

urgent intervention is an active ban of hookah compressors for the entire park, for which no new legislation is needed. Compressor fishermen from neighbouring fishing villages should be targeted in alternative livelihood programmes such as the development of a fishery for large coastal pelagics or mariculture initiatives.

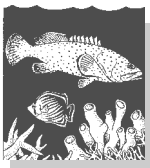
- II. A second important intervention would be to stop 'meting' by park inhabitants. The latter intervention may be facilitated by freeing local fishermen from the exploitation of middlemen, so they can earn sufficient income from their bagan activities. Park inhabitants should also be directly targeted in alternative livelihood programmes such as eco-tourism and/or extensive mariculture in multiple-use zones.
- III. The marine resources of Komodo National Park cannot be protected without an effective enforcement programme, including frequent patrols of all the Park's waters. If the park management cannot afford or is not willing to organise these patrols, other institutes, including NGOs, can make sure that law enforcement is indeed implemented.
- IV. Corruption and lack of political will at the local level is a major barrier to be overcome before marine reserves can be successfully implemented in Indonesia. Community awareness and education therefore has to be taken to higher levels and should include government awareness and cultivation of political will.
- V. The present status of the resource can be described with the following characteristics:

- a. highly damaged and continuously degrading coral reefs,
- b. continuing destructive fishing practices inside the park,
- c. high fishing effort and pressure on demersal stocks like lobsters, shellfish, groupers and Napoleon wrasse,
- d. few economic alternatives available to local communities, and
- e. questions without answers on how to speed up coral reef rehabilitation.

VI. Detailed management objectives should:

- a. stop degradation of the coral reefs and keeping the damage at a level which is not higher than what was recorded in 1996,
- b. stop all destructive fishing practices, including compressor fishing, 'meting' and fishing with 'bubu' traps,
- c. implement full protection of demersal stocks, at least by banning the use of hookah compressors and by closing all known fish-spawning aggregation sites to all types of fisheries,
- d. promote a shift of fishing effort from demersal fishing inside the park area to pelagic fishing inside and outside the park area,
- e. support members of local communities to enter into compatible enterprises like eco-tourism, mariculture or pelagic fisheries,
- f. develop a feasible methodology for the enhancement of coral reef rehabilitation.

VII. We need supporting materials from outside sources to convince the park management of the need for a hookah ban!



## An overview and comparison of destructive fishing practices in Indonesia

by Lida Pet-Soede<sup>1</sup> & Mark Erdmann<sup>2</sup>

### Introduction

Indonesia is richly endowed with marine natural resources, and its people are highly dependent upon them for food, coastline protection, and other ecosystem functions. Despite this strong dependence, and an adequate legal framework to protect them, destructive fishing practices (DFP) continue to pose some of the greatest threats to the sustainability of Indonesia's marine ecosystems, particu-

larly its coral reefs. Here we present an overview of DFP in Indonesia, with detailed descriptions of those fishing techniques most destructive to its coral reefs. For each of these capture methods, we describe the technique as practised in Indonesia (with regional variations noted when applicable), the species most commonly targeted by each capture method, data on typical yields and profitability (when available), as well as a subjective assessment of which of these destructive techniques pre-

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sent the greatest threat to Indonesia's coral reefs. This overview draws upon the scattered literature which has been published on Indonesian DFP, but is based primarily upon our own personal observations and surveys throughout the archipelago, with a focus on the fisheries of the Spermonde (Sulawesi), Riau (Sumatra), and Kepulauan Seribu (Java) archipelagos.

Additionally, we briefly examine some of the socio-economic and cultural factors influencing the use of DFP in Indonesia. An understanding of these forces is critical in order to design effective education and enforcement programmes to promote the adoption of more reef-friendly capture techniques.

## Definition of DFP

With increasing attention being focused on the use of DFP worldwide, it is inevitable that varying interpretations of what constitutes a 'destructive practice' will arise. For example, although blast fishing may be considered a 'consensus DFP', some workers have also considered such practices as live-finning of sharks as destructive. For the purposes of this paper, a destructive fishing practice (DFP) is one which results in direct damage to either the fished habitat or the primary habitat-structuring organisms in the fished habitat (e.g. scleractinian corals in a coral reef fishery). Examples of DFP in Indonesia include blast fishing, cyanide fishing, bubu trap fishing, muroami and inshore trawling.

