THE EFFECTS OF HUMAN POPULATION PRESSURE ON FISHING METHODS: FROM NETS TO DYNAMITE TO CYANIDE

by

N.G. Willoughby[1], Victor Nikijuluw[2] and Kedi Suradisastra[3]

ABSTRACT

Growing population pressure has resulted in greater fishing pressure in coastal zones. Normally this should have resulted in fewer yields per fisher; however, at national level, this expected reduction has not occurred, perhaps as a result of more dispersed fishing grounds, changes in technology and more effective effort application. Furthermore, statistical data from Indonesia do not support the hypothesis that fishers' absolute earnings are declining. The truth of this situation with respect to fishers active in the coastal fisheries (especially the coral reef fisheries) and the usefulness of government statistics in this regard, are examined. Traditional fisheries management methods are analysed, and their role in maintaining subsistence fisheries is assessed.

In order to counteract the perceived or real losses of earnings, some inshore fishers are changing from traditional fishing methods to destructive, non-sustainable methods using dynamite or cyanide. Three such fisheries are examined: dynamite (blast) fishing, the use of cyanide to catch live food fish, and the use of cyanide in the aquarium fish trade. An appraisal is made of which segment of the fishing community is using these methods, and why they are using them.

Strategies to counteract the non-sustainable, reef-destroying methods are discussed: reducing open access and strengthening traditional management; providing alternative employment opportunities in ecotourism; developing sustainable culture methods and encouraging the use of less harmful capture methods for aquarium species.

1. INTRODUCTION

Following the UN Conference on the Environment and Development (UNCED, Rio de Janeiro, 1992), many world bodies have moved towards encouraging more responsibility in the use of the world's natural resources, hoping for greater sustainability than might otherwise be expected. The Food and Agriculture Organization of the UN is among these bodies, and has recently produced a document (FAO/UN, 1995) outlining a voluntary code for 'responsible' fisheries.

This paper considers the trend towards 'irresponsible' fisheries and the pressures driving the trend.

[1] Marine Resources Evaluation and Planning Project, Jakarta, Indonesia; Central Research Institute for Fisheries, Jakarta, Indonesia & Natural Resources Institute, Chatham, United Kingdom.
[2] Research Institute for Marine Fisheries, Jakarta, Indonesia;
[3] Marine Resources Evaluation and Planning Project, Jakarta, Indonesia.

In prehistoric times, the amount of human fishing and gleaning activity in coastal zones was insufficient to have significant adverse effects on local stocks. Apart from leaving piles of shells or fish bones and the occasional pieces of broken boat in settlement areas, there was little lasting evidence of human activity. This was not necessarily because the prehistoric coastal inhabitants were more environmentally aware than people of today (though they might have been) but because the carrying capacity of the coastal zone was sufficient for all those who wished to use it.

Times have changed. Developments in medical, agricultural and physical sciences have allowed enormous increases in human populations, particularly over the last 100 years. Coastal zones, which contain 70% of the world's population, are frequently the areas with best soil, easiest trade, or most pleasant climate. These areas, now densely populated, have some of the biggest problems in maintaining the sustainability of their environments. The pressures on the resources of the coastal zone from traditional and more recent population sectors are growing rapidly, and many fishers who used to use sustainable practices have turned to destructive, non-sustainable methods.

2. INDONESIAN COASTAL FISHERIES

Two types of fisheries dominate Indonesia's coastal areas: normal capture fisheries, which produce most of the country's fish; and the brackish water or 'tambak' culture fisheries, which produce large quantities of fish and high value prawns.

2.1 The coastal fishery

The total value of marine fisheries to the economy is approximately Rp2 900 billion (US$ 1 250 million).

Indonesia's marine fisheries are made up of the coastal fisheries, which contribute approximately 90% of the catches, and the offshore tuna fishery which contributes about 10%. Unfortunately it is not possible to separate some of the parameters of these two groups satisfactorily, so the following data refer to the whole marine sector.

