protein^{-1}$ hr^{-1}). Na^+, K^+–ATPase activity (22.36–54.27 µmol Pi.mg $protein^{-1}$ hr^{-1}) in gills of Day 60 juveniles did not change significantly ($P>0.05$) during the 48 h exposure to the treatments.

The results of this study show that grouper larvae and juveniles are efficient osmoregulators over a wide range of salinities, although adaptive capabilities of the fish vary with stage (Day 20 larvae were less tolerant to high salinities than Days 40 and 60). Moreover, physiological response and survival of larvae

(Day 20) and early juveniles (Day 40) may be affected by the interaction effect of temperature (30°C) at high salinity (40 ppt). This development of tolerance limits may reflect their ontogenetic response to actual conditions existing in the natural environment.

Essential fatty acid requirement of juvenile grouper *Epinephelus coioides*

O.M. Millamena & Nelson Golez

Aquaculture Department, Southeast Asian Fisheries Development Center, Tigbauan, Iloilo 5021, Philippines

Feeding trials were conducted to determine the essential fatty acid requirement of grouper *Epinephelus coioides* juveniles. Experimental diets were formulated to contain 42.5% protein and 10% lipid. The semi-purified diets contained fish meal, casein and gelatin as protein sources, and beef tallow as lipid source supplemented with pure n-3 highly unsaturated fatty acid (HUFA) esters. The basal diet without HUFA supplementation contained 0.25% n-3 HUFA. Graded levels of n-3 HUFA were added to the basal diet at 0, 0.5, 1.0, 1.5, and 2.0% of the diet. *E. coioides* juveniles, initial body weight (BW) = 1–2 g, were reared in 250-l fiberglass tanks at a density of 25 fish per tank in a completely randomised design with three replicates per treatment.

Tanks were supplied with sand-filtered seawater in a flow-through system with adequate aeration. They were fed the experimental diets for 60 days at a feeding rate of 25–30% of BW per day. Data on percent weight gain, specific growth rate, survival, and feed conversion efficiency of grouper were subjected to one-way analysis of variance.

Results showed that fish fed with diets supplemented with n-3 HUFA had significantly higher ($P>0.05$) weight gains than the unsupplemented diet (control). Growth improved with HUFA supplementation and the best growth response was attained at 1.0% n-3 HUFA. Beyond this level, growth tended to decrease until the highest HUFA level. Survival rates did not differ significantly among treatments. This information is useful in developing a practical diet for grouper juveniles.

Common ectoparasites of groupers in Indonesia

Isti Koesharyani[1], Kei Yuasa[2], Zafran[1] and Kishio Hatai[3]

1. Gondol Research Station for Coastal Fisheries, P.O. Box 140, Singaraja (81101) Bali, Indonesia
2. Japan International Cooperation Agency
3. Division of Fish Disease, Nippon Veterinary and Animal Science University

The seed production of groupers has been developed in Gondol Research Station for Coastal Fisheries. One of the serious obstacles in the seed production of groupers is a frequent outbreak of parasitic diseases in broodstock. In the present study, parasitological examination was conducted throughout the year on the broodstock of six species of groupers being reared in the Center, namely *Epinephelus bontoides, E. malabaricus, E. coioides, E. fuscoguttatus, Cromileptes altivelis* and *Plectropomus leopardus.*

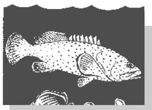
Parasites were collected from skin and gills of the fish. Low-salinity sensitive parasites were collected by dipping the fish into freshwater or water of 5 ppt in salinity. Skin flukes were fixed in alcohol-formalin-acetic acid (AFA) and stained with alum-carmine. Gill flukes were fixed and stained with ammonium picric glycerol. The other parasites were observed without staining. All of the specimens were morphologically observed using microscope under low magnification.

A parasitic protozoan, *Cryptocaryon irritans,* was detected from gills and body mucus in *E. bontoides, E. malabaricus* and *Cromileptes altivelis*, while another protozoan, *Trichodina* sp. was detected only from gills of *E. bontoides. C. irritans* caused mortality as high as 90%, when it infected the gills. Among three kinds of gill flukes, *Haliotrema* was frequently observed in *C. altivelis* only.

A heavy infestation of gill flukes showed pathogenicity to the fish. Skin flukes were the most common parasites observed in groupers. However, they did not cause mortality. *Lepeoptheirus* sp., a parasitic copepod, was observed in groupers with poor appetites. This parasite sometimes caused mortalities in *E. coioides, E malabaricus, E. fuscoguttatus* and *P. leopardus* when no treatment was conducted.

Table 1. **Ectoparasites observed in groupers, and their host species, pathogenicity and frequency.**

Parasites	Sampling site(s)	Host species	Pathogenicity	Frequency
Protozoa				
Cryptocaryon irritans	gills / skin	*E. bontoides*	+++	++
		E. malabaricus	++	+
		C. altivelis	+++	++
Trichodina sp.	gills	*E. bontoides*	++	+
Gill fluke				
Haliotrema sp.	gills	*C. altivelis*	++	+++
Pseudorhabdosynochus sp.	gills	*C. altivelis*	++	++
		E. malabaricus	++	++
		E. coioides	++	++
		E. bontoides	++	++
Diplectanum sp.	gills	*E. malabaricus*	++	++
		P. leopardus	++	++
Skin fluke				
Benedenia sp. or *Neobenedenia* sp.	skin	All fishes	+	+++
Copepod				
Lepeoptheirus sp.	skin	*E. coioides*	++	++
		E. malabaricus	++	++
		E. fuscoguttatus	++	++
		P. leopardus	++	++



Grouper aquaculture in Hong Kong

Source: *Aquaculture Asia* 3(3): 39

Market demand

- Hong Kong consumed 28 000 tonnes of live fish in 1997.
- About 35 per cent by weight and 50 per cent by value of live fish consumed are groupers.
- Market price of grouper varied greatly with species:
  - Red grouper (*Epinephelus akaara*) highest at US$ 42/kg;
  - Spotted grouper – coral trout (*Plectropomus* spp.) at US$ 42/kg; and
  - The rest at around US$ 20/kg.

