

Annex 1

DESTRUCTIVE FISHING PRACTICES IN SOUTH SULAWESI ISLAND, EAST INDONESIA AND THE ROLE OF AQUACULTURE AS A POTENTIAL ALTERNATIVE LIVELIHOOD

IMPROVING COASTAL LIVELIHOODS THROUGH SUSTAINABLE
AQUACULTURE PRACTICES

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EXECUTIVE SUMMARY

Because fisheries have inescapable ecosystem impacts, the task of finding the balance between promoting fishing to make the fullest contribution possible to development and food security – without perturbing marine ecosystems unsustainably – may be one of the most difficult challenges to sustainable development. A historical lack of effective integrated coastal and marine management in Indonesia has resulted in competition for limited resources, environmental degradation, over-fishing and poverty for small-scale fisherfolk.

Under a reorganization of the Indonesian government in 1999, the Ministry of Marine Affairs and Fisheries (MMAF) was founded to help shift emphasis towards improving the quality of life of fisherfolk through the coastal community economic empowerment plan and decentralization of the fisheries sector. Out of a total US\$ 168 million budget for 2003, 85% will be decentralized to district and provincial governments. US\$ 42 million (25%) of this is earmarked for income-generating activities and infrastructure development. MMAF is charged with encouraging small-medium-scale enterprises, including aquaculture, and the breaking of indebtedness through the provision of capital (mainly revolving funds), markets and technology, law enforcement and fostering community-based resource management.

Increasing population pressures, the Asian financial crisis and traditionally migrant fisherfolk competing for open-access resources using increasingly destructive methods, have led to dramatic declines in coastal resources, particularly coral reefs and fish stocks throughout the Indonesian archipelago.

Indonesia has up to 86,000 km² of coral reefs, more than 50% of the Southeast Asian and 14-18% of the world total. Its economic value has been estimated at US\$ 1.6 billion/year, with a net present value of US\$ 14 billion. More than half of Indonesian coral reefs are threatened by destructive fishing practices, including over-fishing, blast and cyanide fishing, inshore trawling, coral extraction and fine mesh nets. Together, destructive fishing practices have the potential to result in a net economic loss to Indonesia of US\$ 170 million/year (mainly due to coastal protection, tourism and fisheries) over the next 20 years.

Blast or dynamite fishing has been used since the 1940s as a quick and easy way of catching food fish. It is accounting for losses of 3.75 m² per 100 m² of Indonesian coral reefs per year. The net economic loss to Indonesia over the next 20 years due to blast fishing has been estimated at more than US\$ 570 million. Possibilities for control include bans on waterproof fuses, legislating tenure to local communities, education of fishers, enforcement of legislation, economic empowerment to break indebtedness and promotion of alternative livelihoods.

Cyanide fishing has been practiced since the 1980s for catching high-value reef fish for the live trade in food and aquaria. Cyanide use leads to the death of coral and associated reef-dwelling organisms, and is leading to the progressive over-fishing of high-value reef fish throughout Indonesia and beyond. The net economic loss to Indonesia over the next 20 years due to cyanide fishing has been estimated at greater than US\$ 920 million. The live reef food fish trade based on cyanide is destructive and unsustainable and requires separate legislation and management. Key priorities include education of all parties involved, establishment of quotas and restrictions, obligatory reporting of captures and data management, stricter

controls over cyanide use, eco-certification of aquacultured and cyanide-free fish, establishment of marine protected areas and seasonal or areal bans and the use of the CITES framework for monitoring and enforcing legislation.

Sulawesi has the largest coral reef area in Indonesia, at the epicenter of worldwide marine biodiversity, but is one of the areas most threatened in Southeast Asia by destructive fishing practices. Various coastal management projects have recently been or are being conducted in Sulawesi with varied, but occasionally encouraging, results. South Sulawesi has a large and growing marine fishery producing 306,000 mt worth US\$ 133 million in 2001. The industry employs ever-increasing numbers of fishermen (up from 47,000 in 2000 to 60,000 in 2001), but diminishing average size and lack of high-value species indicate that serious over-fishing is occurring.

There are special problems related to traditional Indonesian fishermen fishing the MOU Box area of northwest Australia. What is required now is a coordinated effort between the Australian and Indonesian governments and local fisherfolk to educate, economically empower and develop alternative livelihoods (including, but not limited to, aquaculture) for the participants. Both governments have already agreed to this, but prompt action is required since the declining resources within the MOU Box are already forcing fishers into more destructive and/or illegal practices or out of fishing entirely.