Marine fisheries statistics (Table 1) show that recorded landings rose steadily over a ten year period, from 1.7 million t in 1984 to 2.9 million t in 1993. The number of marine fishers has also risen steadily from about 1.3 million in 1984 to 1.9 million in 1993. Productivity per fisher rose from 1.32 t/yr in 1984 to 1.56 t/yr in 1990 and has since fallen slightly to 1.53 t/yr. The value of the fish caught, after adjustment for inflation, has also increased over at least the last 5 years (DJP 1995), and the average price obtained by fishers for their catches has been calculated as Rp1 000/kg (US$ 0.44/kg) (Mathews, 1996). In broad terms, therefore, there is little evidence to suggest that the average Indonesian coastal fisher is worse off than he or she was in the 1980s.

These data are thought to hide many inconsistencies, with fisheries for certain stocks or in particular parts of the country developing, while those in other areas have declined significantly.

First, the data concern fishers who wish to sell their catches, and thus bring them to central markets. Many, perhaps the majority of subsistence fishers, fish to eat, not to sell - and are therefore distinguished here as 'subsistence' rather than 'artisanal' operators. Their catches are for consumption by family members. The number of purely subsistence fishers is unknown, but may be considerable. The amount of fish held by fishers for their own consumption is certainly in the order of several hundreds of thousands of tonnes. For example, if each member of a fisherman's family of four eats only 1 kg of fish/week, this would be equivalent to 400 000 t of fish/year, an extra 15% to total estimated marine landings.

Secondly, it is apparent that in very many cases the whole fishing operation is very much more expensive than it used to be. This is partly because the fish to be caught are farther away, requiring the use of a boat with an engine to reach newly located fishing grounds, plus the amount of gear needed to justify (repay) the costs of boat and engine investment. Thus today's artisanal fisher has to invest much more in his business than in the past. Another feature is that the stocks closest inshore are being, or have already been, fished out, and efforts to extract the last fish have resulted in damage to habitats, which is likely to prevent re-establishment of a fishery at a later date.

Thus government statistics are considered inadequate to cover traditional subsistence fisheries in the near inshore zone, where traditional management controls might be expected to operate. The next section discussed what state these are in, and whether they have they been very effective in counteracting stock depletion and habitat destruction.

2.2. 'Tambak' aquaculture

The second major fisheries activity in coastal zones is brackish water aquaculture, or 'tambak' fishery. Although the tambak fishery employs only one tenth of the number of people in the marine fishery sector, its productivity and the value of the shrimp and fish produced makes it worth slightly more than half the marine fisheries value, nearly Rp1 800 billion (US$ 760 million).

Table 2 presents data on tambak fisheries between 1984 and 1993. During this time, yields and values of the fishery more than doubled as more and more coastal land was converted for tambak use. The average price to the fishermen for the shrimps and fish caught by this fishery has been calculated as Rp5 000/kg (Mathews, 1996), five times that for marine fish.

However, tambak operators are seldom ex-fishermen; they are more likely to be ex farmers who are used to the idea of providing regular inputs to a farming system, rather than the bursts of 'hunting' activity characteristic of fishing. While presenting a potential, though little used, source of alternative employment for coastal

fishers, tambak fisheries have rather little relevance to the effects of coastal fishers on the marine habitat. (The cutting of mangrove areas to permit more tambak farming is another environmental problem, but not one which will be considered here.)

3. TRADITIONAL FISHERIES MANAGEMENT

Many inshore and coastal fisheries are under considerable stress from over-exploitation because of the number of people who feel they have a right to take from the limited resources. Traditional management techniques may be able to deal with this problem to a certain degree.

Traditional management is frequently viewed as the panacea of fisheries regulatory methods. Surely, if the management of a resource is left to the people who have been living with it and controlling its utilization safely for centuries, everything will be all right? If the traditional stake-holders are kept in the system, won't this help maintain sustainable management? Some of the types of management operating in different parts of Indonesia, and how well tradition is withstanding modern pressures, are discussed below.

There are four main features which can be used to describe different types of traditional regulation of marine stocks (Blowfield 1995):

- Territorial sovereignty. This usually means that the village immediately opposite a fishing ground or reef exerts exclusive control over who should fish or collect marine produce from that area. Permission for villagers from other areas to fish within the zone may be given by the village authorities. This can be either as a right, if the 'visitors' have kinship ties, or for a fee of some sort (cash or in kind) if they are not taking stocks of importance to the controllers.