## Blast fishing

First introduced by the Japanese during WWII, blast fishing is so pervasive in Indonesian coral reef fisheries that it might in some respects be considered a 'traditional' fishing method. Although the explosive used has evolved from actual dynamite (first from WWII munitions, then from international development civil engineering projects) to home-made kerosene and fertiliser bombs in beer bottles, the basic technique remains the same. Schooling reef fishes are located visually, after which the capture boat moves within close range (within 5 m) and throws a lighted bomb into the middle of the school. After the bomb has exploded, fishermen enter the water to collect the fish which have been killed or stunned by the resulting shock wave, using either free-diving or hookah (surface-supplied compressed air) techniques. Typical target species include schooling reef fishes such as fusiliers, surgeonfish, rabbitfish, and snappers, as well as small pelagics such as scad and sardines.

The associated damage of such blasting to the reef framework is well-documented; branching, tabu-

late and foliose hard corals are shattered, while massive and columnar corals are often fractured. Depending upon the distance from the substrate at explosion, a typical 1 kg bottle bomb can leave a crater of rubble of 1–2 m in diameter (McManus et al., 1997; pers. obs.). While this effect is quite localised, reefs which are subject to repeated blasting are often reduced to little more than shifting rubble fields, punctuated by the occasional massive coral head. These reefs face dim prospects for recovery due to the unsuitable nature of unconsolidated coral rubble as a recruitment substrate for coral larvae. Additionally, the greatly-reduced three dimensional structure of such reefs makes them less attractive to emigrating adult and settling larval fishes, reducing their fishery potential for years to come. Finally, in addition to damaging the reef framework, blast fishing results in extensive side-kills of non-target and juvenile fish and invertebrates.

Although blast fishing is illegal in Indonesia, it is still widely practised. In the Spermonde Archipelago in Sulawesi, we estimate that up to 15 per cent of the fishers in some villages are blast-fishermen, with their catches supplying 10–40 per cent of the total landings for the 16 000 km<sup>2</sup> reef fishery (Pet-Soede & Erdmann, in press). Operations range from individual fishermen using 1–3 bombs per day for subsistence yields (up to 5 kg/day), to large-scale operations involving crews of 15–20 on board 15 m vessels. These larger operations may range several hundred kilometres from their home islands, remaining at sea for 7–10 days and catching up to 2 t of fish per trip. The financial rewards of this risky trade are alluring; divers working for medium- and large-scale operations can clear US\$ 50–150 *per week*, more than many government officials and up to ten times the wage of the average day-labourer in Indonesia.

Blast fishing appears to be much more prevalent in eastern Indonesia, where much lower human population densities lessen the chances of detection and capture by police patrols. Furthermore, observations in the Riau and Kepulauan Seribu archipelagos suggest that schooling fish stocks (and water clarity) are often so reduced in areas of western Indonesia as to make blasting financially non-viable (Erdmann, in press). The situation in these areas may unfortunately be a harbinger of the future of eastern Indonesia as well.

## Cyanide fishing

Perhaps the most publicised DFP in Indonesia today is the use of sodium cyanide (in sea water solution) to stun reef organisms which are desired for live capture. Cyanide (locally referred to as 'bius' or 'drugs') is the 'gear' of choice in three

main fisheries in Indonesia: ornamental fishes, live reef food fishes (mostly grouper and Napoleon wrasse), and rock lobsters (*Panulirus* spp.). In each of these fisheries, the basic technique involves divers, often supported by hookah, using bursts of cyanide solution from squirt bottles to stun their targets. While an 'overdose' results in death of the target organism, a properly calibrated squirt allows the diver to easily remove the anaesthetised animal from its refuge in the reef framework, often after some breakage of the coral surrounding the refuge. In addition to decimating target species populations, this practice often results in what Johannes and Riepen (1995) term 'extensive collateral environmental damage'. Cyanide solution in concentrations used to capture large reef fish has also been shown to be lethal to most reef organisms, including smaller fishes, mobile reef invertebrates, and most germane to this discussion, hard corals (e.g. Jones, 1997).

By far the most prevalent of these cyanide fisheries in Indonesia is the live reef food-fish trade, which we focus upon here. This trade in Asia and the western Pacific has been extensively documented by Johannes and Riepen (1995), with additional details of the trade specific to Indonesia provided by Cesar (1996) and Erdmann and Pet-Soede (1996). Here we focus on trends which seem to have developed in the trade since those reports were made.

In extensive interviews conducted by one of us (LPS) during July–August 1997, fishermen, live-fish exporters, and buyers from the primary export destination of Hong Kong all expressed similar concerns over the rapid decline in live fish catches throughout the Indonesian archipelago. Independent evidence from a number of lines of investigation strongly support the claim that the wild-capture of live grouper in Indonesia is declining. In our region of primary focus, the Spermonde in S. Sulawesi, the larger cyanide operations are forced to travel much further afield than was the case in 1995, and the interval between pick-up times by live fish transport vessels (LFTV's) has increased. Part of this is explainable by the trend towards air shipment of live fish (now accounting for approximately 75 per cent of export volumes from S. Sulawesi), but even this trend towards more expensive air shipment hints of a demand for the product which is in excess of supply.