Production

Fry supply

- No hatchery in Hong Kong. Fry for culture are either captured locally from the wild, (for most seabream species) or imported (for groupers, snappers, etc.).
- Recently imported fry mostly come from hatcheries in Taiwan:
  - Green grouper (*Epinephelus tauvina/malabaricus*);
  - Brown spotted grouper (*Epinephelus areolatus*);
  - Giant grouper (*Epinephelus lanceolatus*);

- Red snapper (*Lutjanus erythropterus*); and
- Mangrove snapper (*Lutjanus argentimaculatus*).

• New cultured species from hatchery-produced fry, include:
- Cobia (*Rachycentron canadum*); and
- Spotted sweetlip (*Plectorhynchus picus*).

• Quality of fry imported varied greatly. For groupers, survival was very low at 10–20 per cent.

• Imported fry is also a source of disease introduction to the existing stock.

Grow-out culture

• In floating cages in designated culture zones; average farm size with raft area of about 250 m^2.

• Culture period varied on species and market size:
- 18–24 months for *E. tauvinus/malabaricus;*
- 36–48 months for *E. lanceolatus.*

• Traditionally fed with trash fish supplied from purse-seiners or trawlers, which become scarce in winter months. These are gradually being replaced by moist pellet feed developed by the Government.

• Major problem: environmental deterioration of culture sites due to lack of tidal flush resulting in fish deaths during slack tides, poor growth and disease outbreaks. Also algal blooms.

Research

• Trash fish feeding was identified as one of the major sources of self-pollution causing environmental deterioration of culture sites.

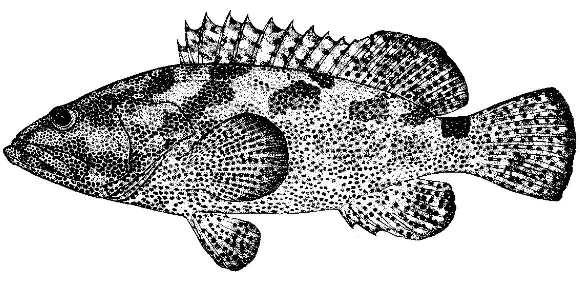
• In 1992–93 a moist pellet feed was developed which was generally suitable for common species cultured in Hong Kong including groupers. The pellet feed consists of trash fish, fishmeal, vitamins, fish oil and alpha starch.

A new grouper web site

A new 'grouper' e-mail discussion group has been announced. The objective of the group is to promote discussion on key issues related to grouper aquaculture—breeding, larviculture, nursing, grow-out, environment, diseases issues, post-harvest and marketing. The discussion group is being established as part of a wider Asia-Pacific regional effort to promote cooperation to overcome some of the key constraints currently holding back the development of grouper culture. More details on this effort can be found at the grouper web site:

http://naca.fisheries.go.th/grouper

Whilst the initial focus of this discussion group may be on grouper culture, it may evolve to become more widely used for discussions on all relevant aspects of marine fish culture in the region—groupers being only one group of species among a wide range of potential marine fish species of relevance to aquaculture development in the Asia-Pacific region.



Breeding seahorses – facts and fallacies

by Craig Lawrence

Source: *Western Fisheries*, Autumn 1998, 39–40

Seahorses, those wonderful little sea creatures that seem to have sprung out of the pages of a fairy tale, are in trouble. As reported in the Winter 1997 issue of Western Fisheries, *the international conservation group TRAFFIC has released a report saying seahorses are under threat worldwide due to a booming demand for them in the international medicine, curio and aquarium trades.*

This is of particular significance to Australia as about one third of the world's seahorse species live in Australian waters, although the largest known exporters are India, the Philippines, Thailand and Vietnam.

In addition to implementing tighter controls on the harvesting of seahorses from the wild, what other measures can be taken to help the plight of these animals? Some scientists believe the answer may lie in establishing an aquaculture industry for seahorses.

Although TRAFFIC acknowledges the development of seahorse aquaculture as a management option, it claims their biology makes them unsuitable for intensive harvesting and they are also regarded widely as the most difficult of fish to rear.

TRAFFIC's view regarding the difficulty of breeding seahorses is not shared by WA Marine Research Laboratory aquaculture scientist Craig Lawrence, who has been successfully rearing seahorses since 1989. While he agrees the rearing process is far from easy, he reckons it can be done by those who are skilled in breeding marine aquarium fish, and have the right equipment and food.

In the following article Craig Lawrence shares with readers some of the knowledge he has gained on rearing seahorses over many years.

There are approximately thirty known species of seahorses, nearly all of which are included in the genus *Hippocampus*. During 1989, I carried out an investigation of the reproduction and spawning of the Western Australian seahorses (*Hippocampus angustus*) in captivity. What follows is a summary of my research and the methods used to successfully raise a number of these fish.

Keeping adults

During the course of the study, I found that adult seahorses would not only accept live food. For convenience, the seahorses were fed live 'enriched' adult artemia.

Artemia are tiny crustaceans that live in hypersaline bodies of water and can be bought in cyst form from the USA. Artemia can be treated like a vitamin pill, by feeding them on freeze-dried algae, such as spirulina, or hufa enriched diets, before passing them on as a bio-encapsulated food to seahorses.

Contrary to previous reports, our adult seahorses would not accept adult artemia unless they were 2.5 mm or greater in length. They also showed no interest in small fish or in cannibalising juvenile seahorses.