- Regulation of exploitation. Territorial sovereignty refers to who uses a resource; regulation of exploitation refers to how and when. The 'sasis' of Maluku are a good example of the latter, deciding when the village should allow individuals to fish. Communities may also cooperate in communal fishing, with everybody in the village playing a part and sharing in the catch.

- Individual access rights. These permit a particular individual, either from within or outside the community, to fish in certain waters. Although the rights will benefit that person, they may not necessarily contribute to the welfare of the whole community.

- Communal resource exploitation. This is social insurance, related to the 'sasis', in which all members of the community benefit from a period of resource exploitation irrespective of their social status within the village. This will certainly help maintain the cohesion of the community, without which the sustainability of the resource would be at greater risk from external influences.

Several different types of community management regimes have been recognised by fisheries anthropologists.

Sasi: The 'sasi' ('prohibitions' or 'witness') of Maluku consist of a series of rules set up, in some cases, at least 400 years ago, and managed by the village authorities, to ensure that the community's natural resources were distributed equally among the inhabitants. For the marine 'sasi' the rules govern the area to be fished, the species, the gear, the times and the penalties for non-observance. The penalties can be as serious as expulsion from the village (Nikijuluw & Naamin, 1994; Kissya 1993). The system combines territorial control with regulation of exploitation. Although the system is still strong, it is under threat from external fishers.

Panglima Laut: This system (meaning 'sea commander') is found in Aceh, in northern Sumatra. An individual is responsible for overseeing fisheries-related socio-cultural traditions, including settling disputes, and determining the areas to be used for mooring, fish sales etc., as well as the actual fishing operations. This system appears to be on the decline, perhaps because the younger generations are less interested in it, or the controls it places on them (Nikijuluw & Naamin, 1994).

Ambo Island Royalty System: The authorities governing the Ambo Island group in the Straits of Makassar found it necessary to develop a system of royalty charges for fishing. These charges started to be levied against both the Ambo islanders and visitors, as the number of visiting fishers wishing to fish around Ambo grew rapidly at the start of the century. The system makes different charges for native villagers and visitors, and results in the islands generating revenue from all concerned for community activities. Unfortunately not all outsider fishers agree with the rates charged, and the system currently needs re-examination (Naamin & Badruddin, 1992).

Separation of Target Species: Conflict is reduced if fishers are not attempting to take fish from the same stock. An instance was noted in Central Java - not an area where traditional management would be expected to retain much importance - in which incoming fishers were permitted to settle provided they used fishing gear which would not catch those stocks usually caught be local residents. By using multi-hook unbaited longlines in an area fishing with gill nets and traps, the new fishers caught mainly rays, and were allowed to remain in the area on payment of a fee to the village authorities (Sya'rani & Willoughby, 1985).

There are many areas of Indonesia in which 'traditional management' is hard to define, yet community support is widely practised. In much of the world, fishers are secretive about their fishing areas, methods and catches. In several parts of eastern Indonesia, the knowledge or ability of one fisher becomes common property for the potential benefit of the whole village. Thus in Biak and other areas of Irian Jaya, the fishers frequently share catches with their neighbours; the Sangir fishers of North Sulawesi share their knowledge of good fishing grounds; and the Minahasan fishers prepare and discuss their plans before departure (Suradisastra, 1996). In situations where many sorts of disaster might befall a fisher, these social requirements are a community insurance policy, encompassing a much larger group than merely family ties.

Unfortunately all these traditional management systems rely on the goodwill of the individuals concerned and a willingness to abide by the authority of the village elders who set the rules and the village community which enforces them. They are not supported comprehensively by national or provincial laws. As younger members of village communities return from provincial or national centres where they have been educated, they are frequently less willing to accept the communal controls which were accepted by their fathers.

Common fisheries - the tragedy of open access

Traditional fisheries are frequently viewed as a common property resource and suffer from the 'tragedy of the commons'. Nobody owns them so everybody can take what they need - or more. In fact traditional fisheries are open access rather than common property, and it is the open access and lack of legal control at village level which allows problems to develop.