Aquaculture has been prioritized by the Indonesian government to help economic growth, increase exports (shrimp, grouper and seaweed) and provide food for its people (tilapia and milkfish). South Sulawesi has many institutions to develop aquaculture, but little cooperation and even competition among them. Even so, the brackishwater culture of shrimp (*Penaeus monodon*), milkfish and seaweed headed an industry producing 112,000 mt worth US\$ 169 million from 87,000 ha in 2001.

Any aquaculture activity planned as an alternative livelihood for coastal communities must be placed within the context of an integrated, community-based coastal management plan. This must include full discussion, education, empowerment and support of local communities, who must be given the right to own, manage and control their own resources so that they can conserve and utilize them sustainably.

Grouper culture is growing rapidly in Indonesia due to the success of the Gondol Research Institute for Mariculture (GRIM) in Bali, permitting the supply of hatchery-reared grouper fry to the on-growing industry. The industry may now produce as much as 3,000 mt worth up to US\$ 20 million, although real data is scarce. In South Sulawesi, the industry remains small (<100 cages in total), but has been earmarked by the government as a key area for grouper culture.

Grouper culture has benefits of high potential profitability, somewhat proven technology, reductions in the demand for wild seed and market-sized fish, and hence alternative livelihood and environmental benefits. However, there are many constraints to its suitability as an alternative livelihood for poor fisherfolk. These include the high technology, capital-intensive and long-term payback characteristics of grouper farming, the difficulty of breaking indebtedness and persuading fisherfolk to change vocations, the lack of tenureship of resources, the difficulty and seasonality of maturation and larval rearing, the shortage of suitable sites and reliance on trash fish, the reduction in demand for wild seed limiting current

livelihoods, and limitations on the current market, which is controlled by traders and wholesalers leading to unfair distribution of profits.

Measures required to promote grouper culture in Indonesia include an integrated coastal management policy, research and development of culture techniques (including pond culture of juveniles and adults), diversification of cultured species, economic and educational empowerment of coastal communities, assistance with disease control and nutritional requirements, and the development of marketing strategies for seed and market-sized fish to broaden the demand for cultured grouper.

Shrimp farming is currently on the decline throughout Indonesia. In order to maintain the industry, more research (especially into disease prevention) and support is required if the 100,000 people currently involved in the industry in South Sulawesi are not to be added to those seeking alternative livelihoods.

Milkfish culture, in both hatchery and on-growing phases offers potential livelihoods for coastal fisherfolk in South Sulawesi. Polyculture of milkfish and shrimp (and possibly tilapia) can help generate food and jobs for local people. Assistance is required in refining husbandry techniques aimed at improving the economics of milkfish farming.

Seaweed culture is a growing industry in South Sulawesi and Indonesia in general. It has the potential to provide sustainable livelihoods to many poor fisherfolk, especially women, and has been recognized and promoted as such by the government through the Indonesian Seaweed Association. Although currently not particularly profitable, further development of processing and marketing aspects should result in larger and more lucrative culture and capture industries in the future.

Other aquaculture-based alternative livelihood possibilities include seabass, lobsters, giant clams and other mollusks, tilapia, Siganids and coral reef organisms for the aquarium trade. Most of these and some other fish species have received attention, but have yet to be fully exploited in South Sulawesi.

Cyanide is commonly used to catch marine organisms for the US\$ 200 million worldwide aquarium trade. The Marine Aquarium Council (MAC), together with various NGOs, are promoting efforts in Indonesia to introduce non-destructive fishing methods, introduce standards and eco-certify such organisms. Such schemes offer potential livelihoods to fisherfolk currently using unsustainable capture methods in this trade in South Sulawesi.

Fish Aggregation Devices (FADs) have been used to attract migratory pelagic fish species and increase local catches in demonstration projects off Komodo Island and in the Philippines. Fishermen in South Sulawesi have the necessary skills and could be encouraged to adopt such devices to provide employment, high income, and reduce destructive fishing practices.

The establishment of community-managed Marine Protected Areas (MPAs) within a coastal management plan (preferably including grouper spawning aggregations, source reefs and nursery areas) has the capacity to preserve local fishery resources and livelihoods, promote tourism and maintain biodiversity. Management should be entrusted to local communities, but supported by government, since, of the 6.2 million hectare of existing Indonesian MPAs, fewer than 3% of them are currently rated as being managed effectively.

Environmentally sustainable tourism, which is capable of sustaining the functions of the marine ecosystem, presents an increasingly important opportunity for alternative livelihood generation. This is particularly true for areas with limited natural resources. It must be well managed, however, and integrated within an overall coastal management plan to fulfill its potential.