Mating

One of the most amazing things about seahorses is that the males give birth, instead of the female — what is termed 'paternal brooding'. Instead of the female's eggs being fertilised inside her, these are deposited into a special abdominal pouch in the male and fertilised.

Although this fact has been widely reported, first hand information on the breeding of seahorses in captivity is limited. What I discovered was that a number of aspects of reproduction in the Western Australian seahorse differ significantly from those reported in other species of seahorses.

Before courtship, the male seahorse prepares his pouch for the receipt of eggs. The opening of the pouch that usually appears as a vertical 5 mm slit, is dilated to produce a round hole about twice this size. Through contraction and extension of the upper torso, the male stretches the dark fold of skin over the abdomen into a comparatively large opaque sac-like pouch. The previously small slit develops into a 10 mm diameter opening that is almost horizontal.

Early courtship involves repeated passes by the male who undergoes rapid colour changes whenever he is close to his mate. Male Western Australian seahorses repeat courtship behaviour from October onwards, expanding their pouch every three to four weeks to receive eggs. If a male is unsuccessful in obtaining eggs, his pouch recedes and is then prepared again, over a similar time span.

The egg transfer takes place with the male intertwining tails with the female, positioning himself face-to-face with his mate but slightly lower, so his pouch opening is directly below her oviduct. In contrast to several reports I have read about seahorse breeding, the female West Australian seahorse does not possess an intromittent organ, termed an ovipositor by these authors, for egg transfer.

The female, positioned above the male's inflated pouch, squirts a string of eggs through the water into it. An egg transfer takes approximately 30–60 seconds and may be repeated from one to three times. The eggs are soft and oval in shape, with an average diameter of 0.65 mm.

Immediately after transfer is complete, the pair separate and the male's brood pouch deflates, compressing the eggs to his body. The newly pregnant male's pouch then changes from a light opaque colour to dark brown, irrespective of his overall body coloration, and its opening reverts to a vertical slit in the ventral wall. The entire process from courtship to separation takes around 85 minutes.

The pregnant male's pouch swells in proportion to the number of young developing within. A male carrying one to two young is barely discernible from one without juveniles, except that the pouch is darker in colour. However, a male carrying many young can be easily distinguished by a swollen pouch; immediately before birth a male pouch with 600-or-so young inside will strongly resemble a table tennis ball! The number of baby West Australian seahorses born from one mating ranged from one to 623.

Note that ideal conditions for mating are stable warm water (temperature ranging from 21–23°C), good daylight, adequate nutrition and 'attachment sites' for seahorses to hold onto (in my case, simulated by the use of artificial weed). Appropriate light levels and water temperature appear to be the triggers necessary for breeding in *H. angustus*.

Birth

Just before birth, the male shows signs of distress and respiration increases to 72 beats per minute. Juveniles are usually born between midnight and dawn, arriving all at once or in multiple batches 24 hours apart.

After giving birth, the male flushes out his pouch, which returns to normal proportions over a two- to three-day period. Fourteen days after flushing, the male can be observed courting his mate and expanding his pouch in preparation for receiving eggs again.

At birth, juvenile *H. angustus* average 10 mm in length and are completely independent of parental care. Immediately after birth, they head directly to the surface and within an aquarium environment tend to mass together, becoming interlocked if not dispersed by currents. Initially, juveniles are semi-transparent, but over the 14 days following birth, the majority change in colour from an opaque pale brown-yellow to white or black. They are attracted to light for the first 14–21 days, much of this time being spent skimming the surface, apparently searching for food.

Feeding juveniles

As juvenile West Australian seahorses have a well-developed yolk sac and after birth will eat 'instar I' artemia nauplii (juvenile artemia, less than 24 hours old), they are relatively easy to feed. Juvenile *H. angustus* possess a small tubular snout 0.8 mm in diameter and consume their prey whole, like adults.

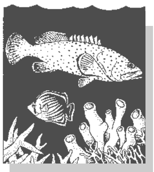
Consequently, prey size is very important, as the seahorse juveniles will starve if offered food too large for them. For example, juvenile seahorses can consume instar I nauplii on the first day after birth, but are unable to cope with instar II nauplii (juvenile artemia, less than 48 hours old) until after seven to ten days. This means that hatching and harvesting of artemia nauplii must be closely monitored to ensure the desired prey size.

Rearing juveniles

A number of methods of rearing juveniles were trialed, the most successful being recirculating tank culture and green water culture. Great care must be paid to adjusting flow rates so that aggregations of juveniles are dispersed. In recirculating systems, reverse flow filters are preferable, as it is not uncommon for juveniles to rest on the bottom.

Reverse flow systems take water from the top of the tank and push it up through the gravel at the bottom, providing the juveniles with a cushion of water. In contrast, conventional flow filters push water down from the top of the tank, potentially forcing delicate juveniles into the gravel bottom. Unlike adults, juveniles do not use their tails to anchor themselves until they are 14–17 days old.

The major cause of mortality in juveniles is due to poor swim bladder inflation, owing to the oily layer that commonly forms at the top of ponds and tanks preventing access by juveniles to the surface air vital for initial inflation. This situation may be rectified by using a protein skimmer, which removes the oily layer. Growth rates of juvenile seahorses ranged from 2–5 mm per week, with an average rate of 2.32 mm per week.



Is mariculture the remedy to problems of coral reefs of coastal communities?

by Don E. McAllister[1]

Over-harvesting, destructive fishing practices and other harmful human activities on coral reefs give rise to concerns about the conservation of these biodiverse and productive ecosystems and continued production of their living aquatic resources. These resources are essential for the livelihood, and social and nutritional well-being of coastal communities (McAllister, 1988). The worthy concerns about these resources in turn give rise to proposals for solving the problems. One solution which keeps surfacing, supported by resource-oriented sectors, global and regional financial institutions, conservationists and others, is mariculture: simply raising the fish or invertebrates in *ex situ* (off-site) ponds or tanks. Production of the resource will be assured and pressure will be taken off the reef. Simple solutions may in some cases be effective, but may also avoid important issues (McAllister, 1996).