4. OVER-EXPLOITATION - THE PRESSURE FOR CHANGE

There are two areas from which pressure on traditional management systems will develop - internal pressures from people within the system, and external pressures from non-village resource users.

When human population pressure builds up beyond the carrying capacity of the resource (be it field, forest or ocean), either some people have to move away, or the rate of resource utilization becomes non-sustainable. Traditional management begins to break down: for example, if too many village residents insist on the right to feed their families from the resource, and the local traditions and taboos are insufficient to prevent this.

Another scenario is that people from outside the traditional control area perceive a fishing (or farming or forest) opportunity and take it, with no reference at all to local authorities, thus increasing resource use and ultimately destroying that resource. If persuasion and local policing cannot solve the problem, and the villagers have only limited legal jurisdictional rights, the external fishers are likely to strip the area of its resources before moving on to the next village to do the same.

4.1 Traditional methods and overfishing

What is overfishing? In simple terms, it is too many fishers trying to take more fish than possible on a sustainable basis from a stock. Too many boats or too many fishers are permitted to fish in an area; or they are allowed to use too much or the wrong type of gear, resulting in the breakdown of sustainability.

With a dwindling fish resource, fishers will find their catches declining, unless they adapt to the new conditions. If they remain as fishers, they would have to use progressively smaller and smaller meshed nets to maintain catch rates. This means

that they will take smaller or younger fish, which have not had a chance to breed, and this would quickly result in overfishing and a serious depletion or wiping out of stocks.

Most fishing regulations are designed to reduce the pressure on stocks - and usually aim to do this by making fishing less efficient in terms of either capture or economics. If a boat is only allowed to fish at certain times of year, or using types of gear which let more fish or certain types or sizes of fish escape, or adds taxes to the costs of the boat, gear or its operating costs, this should reduce the amount of cash left to the fisher at the end of the fishing year. He or she will try and counteract this by finding methods (within or without the law) to increase the amount or value of fish caught.

4.2 Expectations

In addition, but very importantly, people's expectations throughout the world are rising, partly as a result of advertising and greater mobility of populations. In the recent past, fishing from an inshore, sail-powered or paddled boat was sufficient, and would provide food for the family with perhaps a bicycle and radio as luxuries. Now fishers aspire to outboard engines, televisions and motorbikes - and why not? These are normal aspirations, but more raw material (in the form of fish) is needed to pay for them in a situation where more fishers are chasing fewer fish. The outcome is initially overfishing through excessive use of legally approved gear or illegal gear of conventional style (smaller meshed nets, narrower barred traps etc.). Later come unconventional, illegal and destructive methods such as dynamite and cyanide fishing.

4.3 Data sources

While obtaining data from fishers is never easy when asking questions on behalf of governments about the fishers' legal operations, the problems of obtaining valid data become much greater when the operations are of questionable legality or are known by all concerned to be totally illegal. Thus more of the following data are anecdotal than would be preferred, and have few hard facts to support them. Much can certainly be improved and updated by workers who have close ties with fishing communities.

5. DYNAMITE (BLAST) FISHING

Although fishing with dynamite and other explosive devices is banned world-wide, it happens, and has probably been happening since shortly after dynamite was invented. It was apparently a major cause of the decline in Mediterranean fisheries (D. Bellamy, pers.comm., 1996) so is not (or was not) exclusively a destroyer of coral reef environments.

5.1 The explosive supply

Dynamite supplies in many countries are officially kept only by government organizations or specially licensed groups such as mining companies. However, illegal supplies can always be obtained from corrupt sources, or alternatively, explosives devices can be made from material purchased legally in firecrackers or fertilizer mixtures (Suradisastra, 1996). Invariably those who wish to obtain explosives apparently have little difficulty in obtaining supplies.

5.2 The operators

Many coastal fishermen throughout the world can provide precise technical information on how to create local bombs for fishing purposes, yet deny personal involvement in their usage. In areas where blast fishing is known to take place, the local villagers may happily buy the fish, yet the village will certainly say that those who use the explosives are from the next village or are visitors to the area.