Furthermore, we have witnessed an impressive increase in the prices paid to fishermen for live fish. Since late 1995, prices paid to fishermen for live coral trout (*Plectropomus leopardus*) and Napoleon wrasses (*Cheilinus undulatus*) have almost doubled, from US\$ 11/kg to \$ 18.8/kg for 'super'-sized *P. leopardus* (0.6–1.2 kg) and from US\$ 22.2/kg to \$ 40/kg for *C. undulatus*.<sup>1</sup> While declining stocks are not the only explanation for the increased prices, it definitely appears that demand is outstripping supply.

Underwater observations also suggest declining target species' populations. In underwater visual surveys conducted throughout the Spermonde, the highest-valued species (including *Plectropomus* spp., *Cheilinus undulatus* and *Cromileptes altivelis*) were extremely rare. Even in the Bunaken National Marine Park (which at the time of this writing had three live fish cages anchored within park boundaries), divers report disappointment at the general dearth of grouper and Napoleon wrasse. Additionally, divers working within the live-fish trade report declining sizes of target species, with juveniles now accounting for a substantial percentage of the catch (see description of Riau archipelago below).

Finally, additional evidence of declining catches comes from estimates of overall export volumes. As explained in Johannes and Riepen (1995), the overall export volume of live fish from Indonesia is an extremely elusive figure, complicated by rampant under-reporting of volumes for tax purposes and by potentially large volumes of fish that are caught and exported illegally by foreign LFTV's. Those estimates which have been made have used different sources of information, and have generally not been repeated during successive years, making it difficult to analyse trends in export volumes. Estimates of total wild-caught export volumes in 1995 range from the official government figure of 1003 metric tonnes (t) to 2200 t (Erdmann & Pet-Soede, 1996), upwards to 6000–9000 t (Johannes and Riepen, 1995). By comparison, projected 1997 total export volume ranges from 1080 t (from our own catch estimations<sup>2</sup>) to 2000–3000 t (Bentley, pers. comm.<sup>3</sup>), with an intermediate estimate of 1200 t by a prominent Hong Kong buyer (LPS, unpub.). Although comparing these estimates is admittedly a suspect exercise, the general trend does support the hypothesis of a decline in

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1. The price paid to fishers for Napoleon wrasse has actually decreased in S. Sulawesi, apparently owing to the high risks associated with storing these fish, whose export is banned. The July 1997 price for Napoleon wrasse there was US\$ 16/kg.
  2. Based on extensive surveys in 1997, we estimate a total export production (mortality accounted for) of 45 t of live grouper and wrasse per month from Ujung Pandang (note that official fisheries statistics report an average of 16.6 t/month from UP). Assuming that UP accounts for 50% of current Indonesian exports, this gives a projected total export volume of 1080 t.
  3. Based on field interviews and analysis of trends in official fisheries statistics.

wild-caught live fish export. This is in keeping with predictions of a collapse of the Indonesian wild-caught grouper fishery by the year 1999 (Johannes & Riepen, 1995; Cesar, 1996).

An associated trend we have observed recently in the live food-fish trade in South Sulawesi is the move away from direct capture by cyanide-squirting divers to the prevalent use of both hook and line, and especially bamboo mesh 'bubu' traps to catch serranids. These bubu traps are often baited with cyanide-tainted fish, with the objective of anaesthetising the trapped groupers to prevent self-inflicted injury. We estimate that of the total volume of fish exported from S. Sulawesi, almost 55 per cent are now caught by traps and 15 per cent by hook and line, with the remaining 30 per cent caught by cyanide divers.

The reasons behind this apparent shift in capture method appear to be twofold. Most importantly, declining stocks on many of the reef systems of the Makassar Strait make the use of large cyanide catcher boats less efficient and far less profitable than the less capital-intensive medium-scale trap operations. According to Panayotou (1985), this is a common phenomenon in overexploited Asian fisheries; as stocks dwindle, large-scale operations typically experience a negative return to capital while small- to medium-scale operations remain profitable. A further factor contributing to this shift may involve increased 'enforcement' resulting from the publicity over cyanide fishing; owners of large-scale cyanide operations complained that the expensive reputation of the live fish trade meant that they had to pay ever-more-exorbitant 'fees' to continue exporting. Small- and medium scale trap-fishers largely avoid this official censure.