A far-reaching and effective solution will take into account all the ramifications; it will be holistic; it may work on several aspects, not a single aspect; it involves the people and communities engaged in the harmful activity, and ecosystem diversity and integrity.

Mariculture as a solution to coastal zone problems may give rise to its own problems. These include:

- Destruction of natural ecosystems when creating sites for culture, e.g. removal of mangroves for shrimp culture.
- Lessening priority to solving other problems on the reefs, which, if solved, could produce a series of environmental, social and economic benefits (McAllister, 1988).
- Depriving local fisherfolk and developing countries of employment and income, when the mariculture of that country's species is conducted in a northern country or another southern country.
- Transfer of resource benefits from the poor to the rich (McAllister, 1989).
- Mariculture may impact upon environments by its own output, affecting local ecosystems; eco-aquaculture principles (McAllister, Hamilton & Harvey, 1997, p. 47–48) and practices are not widespread. Nor have we learned much from the impacts of monocultural agriculture.
- Mariculture may be based on harvest of eggs, larvae, or small adults in the wild. Grow-out mariculture may just be another form of capture fishery (Sadovy & Pet, 1998) and the harvest can be environmentally destructive (Ortiz, 1991).
- Intensive mariculture may foster diseases (e.g. in shrimp and Atlantic salmon mariculture) and pests, and transfers of eggs, larvae or adults may convey diseases to new areas and permit escape into the wild.
- Culture of exotic species may lead to the escape of those species into the wild, when local conditions are suitable for their survival. Successful establishment of exotic species in the wild may lead to degradation of ecosystems or reductions in populations of native species.
- Escape of domesticated or bio-engineered mariculture stock may result in genetic pollution of wild stocks, thereby disturbing their adaptational equilibrium.

This is not to suggest that all mariculture of exotic species is inherently bad. Sometimes it may depend on how the mariculture is carried out, by whom, and where. It might be, for example, that culture of corals and 'live rocks' in developing countries is preferable to harvesting them in the wild.

I will develop only one issue. This is the mariculture in developed countries of tropical organisms originating in developing countries. The harvest and local use or export of reef organisms provides employment and income at the local community level in tropical developing countries. Secondary employment from harvesting is provided for a variety of workers and entrepreneurs, e.g. boat builders, gear makers, middlemen and exporters. The developing countries, mostly hard-pressed for income, are able to generate much-needed hard currency for essential purchases through the export of wild-caught resources.

When mariculture of a tropical reef species is moved to a developed country, then the country of origin loses the community- and national-level benefits it once derived. Investors in the wealthy country benefit; those in the less-well-off country lose.

1. Ocean Voice International, P.O. Box 37026, 3332 McCarthy Road, Ottawa, ON K1V 0W0, Canada, E-mail: mcall@superaje.com

This is a problem that the countries negotiating the International Convention on Biological Diversity wrestled with. The North wanted free and open access to the biodiverse resources of the South, since the South contains most of the countries on the planet displaying megadiversity. But the South argued that it was hardly worth their while to set aside protected areas and sustainably use their resources, if they received none of the bio-industry benefits; they might as well just clear cut their forests and heavily exploit their coral reefs. After much tugging back and forth between North and South, it was decided to include articles in the Convention which provided access by the North, but which assured a fair and equitable sharing of the benefits derived from biodiversity. The first article reads:

> *The objectives of this Convention, to be pursued in accordance with its relevant provisions, are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over these resources and to technologies, by appropriate funding.*

Over one hundred and seventy countries have signed and ratified this agreement. The major exception is the United States, which signed but did not ratify the Convention. If signatories to this Earth Summit agreement hold to their commitments, then there is hope that both North and South, our grandchildren and the environment will benefit.

A current concern is that free trade and investment agreements, like the Multilateral Agreement on Investment (MAI), new MAI-like policies being adopted by the International Monetary Fund, and plans under consideration by the World Trade Organization, will circumvent the responsibilities shouldered under the Biodiversity Convention. If that happens, then the world's poor, and the environment, will become poorer. The touted economic benefits of globalisation have never stood up to close scrutiny, and do so even less today as one card after another begins to fall in the global economy.

The culture of exotic organisms outside their country of origin certainly has the capacity to deprive the South of a share in the benefits to which they are entitled. These and other disadvantages need to be considered when proposing solutions to the many problems occurring on coral reefs.

A planet which is equitably and fairly shared by its humans and wild species, is, I suggest, a better planet to live on, and one which will endure longer. Quick hi-tech fixes alone, such as starting up mariculture and putting in place artificial reefs, will not do the job alone. Not when the clear-cut forests and mono-cultured agricultural fields and paddies are shedding their soils and chemicals onto the reefs. Not when coastal people, with small-scale sustainable approaches are kept out of their traditional fishing grounds by mega-trawlers, and not when women are deprived of a voice, education, economic and family planning tools. And growing populations take more than their fair share of the Earth. Not when national 'leaders' siphon US$ 42 billion from development funds and the economy, and when corporations, not democratic societies, make most of the important decisions.