5.3 The methods

Methods of dynamite fishing vary according to area, but are frequently organized by operators from relatively large boats (10-20m) who employ local fishermen to throw the bombs from their canoes into areas where fish are known to congregate. This is frequently over fairly shallow reefs of 3-10m depth (Wakatobi Divers, pers. comm., 1996) or more rarely over sea-grass beds (Willoughby, 1991). Most of the blast-killed fish, perhaps 80%, sinks to the bottom and is collected by divers from the mother boat using hookah apparatus, an on-board compressor with air piped to the divers below. The fishermen in the boats collect the 20% of fish which float on behalf of the mother boat, and are then paid in fish. Fish of sub-commercial size would probably be collected by the fishermen if they floated, but are more likely to sink and be lost to both the collectors and the fish population. A single bombing may take half an hour to complete, after which the boats move somewhere else. The operations are preferably carried out in strong daylight so that conditions for collecting the fish underwater are at their best. Obviously reefs suffer from the bombing, though the bombing only takes place near them because fish aggregate there.

It might be expected that because bombing is well known to be illegal, it would only occur well way from habitation, in isolated places. It does occur in isolated places: for example, serious bombing affecting isolated tourist dive sites such as in the Tukang Besi Islands of South East Sulawesi, has been reported (Wakatobi Divers, pers. comm., 1996); but unfortunately, nearby human settlement does not save the reefs. A substantial amount of bombing occurs close to the South Sulawesi capital of Ujung Panjang (B. Hoeksema, pers. comm., 1996) and the Thousand Islands of Jakarta also suffer significantly from bombing (R. Harger, pers. comm., 1995).

If the bombing was done by local subsistence fishers on their own reefs and simply to catch enough fish to feed their families, there might be less of an outcry in social if not ecological terms. The fishery of desperation is readily understood, even

if alternative means to satisfy the need were preferable. Unfortunately, it is almost invariably carried out at the instigation of businessman who want large quantities of quality fish to sell, and employ fishermen from nearby areas to bomb their neighbours' common access reefs. While local fishers may try and protest about this and protect their reefs, the boats concerned in the bombing are frequently much more powerful than theirs, so can easily evade 'citizens' arrest'. In some cases they are apparently even prepared to use their explosives on the potential arrestors such as recently happened to wardens in Komodo National Park (cit E Salim, 1996).

There are also potential health problems for the users of explosives. Rather high proportions of these quasi-fishers eventually find a home-made explosive device going off before expected, leaving them with mangled limbs at the least.

A possible solution to the problems of dynamite fishing is one of greater legal empowerment for village ownership of adjacent reefs, as in Bunaken National Park (G. Usher, pers. comm., 1996); this will be considered in more detail below.

6. POISON FISHING

As with blast fishing, poison fishing is banned world wide, so it is difficult to collect information on its use.

Catching fish by poisoning is one of the oldest fishing techniques known to man. Poisons, such as derris root, which de-oxygenate the waters, leaving fish gasping at the surface and easily available for capture, have been used in freshwater fisheries for thousands of years. However, the use of vegetable poisons is relatively benign: the poisons are rapidly dissipated and the effects on other parts of the (usually freshwater) ecosystem are rapidly diluted.

Today's concerns are more potent, chemically manufactured poisons used in coastal zones. The main one of these in Indonesia and other tropical countries is potassium cyanide. This method has been introduced to Indonesia following extensive use in the Philippines fisheries, and is now widely practised in inshore marine fisheries throughout the archipelago. Potassium cyanide is put into bottles from which it can be squirted into holes in reefs which may harbour fish of particular interest.

Cyanide fishing is important in two fisheries: the aquarium trade and the live food fish trade.

6.1 The live fish trade

The export of live food fish to predominantly ethnic Chinese markets in Hong Kong and China is growing rapidly. Exports could be specimens caught by hook and line or traps on the reef flats and slopes, or cultured in marine enclosures, or they could be caught by cyanide fishing.

The method

The cyanide live fish fishery is carried out by two types of fishers: individuals working alone or in small groups in locally modified boats; and well organized teams of divers using specially equipped fibreglass dinghies associated with a larger mothership equipped with tanks for the catches (Erdmann and Pet-Sonde, 1996).