A comparison of live food-fish capture in other regions of Indonesia reveals an interesting spectrum of techniques, which may prove to be a natural progression for the fishery as grouper stocks are progressively decimated. The large-scale cyanide catcher boats described in Johannes and Riepen (1995) are still active on the reefs of remote eastern Indonesia, where grouper are still plentiful enough to make them profitable. Based upon recent observations in the Komodo National Park, these large-scale operations are believed to be efficiently targeting spawning aggregations of groupers on these remote reefs. As adult grouper stocks are decimated, these operations simply move on to new, under-exploited reefs—in much the same way that farmers involved in shifting agriculture cultivate new forest areas as previously-cleared fields become infertile. The situation described above for the reefs of the Makassar Strait appears to be an intermediate step, whereby adult grouper have become too rare to make large-scale

cyaniding profitable, but are still plentiful enough for medium-scale trap fishers to make an excellent living (divers in these trap operations can earn up to US\$ 200 per week, compared to \$ 50 per week for cyanide divers in S. Sulawesi). In the Riau archipelago of Sumatra, a terminal stage in the live grouper fishery appears to have been reached. Here, almost all capture is also done using bubu traps (with no evidence of cyanided bait), but the collected fish are rarely of marketable size. Instead, most fish collected are fingerlings of the 100–300 g size. Practically every village visited in Riau is involved in grow-out of these fingerlings, which are typically fed 'trash' fish for 4–8 months before being exported to Singapore at 500–700 g. Johannes and Riepen (1995) discuss the poor conversion ratios achieved during grouper grow-out, as well as the dangers of fingerling capture in recruitment-limited fish species such as some serranids appear to be.

Finally, the situation in Kepulauan Seribu (NW Java) is almost post-apocalyptic in nature: serranids appear so rare that no targeted fishery for them was observed (Erdmann, in press). In its place, teams of 6–10 rag-clad skin-divers were frequently observed methodically combing the reefs for ornamental fishes. These men were each outfitted with cyanide squirt bottles and hand nets, diving amongst the mostly dead coral heads in search of any flash of bright colour. Sadly, this form of cyanide fishing is the most destructive observed; with a wider range of target species, much larger volumes of cyanide are used, often with daily-repeated exposures. Moreover, this is a small-scale, relatively high value fishery with little capital investment required, rendering it virtually impervious to economic overfishing. It appears the sad fate of these reefs that they may be cyanided until they are reduced to barren carbonate skeletons supporting little more than a community of bioeroders and algae.

### ***Trap fishing (bubu)***

The use of bamboo mesh traps, locally known as bubu, is widespread throughout Indonesian reef fisheries. As described above, this gear is experiencing a resurgence of popularity due to its use in the live reef food-fish trade. Although this gear is not intrinsically destructive, the process of setting and retrieving the trap is largely responsible for the destruction, if any, wrought on the reef. Bubu traps set and retrieved by hookah divers are typically the least damaging, as these traps are often set at the base of the reef slope (though they are occasionally 'camouflaged' by covering with live coral fragments). Those traps set by simply lowering the trap from boatside via a buoyed rope are responsible for the most reef damage. These traps

are often heavily-weighted with wooden 'runners', and can destroy entire stands of branching and foliose corals on the reef slope during their installation and especially removal (by pulling on the rope). If the current trend towards trap-use in the live grouper fishery continues, bubu trap activities will become an increasingly important source of reef damage in Indonesia.

### **Muro-ami**

Muro-ami is a type of drive-in net fishing technique whereby a line of fishermen in the water use scare-lines (typically a line with pieces of sheet or plastic tied off at regular intervals, with a weight on the end) to drive fish down a reef towards a bag net. The scare lines are rhythmically lifted and dropped into the reef framework, often breaking live corals while the fish are driven ahead. Despite the reported widespread prevalence of this technique in the Philippines and elsewhere, the authors have only observed this DFP on a few occasions in Indonesia, notably in the international border areas of Sangihe-Talaud and Riau, as well as in Pulau Seribu. Muro-ami is historically widespread in Pulau Seribu, with the main target being caesionids (fusiliers). In 1995, one of us (M. Erdmann) observed a modified form of muro-ami in Kepulauan Seribu involving a mother ship, three canoes and 20 men, including eight divers on hookah support. In this operation the divers used a wall of exhaled bubbles as their scare line, in addition to banging on the reef framework with hollow metal pipes. The yield from this three hour operation was roughly 15 kg of fusiliers and 15 kg of 'trash' fish. In sharp contrast to the lucrative DFP discussed above, the men in this operation reported making an average of US\$ 25–40 *per month*, plus daily portions of trash fish.