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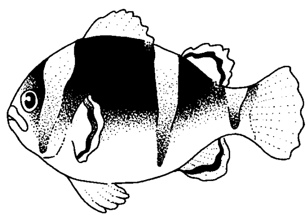
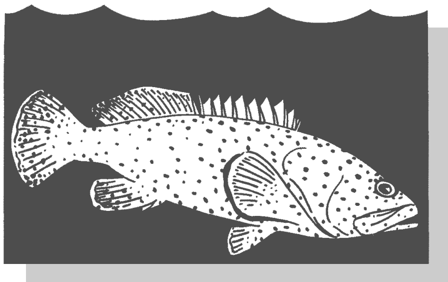




workshops & meetings
live reef fish

Marine Aquarium Council Workshop

by Paul Holthus [1]

The Marine Aquarium Council (MAC) convened a Workshop on the Certification of Sustainable Practices in the Marine Aquarium Industry in the Philippines, 10–11 December 1998. The workshop was organised by MAC and several of its key partners in the Philippines: the International Marinelife Alliance–Philippines (IMA), the Philippine Tropical Fish Exporters Association (PTFEA) and WWF–Philippines, with the latter generously providing logistical and secretariat support.

The primary purpose of the workshop was to create an opportunity for multi-stakeholder discussion on certification in the marine aquarium industry and provide input into development of MAC and certification in the Philippines. In addition, the workshop sought to:

- Identify key issues, difficulties, solutions and priorities for developing certification in the Philippines;
- Improve the understanding of MAC and certification among stakeholders;
- Provide an opportunity for increased exchange of information on the marine aquarium industry; and
- Expand and strengthen the MAC network in the Philippines.

The workshop was very well attended by a wide range of stakeholders. The almost 60 participants represented: the Philippines marine aquarium industry (i.e. collectors and exporters); Philippines government and non-government (NGOs) agencies; other interested parties in the Philippines (e.g., education/research institutions, development assistance programmes, the press); the marine aquarium industry beyond the Philippines (i.e. importers, retailers and hobbyists); international NGOs; and eco-labelling organisations from Indonesia.

The workshop programme was designed to: set the context for the development of certification through overview presentations; outline the issues affecting each stage of the Chain of Custody (collector–exporter–importer/wholesaler–retailer) in more specific presentations; and explore these issues as they relate to developing and applying certification in the Philippines through discussion involving all stakeholders.

Summary of presentations and discussions

The first keynote presentation, from the Bureau of Fisheries and Aquaculture, highlighted the importance of marine resources to the Philippines, the imperative to ensure sustainable use of these resources and the need for the private sector, government and non-government sectors to work in partnership. The MAC Director then outlined the background to the development of the Marine Aquarium Council, how it operates, the status of MAC efforts, and the role of the workshop in MAC development in the Philippines.

The second keynote, by the invited industry expert from Australia, highlighted the need and practices

1. Executive Director, 3035 Hibiscus Dr., 96815 Honolulu, Hawaii. Fax: 1 808 9236023. E-mail: paul.holthus@aquariumcouncil.org

for ensuring quality in the marine aquarium industry and how quality is rewarded in the market place—as evidenced in the higher prices that Australian fish command.

The next session began with a synopsis of certification programmes by MAC and a discussion of how this could be applied to ensure quality and sustainability in the marine aquarium industry through the development of standards, a compliance verification system, actual certification and labelling, and an awareness-raising programme for retailers and hobbyists.

The WRI (World Resources Institute) representative then reviewed the history and status of the trade in live marine fish in SE Asia, the problems associated with this and of the programmes and policies needed to address these issues.

The history and status of efforts in the Philippines to detect and monitor cyanide in fish for export and train fishermen to use nets, and the IMA/BFAR (Bureau of Fisheries and Aquatic Resources) Destructive Fishing Reform Program were described by the President of IMA, the organisation responsible for most of these efforts.

Next, the workshop focused on the critical role and difficult situation of collectors. The efforts to develop a collectors' cooperative at the export level were described, including the difficulties and frustrations. Other efforts were described that focus on developing a village collectors' association. This is composed of members trained in net fishing and fish handling, with a holding facility and an exporter ready to buy their product.

A spokesman for the collectors, who himself had been imprisoned for practising destructive fishing, provided input on the personal and financial benefits resulting from training in net fishing, the development of the village fishing association and supplying quality fish to a buyer interested in quality. The experience in training in net fishing and status of training efforts was then outlined by IMA.

Finally, a representative of Ocean Voice International presented an overview of water-quality issues at the collection, handling and transport level and the critical role water quality plays in fish health and mortality.

The second day began with consideration of export and regulations. BFAR outlined the provisional version of the government Fisheries Administrative Order and how it relates to the monitoring, testing and permitting of live fish export, as well as plans for public hearings before it is finalised.

Senior staff from the BFAR/IMA Cyanide Detection Testing Centers described the current sampling programme, analytical procedures, documentation and summary data for the past 5 years of monitoring, which indicate a decrease in the use of cyanide.

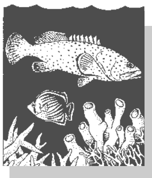
The President of the Philippines Tropical Fish Export Association highlighted the desire and efforts of exporters to provide a quality product and play their part in eliminating destructive practices. He noted that the bad publicity surrounding Philippines aquarium fish hurts everyone involved by reducing demand and that there is a need to promote the positive trends and image of the industry.

To help stakeholders in the Philippines understand the marine aquarium industry and market beyond the Philippines, the workshop also covered Chain of Custody perspectives from importers, retailers and hobbyists. The presentation on the importers' perspective stressed the importance of taking a full Chain of Custody approach to certification in order to ensure the best possible chance that a healthy, good quality specimen arrives in the importing country.

The retailer's perspective highlighted the frustrations of the conscientious retailer in having no control (or information) on the quality of their sources and in trying to identify suppliers of quality fish, noting that quality is survivability which can translate into increased prices in all parts of the Chain of Custody.

Finally, the representative of the hobbyist association reviewed the general characteristics of aquarists in the US, based on the results of an informal survey. He indicated that hobbyists would like to ensure that they do not contribute to destructive fishing practices and are willing to pay more for quality fish and quality practices if these can be guaranteed.