The fishers use cyanide solution in plastic bottles supplied by the anticipated buyers. The solution is squirted into holes in the reef where particular fish are known to be hiding. Target species include rock cod and groupers (*Epinephelus* spp., *Plectropomus* spp., and *Cephalophus* spp) and the Napoleon wrasse (*Cheilinus undulatus*), which is now an illegal export from Indonesia. The cyanide stuns the fish and allows them to be captured after being broken out of their holes in the reef. Many recover from the poisoning sufficiently to be sold as 'live', while those which die simply enter the normal fish marketing system, in either Indonesia or overseas, along with their cyanide.

Erdmann and Pet-Sonde (1996) report that the market for live food fish from Indonesia was probably about 2 200 t in 1995, but other data suggest the total trade from Indonesia could be 9 000 t/year (Nature Conservancy, 1996) (Table 4). Hong Kong and Singapore imported 25 000 t in 1995, with wild fish estimated to have made up 60% of this total, the bulk of which came from Indonesia.

Prices paid to Indonesian fishers range from Rp8 000-19 000/kg (US$ 1.6-3.7/lb), depending on species (Table 3). The same fish sell later on tables in Hong Kong for between Rp200 000/kg and Rp300 000/kg (US$ 40-60). There is even one instance of US$ 5 000 (Rp11 000 000) being paid for a 40 kg Napoleon wrasse - Rp275 000/kg! (Erdmann and Pet-Sonde, 1996).

Buyers in Hong Kong and Singapore estimate that Indonesian fisheries for the live fish trade will be exhausted in 3 - 4 years, and that they will then concentrate on Papua New Guinea and the Pacific Islands (Johannes and Riepen, 1995).

The total value for the live food fish trade could be about US$ 20 million to Indonesia on the basis of the 2 200 t/year catch and US$ 4/kg paid to the fishers. However, many fish will die for each one which reaches the market. Data from Erdmann and Pet-Sonde (op. cit.) indicate that approximately equal quantities of live and dead groupers are landed in Ujung Pandang, one of Indonesia's centres for this trade. They suggest that the dead fish are cyanide fish which did not live long enough.

The problems for reefs which are fished using poison is that not only are the coral areas killed by the poison, but also that large pieces of coral may need to be removed in order to extract the fish from its hole in the reef, further degrading the reef as a habitat. Johannes and Riepen (op. cit.) report that the concentrations of cyanide used are hundreds of times in excess of that needed to kill many of the reefs' corals and other invertebrates.

While the dynamite fishery may primarily supply national consumption, Indonesian domestic markets for live marine fish caught by the cyanide fishery are thought to be very small compared with the overseas markets. Thus virtually all the live fish is thought to be exported. The fishers operating in this sphere are therefore operating solely in the cash economy.

6.2 The marine aquarium trade

The aquarium trade in Indonesia has been studied by Lillie & Setiawan (1995) among others. The most recent government statistics on this trade (largely for 1993) are a little confusing as they deal sometimes in the number of fish exported and sometimes in the weight of fish exported, including the water and packaging.

If it is assumed that half the fish counted as exported are marine (though it may be significantly less than this), a figure of about 20 million fish/year for 1993 is reached. On the basis of prices quoted by Lillie as being those charged by an Indonesian dealer in the provinces, and down-grading this to what the dealer might pay the fisherman, a price of Rp1 000/fish is reached (which is thought to be not unreasonable), giving the overall trade a value of about US$ 10 million at the level of the primary supplier - the fisherman.

As with live food fish, most aquarium fish are caught using cyanide to stun the fish, then breaking the reef apart as necessary to extract them. This technique was brought into the country from the Philippines, where many reefs have been wiped out by its use. The poisoned fish have to live much longer than those destined for the live trade, so the balance between stunning and recovery is much finer, and it is probable that at least 5 fish are killed for each one which lives for more than a few days in the tank. Thus the destruction to the reefs is likely to be much greater than is implied by the export of 20 million fish/year, because in all probability 100 million/year are in fact being taken. This analysis does not take into account the small but growing interest among the upper echelons of Indonesian society for tropical marine aquaria.