### **'Tiger' nets**

The final DFP we shall mention are inshore bottom-trawlers, locally known as 'harimau' or 'tiger' nets. Commonly operating over soft-bottom communities, these trawl nets (which frequently target prawns) can severely disturb the seabed and result in large percentages of unwanted bycatch. For these and other reasons, trawl nets have been banned from use in Indonesia since 1980. Because of this, trawl net operations are rarely observed in Indonesia, though they are frequently reported in the international border areas of Riau (allegedly Thai trawlers) and Sangihe-Talaud (reputedly Filipino trawlers). Recently, however, another type of tiger net has been reported from N. Sulawesi, the so-called 'curtain of death' in the Lembeh Strait (Cochrane, 1997). Though not considered a DFP by our definition, this Taiwanese-sponsored trap net has had such a devastating effect on the marine

resources of N. Sulawesi as to merit a brief mention here. Set across the narrow, plankton-rich Lembeh Strait, this extensive trap-net system operated for at least 11 months in 1996 and 1997, capturing during that time over 1400 manta rays, 750 marlin, 550 pilot whales, 300 sharks (including whale sharks), and 250 dolphins, among others (Cochrane, 1997). Though the net has been removed (at least temporarily), its effect on the budding ecotourism/diving industry in North Sulawesi is only beginning to be realised.

### **Comparison of DFP effects**

While all of the above mentioned techniques are considered destructive, it is useful to examine the comparative damage wrought by each in order to prioritise management/enforcement activities. Such a comparison is obviously dependent on two factors: 1) the amount of destruction caused by one 'unit' of each DFP (e.g. one bomb), and 2) the frequency of use of each DFP (making this comparison site-specific). In our Indonesian experience, muro-ami and inshore trawling are generally so infrequent as to place them low in this comparison, despite their potential for habitat degradation. Likewise, bubu traps are not intrinsically damaging, though the increase in frequency of use for the live fish trade coupled with damaging installation techniques indicate that this is a growing source of reef degradation in Indonesia. In terms of overall destructive capacity though, blast fishing and cyanide fishing are indisputably the 'heavy-weights'. But which one poses the greatest threat?

In our opinion, blast fishing in Indonesia is by far the more destructive force. While reports from the Philippines indicate that cyanide fishers there often use vast quantities of the poison (Johannes & Riepen, 1995, report an incident of dumping 200-litre drums on the reef flat!), our experience in Indonesia has been that fishers are quite sparing in their use of cyanide. The observed result is that one bout of cyanide fishing on a reef kills far fewer corals than a day of blast fishing. This comparison is supported by McManus et al (1997), who suggest that coral death from cyanide exposure 'may not be that high.' A modeling exercise reported by those authors suggests that blast fishing is significantly more destructive to reefs, both in terms of causing higher mortality and greater reduction in the regrowth capacity of hard corals. In an economic analysis of Indonesian coral reefs, Cesar (1996) also shows that blast fishing accrues a larger cost to society than cyanide fishing, primarily by destroying a wider fisheries base and by impairing the coastline protection function of fringing reefs. Interestingly, many of the exporters in the live grouper trade made these points as well during interviews. One exception to this generalisation

was the situation observed in Pulau Seribu, where teams of divers were subjecting reefs to daily exposures of high concentrations of cyanide while searching for ornamental fishes—this type of treatment may actually be worse than blasting.

We do not mean to suggest that cyanide fishing in Indonesia is a minor environmental threat with reduced need for management. To the contrary, cyanide fishing may in large part be responsible for local extirpation of grouper stocks throughout Indonesia, and its use precludes the development of what could be an extremely lucrative *and* sustainable fishery (Johannes & Riepen, 1995). Our point is simply that although blast fishing is a more decentralised fishery with a lower public profile than the 'big-money' cyanide trade, it is nonetheless an extremely damaging practice which is deserving of top prioritisation in reef management and enforcement agendas.

### **Ethnic groups involved and socio-economic background**

Although destructive techniques are practised throughout Indonesia, certain ethnic groups seem particularly partial to the use of DFP. These groups include the Bugis, Bajau and Makassarese of Sulawesi, and the Madurans of NE Java. Representing the strongest sea-faring traditions in Indonesia, these four groups range widely throughout the archipelago, occasionally travelling over a thousand kilometres from their homes in search of under-exploited reefs. This extreme mobility results in two important characteristics of DFP in Indonesia: 1) Paradoxically, the most remote reefs in Indonesia are often the most destroyed; and 2) As these fishers are not bound to a 'home' reef system, they are never forced to deal with the destruction they bring to bear. Rather, as one reef system becomes unproductive, they simply move on. An interesting counter-example of this phenomenon comes from a Bajau village in the Tukang Besi archipelago, where these normally nomadic fishers were settled into a permanent village. One of the elder fishermen in this village explained that their fishermen had mostly given up blast-fishing after dramatic declines on their home reef were attributed to this DFP (Jos Pet, pers. comm.). This isolated experience provides support for the widely-held belief that education and especially marine tenure systems may be an excellent means of controlling DFP (see below).