1. INTRODUCTION

Fisheries inherently have inescapable ecosystem impacts, meaning that it is impossible to eliminate undesirable impacts while allowing development. Rather, the sustainability question for fisheries is, “How much perturbation is sustainable?” (Rice, 2002). This aspect of fisheries has long been recognized; tools and legislation have been put in place to enable it both ecologically and economically. However, only recently has it become clear that for a resource management regime to obtain and keep support, it must also be sustainable on social and institutional criteria, with high emphasis placed on the viability of coastal communities. In the developing world, this means that the fishery itself must sustain the system that manages the fishery in the absence of stable governance systems. These added dimensions of sustainability make the task of finding comprehensive solutions much more difficult, but nonetheless urgent, since fishery-dependent communities are much more difficult to rebuild once their fishery has collapsed.

Complications in fishery sustainability also result due to the wide range of factors promoting unsustainable behavior, including inappropriate incentives (usually rewarding short- rather than long-term gains), high demands for limited resources, poverty and lack of alternatives, inadequate knowledge, lack of effective governance and externalities, including pollution and competing demands on the resource. Many tools have been developed to address these unsustainability factors, including rights-based access to fishing (to promote sustainability), transparency and participatory governance, increased support for science, management, enforcement and planning, distribution of benefits, integrated policy development (to see sustainable fisheries as part of an integrated coastal management plan), precautionary approaches, better informed policy-makers, technical experts and public, and market incentives (for example, eco-certification and labeling to reward sustainable practices with better economic returns).

However, despite knowledge of these factors and tools in sustainable fisheries, a cross-evaluation of these pressures and pathways completed during a recent expert workshop in Bangkok (FAO, 2002a) produced a new and discouraging insight. This was that any suite of measures implemented to alleviate pressure from one set of sustainability factors always seemed to increase pressures from some of the other factors. Thus, the task of finding the proper balance, where fishing makes the fullest contribution possible to development and food security without perturbing marine ecosystems unsustainably, may be one of the most difficult challenges to sustainable development that we face (Rice, 2002).

2. CORAL REEFS AND REEF FISHERIES IN INDONESIA

2.1 Current Status

The Indonesian coastal zone supports approximately 60% of its 212 million people (WRI, 2002). Sixty-seven percent of Indonesia's 7,000 coastal villages are adjacent to coral reefs and are heavily dependent for both their food and livelihoods on a wide variety of reef and reef-associated animals for consumption and trade. Altogether, there may be 3.4 million people in Indonesia who directly and indirectly work in fisheries, producing 5.5 million mt of total marine fish production (95% from small-scale producers) in 2001, and generating US\$ 1.6 billion/year (mainly shrimp and tuna) or about 2% of Indonesia's GDP (Nikijuluw, 2002; WRI, 2002). However, there are few examples of integrated coastal and marine management and many areas of competition among various parties for the same, often limited, resources. Inevitably this has led to a decline in environmental quality and reduced quality of life and income for local communities (Dahuri and Dutton, 2000).

Indonesia is at the epicenter of global marine diversity, being the meeting point for Pacific and Indian Ocean flora and fauna, and has more than 480 reef-building coral species (60% of the world's total), with each unit of coral reef in eastern Indonesia containing up to 140 coral species (WRI, 2002). Over 1,650 fish species have been recorded in eastern Indonesia alone, the majority of which are associated with reefs (Chou, 2000). The diversity of reef-associated habitats is also high (Anon, 2001; WRI, 2002). There are at least 14,000 units of coral reefs in 243 locations distributed around the Indonesian archipelago, with an estimated total area of 51,000-86,000 km² (approximately 51% of Southeast Asia's and 14-18% of the world's coral reefs) (Dutton et al., 2001; Hodgeson and Liebler, 2002; ICLARM Reefbase, 2002; Tomascik et al., 1997; WRI, 2002).

2.2 Fisheries and Coastal Management

Integrated coastal and marine management (ICMM) efforts in Indonesia typically must address six inter-related and often overlapping issues:

1. Lack of knowledge and monitoring of coastal and marine resources and processes
2. Under-valuation of coastal and marine resources
3. Lack of empowerment of coastal communities and marine resource users
4. Lack of clarity regarding legal authority and planning frameworks for ICMM
5. Lack of institutional capacity to undertake ICMM (experience has shown the value of broadening stakeholder participation to better utilize the knowledge and local capacity of resource users), and
6. Lack of integration between initiatives (an exception is in Proyek Pesisir, where a learning team has been established within the Center for Coastal and Marine Resources Studies at IPB University in Bogor) (Dahuri and Dutton, 2000).