Despite the enormous sums paid to fishers for live food fish, the value of aquarium species per kilogramme is much greater. If the fisher is paid Rp1 000 for an average 10g fish, this gives the equivalent of Rp100 000/kg or US$ 43/kg to the fisher. For more valuable species such as the butterfly fish, prices of up to U$ 200/kg would be reasonable. When it becomes possible to farm or ranch these species, the value of the crop will be very high indeed - though prices would probably decline as the farmed supply improves.

Fishermen who operate in this trade are commissioned by local buyers to find certain types of fish which are of interest to the consumer - primarily the hobbyists in Europe or the USA, through wholesalers in Singapore. As the fish requested by the aquarium trade are generally small, the individual cyanide operations harm the reefs less than those for live food fish, though they may be more frequent. This work may also employ women and children to collect those species which exist in reef pools.

6.3 The tempted fishers

Earlier, it was acknowledged that the average Indonesian artisanal fisher is probably not significantly worse off economically than ten years ago (though they might perceive themselves to be). However, much empirical evidence suggests that the poorer elements of fishing society, the subsistence fishers who fish or glean around inshore reefs, are finding it harder to catch or collect sufficient extra marine protein to supplement their family diets than they did in the past.

The possibility of some of these fishers turning to blast fishing or cyanide fishing is real, though it is suggested that this would be of marginal importance to either fish stocks or reef health in most places. Furthermore, there might be considerable sympathy with such activities of desperation fishing - were it not for the fact that they were on the slippery slope of their own local habitat destruction. There are less environmentally damaging methods of catching fish for the aquarium trade (e.g., netting, see below). To stop small-scale users of cyanide catching fish for the aquarium trade, it may be enough to provide some educational support in the use of these methods, or to provide alternative employment to ensure financial security.

The main problem is considered to be fishers who choose or feel forced by their economic circumstances to take part in destructive fisheries. These are fishers who would be employed by businessmen (usually non-fishermen) to obtain either dynamited fish for food, or poisoned species for the live food fish trade or large quantities of aquarium species. These would be the ones who would target their neighbours' reefs for dynamiting or cyaniding. They are driven by short-term greed, and have a disregard for the long-term consequences of their activities.

7. SOLUTIONS

Are there solutions to these problems - the downward spiral from a sustainable traditional fishery through non-sustainable methods to illegal and definitely destructive methods? Part of the problem is that too many people are trying to catch too few fish, but the other side is that there are fishers or ex-fishers who are keen to maximise their personal profits through commercial activities of dubious legality, at the expense of the environment and their fellows. No solution is complete by itself, but several possible solutions can be put forward.

7.1 Open access

Common rights exist in many parts of the world, and not only in fisheries. Bunaken National Park near Manado seems to have less bombing and cyanide fishing than most areas, even less than other national parks such as Komodo - see earlier. Usher (pers. comm., 1996) puts this down to the 'ownership' of access given to the 20 000 fishermen living in the park and fishing, sustainably and non-destructively, in its waters. The villagers actively prevent others coming from outside the park to destroy the habitats of their fish, and with it their livelihoods. At present Indonesian law does

not give villagers any legal rights over the waters offshore from their villages (though this may shortly change, as a Presidential decree is in draft). Once village groups are given legal control of their resources, they may guard them better.

7.2 Traditional management

How might the passing of such a decree affect traditional management systems? It is thought that a law giving villagers modern, legal rights over water areas, rather than just traditional rights, would give great support to local authorities who are trying to maintain traditional control methods. There would still be a need for timely support from law enforcement staff to make the supporting law work well.

7.3 Employment opportunities

Alternative employment opportunities outside fishing are always being sought by some members of the community. Fishing is often the employment of last resort for poor people, especially in areas where certain sectors of the community are prevented from owning land or cultivating crops. If dynamite and cyanide are banned and this ban is enforced, fishers will be put out of employment.

Ecotourism

One of the groups pressing hardest for such bans to be enforced would be the tourist industry, as dynamite and cyanide adversely affect reefs on which their businesses depend. If there was more paid employment in the tourist industry for local people when such businesses were initiated, not only would some of the potential bombers or cyaniders be taken out of that sphere, but they would then have vested interests in keeping others out of it. The village as a whole might also be persuaded to feel greater ownership of the attractions appreciated by the tourists.