The workshop included time for discussion after each presentation as well as discussion sessions on Reef and Collector Issues and on Export and Regulation Issues. These discussions resulted in numerous ideas and issues for MAC to follow up. The closing summary discussion considered and endorsed an indicative MAC Workplan for the Philippines as a framework to guide MAC in its development and activities in the Philippines.



Recommendations following the Workshop on the Impacts of Destructive Fishing Practices on the Marine Environment (December 1997)

In December 1997 in Hong Kong, the Workshop on the Impacts of Destructive Fishing Practices on the Marine Environment sponsored by the Asia-Pacific Economic Community (APEC) was held. The following recommendations put up by the workshop participants have recently been made available.

General recommendations to address destructive fishing:

- APEC economies should be encouraged to adopt and follow the FAO Code of Conduct for Responsible Fishing;
- APEC economies should consider entering into bilateral agreements relating to aspects of destructive fishing practices of mutual concern as an interim measure;
- APEC should establish a small task team to draft a framework for co-operative action to address destructive fishing practices in the region, to set management standards, protocols for export and import, sharing of experience, and to survey the needs for sharing of data and information;
- An existing network within APEC be tasked to act as a node for dissemination of information on destructive fishing practices, and sustainability of reef ecosystems at risk from trade in live fish;
- Work to build capacity in source economies on the development of alternative and sustainable fishing practices and the necessary institutes to support this;
- Efforts be encouraged within APEC on developing protocols and capacity for the culture of alternative fish species, including environmental and fish health issues, and alternative sources of feed;
- Small working groups of experts should be established to develop approaches to managing and mitigating specific destructive fishing practices, such as dynamite fishing and trawling;
- Review current laws and regulations on destructive fishing practices and amend, introduce or proclaim to ensure adequate penalties and scope, as well as dissemination to interested parties;
- Collate existing public education means available in APEC economies for the purpose of evaluating their utility for public education more broadly across the APEC Region;
- APEC economies should consider establishing a value-added tax on tourism, or other alternative sources of revenue, to establish a domestic fund for the environment to support these and other efforts;
- APEC should convene a workshop of experts in developing community co-management of coastal resources, to share experiences on management, adoption of alternative fishing gear, and development of new approaches to alternative employment and income sources; and
- The Marine Resource Conservation Working Group of APEC should convene a follow-up meeting to this workshop to:
  - Evaluate progress,
  - Develop standards and protocols for inshore fishing, for adoption by APEC economies,
  - Identify mechanisms to strengthen legal and enforcement approaches, and
  - Identify two potential demonstration sites including a comprehensive marine management area, with community co-management, and a second unmanaged area, to identify the benefits of improved management approaches, support the development of these in other areas, and provide opportunities for improvement.

Specific recommendations to address cyanide fishing:

1. Endorse and support comprehensive data gathering and sharing at the domestic and regional levels concerning the live reef fish trade in source and importing APEC economies;

2. Put in place comprehensive monitoring mechanisms at the domestic level to track volume, value and species concerning live reef fish trade in source and importing APEC economies. Specific actions are to:

   a) Adopt, as is or modified accordingly, the Harmonized Code classifications of the recording of trade in live reef fish commodities, as refined by Hong Kong for these trades, in both exporting and importing economies (see Table below);

b) Develop a simple instruction manual to aid species identification for those involved in commodity classification, to include multilingual common names, as well as trade names, pictures and simple descriptions for identification and easy to use; and

c) Undertake domestic trade surveys to monitor fish sizes in trade, species composition for marine aquarium fishes and patterns, volumes and methods of 'fingerling' harvest;

3. Build capacity to test live reef fish in exporting economies to ensure that they have been captured without the use of cyanide or other poisons;

4. Support in importing economies the actions of exporting economies to control the sale of illegally captured live reef fish. Specific action is to develop and implement a standard and internationally recognised set of protocols and tests for cyanide testing export and ultimately, when tests are sensitive enough, at import;

5. Support the development of a medium term plan of action to institute a credible live reef fish certification system in the APEC Region;

6. Establish an informal task group of experts to develop protocols and manuals, and identify training needs to reduce mortality rates at all stages of handling and shipment within the live reef fish trades;

7. Support economically viable and environmentally sustainable aquaculture of live reef fish. Specific action is to actively support, through budget allocations and domestic priority setting, collaborative research among expert centres on alternative sources of live reef fishes that do not depend on wild capture, in order to improve culturing capacity of reef fish species and develop experimental hatchery facilities;

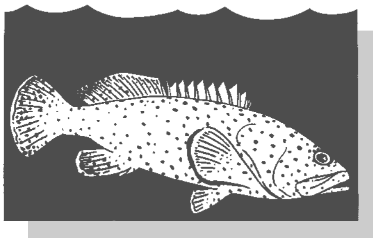
8. Adopt the general precautionary principle of protection of spawning aggregations for sustainable resource use. Support the domestic fisheries agencies and NGOs in research efforts on identification of spawning aggregations through research surveys, and consider creation of marine managed areas controlling harvesting in areas where spawning aggregations are known to occur;

9. Establish an informal group of experts to identify means of dissemination of the value of commodities and pricing systems to all levels of the trade and propose a dissemination system, and to implement such a system; and

10. Seek and provide funding for training and awareness-raising to stop the spread of destructive reef fish capture techniques in small island states in the Pacific and Indian Oceans that supply APEC markets.