One further important socio-economic characteristic of DFP in Indonesia is that the fishers involved typically earn very high salaries, often much more than government officials or university professors. This is in sharp contrast to the widely-held belief that small-scale fishermen in Asia are typically

'forced' to enter destructive fisheries by poverty from Malthusian overfishing (Pauley and Thia-Eng, 1988; Sloan and Sugandhy, 1994). In many cases on remote eastern Indonesian reefs, DFP may actually be the *first* technique to be used to capture reef fishes (local villages often focus traditionally on fisheries of small pelagics instead). Surprisingly, Panayotou (1988) notes that the socio-economic status of small-scale fishermen in Asia in general is often much higher than supposed, with incomes often equalling or surpassing national averages. In Indonesia, it definitely seems the case that the driving force behind the use of DFP is as much greed as it is need.

### **Scope for management**

Managing the diverse range of DFP used in Indonesia will undoubtedly require a multi-faceted approach, involving such actions as increasing enforcement of the existing laws against DFP, educating both fishers and government officials involved directly and indirectly with DFP, curbing the demand for DFP products, and promoting reef ownership rights within Indonesia. Below we briefly touch on each of these approaches while noting primary obstacles to their implementation.

Enforcement of Indonesia's existing anti-DFP laws faces a number of challenges, but we envision a three-pronged approach involving restricting access to materials needed for DFP, enforcement in the field, and enforcement at the landing sites and point of export. Restricting access to materials is perhaps the most difficult approach, as most Indonesian DFP utilise commonly-available materials, including fertiliser and kerosene for home-made bombs and sodium cyanide (which is used widely in the electroplating and mining industries). However, one of the materials needed for making bombs is both illegal and in short-supply—waterproof fuses. Truly restricting the availability of these fuses may help deter bomb production.

Enforcement in the field is often difficult as well; blast fishers and cyanide fishers simply dump bombs and squirt bottles overboard when a police vessel approaches. One innovative approach to combating this in the Komodo National Park is the outright ban of hookah equipment within the park—fishers are presumably much less apt to drop their compressor overboard when approached by a patrol (Jos Pet, pers. comm.).

Enforcement at landing sites and point of export is currently not an option in Indonesia, as the laws against DFP generally require that fishers are caught 'in the act' in order to prosecute them. If the

laws were expanded to make it illegal to possess cyanide-tainted fish or blast-caught fish, the potential for prosecution would be greatly enhanced. Such a change would allow the use of cyanide-detection tests such as those used in the Philippines (Barber & Pratt, 1997). The increasing trend towards air export of live fish would facilitate this process; cyanide-detection labs could be strategically located in each of the international airports in Indonesia. Using this approach on blast-caught fish is more logistically challenging; not only are these fish marketed at a much more decentralised network of landing sites, it is also more difficult to indisputably prove that fish were caught by blasting. The sale of schooling reef fishes with characteristic shattered backbones, bulging eyes and burst capillaries could at least provide the evidence needed for further investigation. With any of these enforcement approaches, the full cooperation of government officials is obviously a prerequisite, something which the extremely lucrative nature of these DFP often prevents.

Though seemingly obvious, educating fishers and government officials to the extremely short-lasting economic benefits of DFP and the long-term effects on local reef fisheries is an approach which is still desperately needed in Indonesia. In our experience, fishers rarely show any ecological appreciation of the maxim that 'healthy reefs = healthy fisheries', and the government officials charged with enforcing anti-DFP laws are rarely given any explanatory background on *why* such practices are illegal. An encouraging example of the value of such education involves the villages in the Senayang district of Riau, one of the chosen sites for the Indonesian COREMAP (Coral Reef Rehabilitation and Management Project). Pre-COREMAP educational activities in the district have resulted in both a district chief and fisher communities which can at least clearly verbalise the threats of DFP and their commitment to alternative methods. For policy-makers in Indonesia, the 'bottom line' seems to be an effective approach; the results of Cesar's (1996) 'Economic analysis of Indonesian coral reefs' have received widespread media coverage and generated a lot of discussion within government circles (M. Erdmann, pers. obs.). Continued educational efforts towards these ends are badly needed.

Curbing the demand for DFP products, especially those from the export-oriented live capture fisheries, is another important approach which unfortunately faces strong consumer resistance. Johannes and Riepen (1995) describe the obstacles faced by aquacultured grouper in the Chinese market, where 'rarity and wildness are major gastronomic virtues.' It may be a bitter pill to swallow, but those governments involved in exporting and

importing these products may have to face the very real possibility that the current demand for live, wild-caught grouper, wrasse and rock lobsters is so far in excess of the supply that 'sustainable' fisheries for these groups are impossible.