Sustainable culture fisheries for food fish

Other countries such as Taiwan are able to culture some of the species of particular interest to the live fish trade. There is no reason why Indonesia should not invest in such culture methods. This aquabusiness opportunity would take the pressure off Indonesia's wild reef stocks, while providing work for people in the communities near the reefs.

Aquarium fish trade

The same thing applies to the aquarium fish trade, though perhaps there are two projects here.

i) Aquarium fish suppliers in the Philippines have had a very bad world press for using cyanide to catch aquarium fish. At one stage, aquarium fish coming from the Philippines were virtually unsaleable because of the suspicion that the fish would not survive for long because of the effects of cyanide. Since them some operators have changed their capture methods to use only sustainable netting operations. This is

a technique which Indonesian aquarium fish collectors could use. It makes fish capture more difficult, but losses are negligible by comparison, and if the relevant government authority was prepared to certify companies using non-destructive methods, sales of their fish would be assured.

ii) Few species of marine aquarium fish are currently bred in captivity, though it must only be a matter of time before commercial and moral pressures force suppliers to develop full non-destructive sustainability of supplies. The country which can develop techniques for breeding even a few of the most keenly sought after species will gain both economically and morally in terms of the sustainable aquarist trade. If we look at the value of fish from different sources or taken by different methods from within the coastal zone (Table 5), it is possible to see where the greatest returns might lie and at the same time help to conserve the coastal reefs by converting them to farmed aquarium fish nurseries and ranches.

ACKNOWLEDGEMENTS

The assistance is acknowledged of many staff and colleagues at CRIFI and RIMF who have contributed to the development of this paper, perhaps unwittingly, during discussions on non-sustainable fisheries. Dr. Chris Mathews and Ir M Badruddin have commented critically but usefully on early drafts.

REFERENCES

Blowfield, M. 1995. MREP Anthropology Guidelines. Unpub.Rept. to MREP and CRIFI. 16p.

DJP. 1995. Directorat Jendral Perikanan, Statistic Perikanan Indonesia, Dalam Angka, 1993.

Erdmann, M.V., and L. Pet-Soede. 1996. How fresh is too fresh? The live reef food fish trade in Eastern Indonesia. *ICLARM NAGA,* 19: 4-8.

FAO. 1995. Administrative report of the Technical Consultation on the Code of Conduct for Responsible Fishing. *FAO Fish. Rep.* 515, 48p.

Kissya, E. 1993. Sasi Aman Haru-ukui. Tradisi kelola suberdaya alam lestari di Haruku. Seri Pustaka Khasasah Budaya Lokal No 2. Yayasan Sejati, Jakarta.

Lillie, A., and A. Setiawan. 1995. Ornamental fish survey. Interim Report to MREP and CRIFI. 62p.

Mathews, C.P. 1996. Research management and development of aquatic production systems in Indonesia. Report to the Participatory Assessment of Agricultural Technology Project (PAATP). 33p.

Naamin, N., and Badruddin. 1992. The role of coastal village communities and fishermen's organisations in the management of coastal resources in Indonesia. *FAO Fish. Rep.* 474, Vol. 2: 490-497.

Nikijuluw, V.P.H., and N. Naamin. 1994. Current and future community management in Indonesia. *IARD Journal*, 16:19-23.

Suradisastra, K. 1996. Study on fisheries social structure in the islands of Biak and Supiori, Irian Jaya. Unpub Rep. to MREP and CRIFI. 10p.

Sya'rani, L., and N. G. Willoughby. 1985. The traditional management of marine resources in Indonesia, with special reference to Central Java. **In**: The traditional knowledge and management of coastal systems in Asia and the Pacific. K. Ruddle and R. E. Johannes (Eds.). UNESCO Regional Office, Jakarta, Indonesia.

Willoughby, N. 1991. Tanga, Tanzania: Integrated coastal zone management plan - fisheries component. Unpubl. Rep. to Govt. of Tanzania and NRI, Chatham, United Kingdom. 23p.