Harmonized Codes - Hong Kong Department of Census and Statistics (Implemented on 1 January 1997)

0301 1010	Live freshwater ornamental fish
0301 1020	Live marine ornamental fish
0301 9912	Fish fry, marine
0301 9921	Giant grouper, *Epinephelus lanceolatus*
0301 9922	High-finned grouper, *Cromileptes altivelis*
0301 9923	Spotted grouper / coral trout, *Plectropomus* spp.
0301 9929	Other groupers
0301 9931	Humphead wrasse, *Cheilinus undulatus*
0301 9939	Other wrasse and parrotfish
0301 9941	Snooks and basses
0301 9999	Other marine fish



noteworthy publications
live reef fish

Hanawa, M., L. Harris, M. Graham, A.P. Farrell & L.I Bendell-Young. (1998). Effects of cyanide exposure on *Dascyllus aruanus*, a tropical marine fish species: lethality, anaesthesia and physiological effects. Aquarium Sciences and Conservation 2: 21–34.

The authors conclude that 'environmentally relevant exposures of cyanide can adversely affect fish and this effect can be measured 2.5 weeks post-exposure. Importantly, the combined effects of exposure and stress both increased the mortality and placed an appreciable metabolic load on the fish as indicated by elevated O^2 consumption rates. Handling stress in combination with anaesthetic cyanide doses could in part explain the delayed mortality reportedly associated with cyanide use in the tropical fish trade.

Dhert, P., P. Divanach, M. Kentouri & P. Soreloos. (l998). Rearing techniques for difficult marine fish larvae. World Aquaculture 29(1): 48.

The authors point out that, with intensive aquaculture, fish larvae are typically fed only one or two species of prey and that these do not even occur in the natural environment. They argue for an extensive approach where larvae are reared at low densities in large tanks under more natural conditions with blooms of wild marine plankton as food. They describe the results of using this approach with turbot and sea bream.

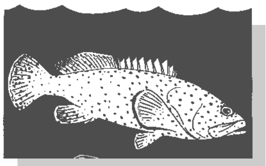
Wangcharoenporn, V. & Lawonyawut, K. (l998). The ornamental fish industry in Thailand. Aquaculture Asia 3(4): 34–35.

Subasinghe, R.P., J.R. Aruther & M. Shariff. (eds.) (1995). Health Management in Asian Aquaculture. Proceedings of the Regional Expert Consultation on Aquaculture Health Management in Asia and the Pacific. FAO Fisheries Technical Paper No. 360, Rome, 142 p.

James, C.M., S.A. Al-Thobaiti, B.M. Rasem & M. H. Carlos. (l998). Growout production of camouflage grouper, *Epinephelus polyphekadion* (Bleeker), in a tank culture system. Aquaculture Research 29: 181–188.

Van Trai, N. & J.B. Hambrey. (l998). Grouper aquaculture in Khanh Hoa Province, Vietnam. Infofish International 4: 30–35.

Leong, T.S. (l998). Grouper culture. p. 423–448. **In:** S.S. DeSilva (ed.) Tropical Mariculture. Academic Press, New York.



miscellaneous
live reef fish

Net-caught ornamental fish export facility in the Philippines

The PMP ornamental fish export facility in Manila, Philippines sells net-caught marine aquarium fish caught by the graduates of the Ocean Voice International-Haribon Foundation for Conservation of Natural Resources Sustainable Livelihoods and Eco-Marketing projects. A new manager for the export facility, Mr Juned Sonido, was appointed in July 1998. Mr Sonido is a B.Sc. Fisheries graduate from the University of the Philippines. He was President and Chair of the Aquarium Science Association of the Philippines, and has had extensive dealings with the Philippine aquarium industry.

For businesses wishing to order fishes from the PMP export facility, Mr Sonido can be contacted by telephone/fax at the facility at: +632 821 8512, or at home at +632 912 4285 or +632 913 4845. His e-mail addresses are: <juned67@hotmail.com> or <PMP@pworld.net.ph>.

Ciguatera Test Kit

As reported in the Editor's Mutters column in the previous issue of the *SPC Live Reef Fish Information Bulletin* an outbreak of ciguatera poisoning caused by the consumption of live reef fish hospitalised more than 100 people in Hong Kong early last year (see also Late News, p 55, this issue). Ciguatera occurs in reef fish in a number of countries from which live reef food fish are sourced. Symptoms of ciguatera poisoning in humans include weakness, diarrhoea, muscle pain, joint aches, numbness and tingling, temperature reversal (cold feels hot and vice versa), nausea, chills, itching, headaches, sweating and dizziness. Although it rarely causes death, symptoms may last for several months and reoccur later.

A test kit for detecting ciguatera poison in fish has recently become available. Called *Cigua-Check*, a package of five tests costs US$ 20 plus shipping and handling. To carry out the test, a grain-sized piece of the fish's muscle is placed in a vial of methanol. A test strip is added, air-dried and placed in a second vial containing a purple liquid. If the strip remains purple after being rinsed, the flesh contains ciguatera and should not be eaten.

For more information or to order the test, contact: Oceanit Test Systems, 1100 Alakea St. 31st floor, Honolulu, HI 96813, U.S.A. Phone: 1 808 539 2345, or contact the company's website: www.cigua.com.

Educational materials wanted

The Nature Conservancy is creating an inventory of all education and awareness materials relating to the live reef fish trade (food fish and aquarium fish).

Anyone possessing, or knowing the source of, such materials is asked to contact:

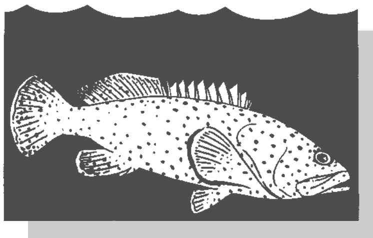
Lisa Hogen
The Nature Conservancy
88 First Street, Suite 600
San Francisco, California 94105, USA

Phone: +1 415 904 9930; fax: +1 415 904 9935;
E-mail: Lhogen@tnc.org

Lisa wants to know not only just what is available, but also:

- title/reference
- what aspect(s) of the subject it addresses,
- in what format, language, etc.,
- availability (any copyright issues, costs etc.).
- produced by whom
- when produced
- medium (if video, what format: NTSC, PAL, etc.)
- target audience
- effectiveness, any known problems with it, etc.