A final approach to combating DFP that has been widely-suggested is the promotion of local marine tenure systems as a means of encouraging villagers to protect their own reef resources (Panayotou, 1985; Johannes & Riepen, 1995). This approach has been highly successful in protecting marine resources in both Asian and Pacific Island cultures with long-standing tenure systems. As described above, the example of the settled Bajau village in Sulawesi demonstrates that 'owning' a reef not only encourages better management of reef resources but also promotes greater ecological understanding of reef processes.

Unfortunately, the current Indonesian framework for coastal resources management is highly sectoral and relies mostly on agencies at the national level; a current management priority is transferring some of this national authority over marine issues to provincial governments (Sloan & Sugandhy, 1994).

Furthermore, marine tenure systems require a strong, socially-structured community of fishers, a condition which is uncommon in our Indonesian experience. Rather, many fishing communities in Indonesia, especially those in South Sulawesi, seem to support the open-access nature of reef fisheries there, and show little interest in efforts to restrict this access. Again, this is likely related to their ultra-mobile fishing style; these fishermen rarely share the perception that overfishing is a problem, and may even view reef ownership as an unwanted infringement which would restrict their current mobility. Even in the Maluku region, the well-known sasi system of traditional marine tenure has generally ceased as the social structure of the fishing communities has been eroded by unemployment, emigration and short-term economic aims (Zerner, 1994). Against this social and infrastructural backdrop, village-based reef ownership schemes face an uphill battle in many parts of Indonesia.

Despite these problems, progress is now being made in strengthening village-based management of coral reefs in some areas of Indonesia. A notable example is the USAID-sponsored Coastal Resources Management Project (CRMP) in North Sulawesi, which is applying several different approaches in instituting community-based reef management schemes in three villages there, based upon models developed in the Philippines (Malik et al., in press). Progress to date is encouraging, and both provincial

and national-level officials appear very interested, if not outright supportive (Crawford, pers. comm.). The initial successes the CRMP has registered serve to highlight the value of applying lessons learned from countries with well-developed local marine tenure systems to establishing such systems in Indonesia. Indeed, there is now a wealth of information on the successes and failures of co-management of coral reefs from a number of Asian, African and Pacific Island nations (e.g. White et al., 1994) which should help to guide development of reef ownership schemes in Indonesia.

The preceding overview of DFP in Indonesia details more obstacles to than successes in efforts to curb the use of habitat-destructive fishing practices. Nonetheless, increasing public awareness of DFP and its devastating effects on Indonesia's reefs, especially among government policy-makers, provides reason for optimism in efforts to promote a reef-friendly fishing tradition throughout Indonesia.

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## Authors' note on effects of Asian monetary crisis

The preceding discussion of the economics of DFP in Indonesia is based upon data from interviews with fishermen through October 1997, before the effects of the current Indonesian financial crisis were being felt. It is not yet clear how the crisis will affect the use of DFP in Indonesia. On the one hand, more fishermen may be tempted by the relatively large financial rewards of using DFP, especially now that more traditional methods may not provide enough income to purchase now-expensive basic commodities like cooking oil. On the other hand, many of these DFP involve relatively expensive operations, including hookah compressors (requiring expensive imported spare parts) and the use of large, far-roving motorised vessels. If fuel subsidies are backed off in April 1998 as planned, those activities, which require large amounts of petrol, may become less profitable. This seems especially likely considering the fact that although prices for

almost all basic commodities in Indonesia have risen up to 500 per cent since the rupiah devaluation in November 1997, the price of fresh fish has remained the same (owing to its perishability). This should make blast fishing, for example, much less profitable.

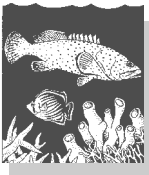
A related issue is the effect of the rupiah devaluation on prices paid for live reef food fish. As of January 1998, prices paid to fishermen in S. Sulawesi had only increased slightly (10–20% over those reported herein for September–October) compared to a 75 per cent devaluation of the rupiah. The net effect is that fishermen are now being paid a lot less (in terms of US\$) for the same fish. We intend to continue tracking the effects of the financial crisis on Indonesian DFP and will report further in the next issue of the *Live Reef Fish Information Bulletin*.