Once compiled, the inventory will be made available on request from The Nature Conservancy.



late news
live reef fish

New ciguatera outbreak in Hong Kong

The following newspaper article from the South China Morning Post, *9 March, describes a second major outbreak of ciguatera caused by the consumption of wild-caught groupers. Readers may recall that in the previous issue of the* SPC Live Reef Fish Bulletin, *Yvonne Sadovy described the first major outbreak, which occurred about a year ago—she had earlier predicted publicly such an outbreak was bound to occur.*

Ban on reef fish urged as 30 fall ill

by Anne Stewart

Coral reef fish should be banned from restaurant menus, Hong Kong Chef's Association president Urs Besmer said last night, in the wake of another ciguatera food poisoning outbreak.

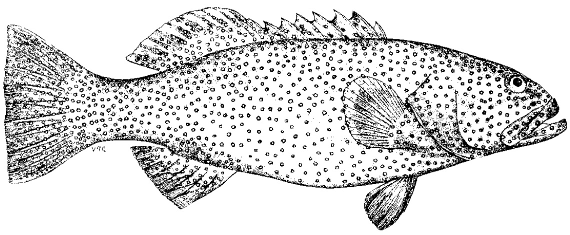
Thirty people, including a two-year-old child, have been struck down with fevers, vomiting, chills, sweat, muscle fatigue and numbness in the past three days, contracted from eating South Pacific coral reef fish. It was the first major outbreak this year. More than 400 people were affected last year.

Over the weekend, three groups of people, eating at restaurants in Yau Ma Tei, Sha Tin and Kowloon City, were sick after eating fish infested with toxic algae. Another two groups of people, eating at home at Sheung Shui and Shamashuipo, were hit with food poisoning.

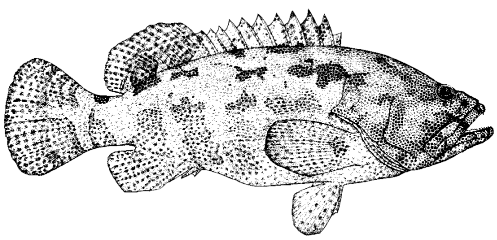
Mr Besmer said the larger species of coral reef fish, which carry the algal toxins, should be taken off menus and the public must stop demanding the delicacy.

'Absolutely they should stop using this. There are also many alternatives and other types of fish', he said. 'It is the duty of the Chef not to serve it. I would recommend they do not put the public at risk like this.'

The fish responsible for the weekend outbreak were coral trout and flowery cod, fished from the waters of Kiribati in the South Pacific and brought



'Coral trout', *Plectropomus areolatus*



'Flowery cod', *Epinephelus fuscoguttatus*

to Hong Kong by a Kwun Tong wholesaler. They were smaller than fish usually blamed for ciguatera poisoning, only weighing 0.9 to 1.7 kg.

The 30 victims comprised 14 males and 16 females, aged from two to 80. Fifteen remain in hospital in a stable condition.

The supplier has stopped selling the fish while the Department of Health and the Agriculture and fisheries Department investigate.

Coral reef fish account for 15 per cent of imported live fish brought to Hong Kong each year, amounting to about 3000 tonnes.

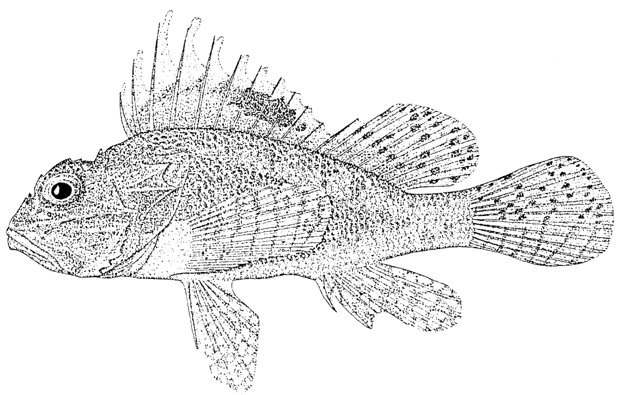
Last year, 420 people were hit with ciguatera poisoning in 117 separate cases. despite the outbreak, a Department of health spokesman said people should not over-react and stop eating fish altogether.'

However, they should avoid eating the head, viscera, liver, gonads and skin, where the toxin is most concentrated.

Those previously poisoned are more susceptible than others. The Department is about to distribute posters in markets and restaurants, on how to avoid ciguatera poisoning.

Subsequent news articles stated that, despite the widespread warnings issued about these fish, 64 more consumers contracted ciguatera within the next four days.

The importer of these fish was described as having spent HK$ 700 000 (US$ 134 000) to buy back the remaining fish from distributors, markets, and seafood retailers in Hong Kong and the Chinese mainland. (One wonders if those who sold or served these fish after the public warning was given are legally liable - Ed.).



PIMRIS is a joint project of 5 international organisations concerned with fisheries and marine resource development in the Pacific Islands region. The project is executed by the Secretariat of the Pacific Community (SPC), the South Pacific Forum Fisheries Agency (FFA), the University of the South Pacific (USP), the South Pacific Applied Geoscience Commission (SOPAC), and the South Pacific Regional Environment Programme (SPREP). This bulletin is produced by SPC as part of its commitment to PIMRIS. The aim of PIMRIS is to improve the availability of information on marine resources to users in the region, so as to support their rational development and management. PIMRIS activities include: the active collection, cataloguing and archiving of technical documents, especially ephemera ('grey literature'); evaluation, repackaging and dissemination of information; provision of literature searches, question-and-answer services and bibliographic support; and assistance with the development of in-country reference collections and databases on marine resources.

PIMRIS

Pacific Islands Marine Resources Information System