## References

- CESAR, H. (1996). Economic analysis of Indonesian coral reefs. The World Bank Environment Department Paper, Environmental Economics Series, Washington, D.C.
- COCHRANE, C. (1997). Sulawesi's curtains of death. *Action Asia* 3: 15–17.
- ERDMANN, M. (in press). Destructive fishing practices in the Pulau Seribu Archipelago. **In:** UNESCO Reports in Marine Science, Proceedings of the UNESCO Coral Reef Evaluation Workshop, Jakarta, Sept. 1995.
- ERDMANN, M. & L. PET-SOEDE. (1996). How fresh is too fresh? The live reef food fish trade in eastern Indonesia. *NAGA*, the ICLARM quarterly, 19: 4–8.
- JOHANNES, R.E. & M. RIEPEN. (1995). Environmental, economic and social implications of the live reef fish trade in Asia and the western Pacific. Report to The Nature Conservancy and the South Pacific Commission. 82 p.
- MALIK, R., S. BERHIMPON, A. WOWOR, C. ROTINSULU & B. CRAWFORD (in press). The environmental and socio-economic context of destructive fishing practices in the village of Tumbak, North Sulawesi. **In:** Proceedings of the APEC Workshop on the Impacts of Destructive Fishing Practices on the Marine Environment. December 1997, Hong Kong.
- MCMANUS, J., R. REYES & C. NANOLA. (1997). Effects of some destructive fishing methods on coral cover and potential rates of recovery. *Environmental Management* 21: 69–78.



- PANAYOTOU, T. (ed.). (1985). *Small-scale fisheries in Asia: socioeconomic analysis and policy*. International Development Research Centre, Ottawa, Ontario.
- PAULEY, D. & C. THIA-ENG. (1988). The overfishing of marine resources: socioeconomic background in South-east Asia. *Ambio* 17: 200–206.
- PET-SOEDE, L. & M. ERDMANN. (in press). Blast fishing in SW Sulawesi: an increasing demand for fertilizer. *NAGA, the ICLARM quarterly*.
- SLOAN, N. & A. SUGANDHY. (1994). An overview of Indonesian coastal environmental management. *Coastal Management*. 22: 215–233.
- WHITE, A., L. HALE, Y. RENARD & L. CORTESI (eds.). (1994). *Collaborative and community-based management of coral reefs*. Kumarian Press, Connecticut. 130 p.
- ZERNER, C. (1994). Tracking Sasi: the transformation of a central Moluccan reef management institution in Indonesia. In: *Collaborative and Community-Based Management of Coral Reefs* (eds. A. White, L. Hale, Y. Renard & L. Cortesi) Kumarian Press, Connecticut. 19–32.



## Wild collection of juveniles for grouper mariculture: just another capture fishery?

by Yvonne Sadovy<sup>1</sup> & Jos Pet<sup>2</sup>

Heavy fishing pressure in Southeast Asia has led to declines in fish catches and overexploitation of many demersal fish stocks, yet demand for fish is projected to grow rapidly, especially in certain sectors such as the high-value live reef-fish trade (LRFT) (e.g. Johannes & Riepen, 1995; Sadovy, in press). Mariculture is viewed as one possible way of relieving pressure on fish stocks, as well as a means of filling the increasing demand–supply gap for marine fishes (Williams, 1996). In discussing the contribution of aquatic resources to global food security, however, Williams (1996) cautions that ‘There is potential for aquaculture to make a large contribution to world food supply, but only if it is environmentally sustainable’.

Most fish culture in Southeast Asia is based on the collection of juveniles (fry or fingerlings) from the wild and their grow-out in captivity to marketable size. Fish production based on grow-out is generally considered, for statistical and management purposes, to represent ‘mariculture’, rather than ‘capture fishery’, production, even though juveniles are taken from the wild, because there is intervention (feeding) in the rearing process to enhance production (e.g. the Food and Agriculture Organization). The possible impacts on stocks of the removal of juveniles from the wild for mariculture, and whether or not production is actually

enhanced through this kind of mariculture practice, are rarely considered. This is despite general concerns that ‘For too long fisheries and aquaculture have been treated as sectors in isolation, a practice that has ignored important linkages and externalities’ (Williams, 1996). We need to examine some of these linkages.

A critical question is whether mariculture practices based on the capture of juveniles from the wild are sustainable, or could be modified to become so. We examine these questions using groupers as an example, because groupers are widely cultured in the region, and are highly desired and valued in the LRFT. They are also among the most vulnerable of the reef fishes to exploitation (e.g. Huntsman et al., 1993; Sadovy, 1996).

In pelagic spawning (in which eggs are released and then drift away) fishes, such as the groupers, early natural mortality rates must be extremely high between egg production and settlement (when young fish change from their planktonic to their benthic phase). This follows from the fact that, in her lifetime, each female is capable of producing millions of eggs but will, on average, only produce two young that survive to adulthood under stable population conditions. What is not known is where the bulk of this early natural mor-

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