Although all large-scale fishing operations are licensed under Indonesian laws formulated in 1985 and 1990, small-scale or subsistence fisherfolk are exempt from such licensing. This

has resulted in some confusion as to what exactly subsistence fishing is. Aside from licensing, the government has also introduced fishing zones (from 1980, but reviewed in 1999) so that only small-scale fishermen can fish in zones 1 (up to 4 miles) and 2 (4-12 miles), while anyone can fish in zone 3 (>12 miles). However, large-scale fishermen have encroached on zones 1 and 2 and created conflicts, general degradation and over-exploitation of the inshore waters (Nikijuluw, 2002).

Destructive fishing methods are also government regulated, with bans on fine mesh, cyanide and blast fishing. However, some local fishermen – non-locals and foreigners – flaunt these regulations, further worsening the situation. Poor enforcement of laws is due to many factors, including the sheer extent of Indonesian waters, and lack of funding, personnel and facilities. For example, the government currently has only seven patrol boats to service the whole of Indonesia, with just six more in the budget for 2003 (Dahuri, personal communication). This lack of fisheries management, particularly for small-scale inshore fisheries, has resulted in environmental degradation, over-fishing and poverty for small-scale fisherfolk. A recent study suggested an average family income of US\$ 40/month, or per capita income of US\$ 10/month, an order of magnitude below that of workers in the manufacture and industrial sectors (Nikijuluw, 2002).

Government legislation from 1993-98 formed a dedicated marine unit (DKN) and conducted a series of projects intended to build knowledge of coastal and marine resources, and institutional capacity for their management. These included ADB-funded Marine Resources Evaluation and Planning (MREP), the multilateral Coral Reef Rehabilitation and Management Program (COREMAP), marine conservation programs of various NGOs, bilateral aid programs (including USAID's Coastal Resources Management Project, Proyek Pesisir/CRMP) and various collaborative research and education programs. However, because fisheries were previously under the jurisdiction of the Forestry Department, they received the least attention, and were based on extraction rather than sustainability (Dahuri, personal communication). A recent review of the projects conducted between 1987-98 suggested that some US\$ 400 million had been spent but that relatively few of the initiatives continued once direct funding via central government agencies ceased. Additionally, few of these projects directly impacted the quality of life of coastal communities or the quality of coastal ecosystems (Dahuri and Dutton, 2000).

In response to these problems, the new Indonesian government in 1999 formulated policies aimed at shifting the emphasis from producing and exporting fish in a sustainable manner to improving the quality of life of fisherfolk, through their coastal community economic empowerment plan (PEMP). This, it was hoped, would be achieved through, among other things, the promotion of aquaculture. To encourage this reformulation of the objectives of fisheries development, the government established the Ministry of Fisheries and Marine Affairs (MMAF) and the Indonesian Maritime Council (IMC), and promoted decentralized government of the fisheries sector to give district and provincial governments more responsibilities in development.

This decentralisation effort resulted in 85% of the US\$ 89 million budget for 2002 being decentralized to local government. A similar percentage of the US\$ 123 million government budget for 2003 – together with soft loans from CRMP, ADB and the World Bank to total US\$ 168 million – will also be allocated to local government. Of this total budget, 25% (US\$ 42 million) will go specifically toward income-generating activities and infrastructure

development, with local government being expected to make their own acts for coastal planning, including coral reef preservation (Dahuri, personal communication).

The main responsibility of the MMAF is to empower small-scale fisherfolk through the development of small-medium-scale enterprises and cooperatives, through providing access to capital, markets and technology, law enforcement and fostering community-based resource management. Over the past three years, 150 of the 300 coastal districts around Indonesia have received US\$ 112,000 each of local government-administered money. Of this money, 75% was in the form of maximum five-year revolving funds as loans to local fishermen, marketers and processors, and 25% as training, education and encouragement of partnerships between local communities and large companies. The indebtedness problem resulting largely from the greed of middlemen and live fish traders will be addressed by provision of credit to local fishermen who do not have access to loans, but have to rely on expensive credit from middlemen (7% per month), or banks (1.7% per month), but with almost impossible requirements (Dahuri, personal communication).

This idea of government loans to help locals out of indebtedness was already tried in the 1970s with the MINA co-op scheme. However, 99% failed due to non-repayment of loans and poor money management of locals who were not used to having money. This problem needs to be addressed with honest middlemen or companies to help control finances (Jompa, personal communication).

The function of the IMC is to help the government coordinate and integrate all marine activities to improve the economic situation of people who depend on these resources. To help in managing the resources, they see the need to include local communities in all stages of development, together with NGOs and private voluntary organizations (Nikijuluw, 2002).

Law No. 22/1999 established a territorial sea under provincial jurisdiction extending 12 nautical miles from the shoreline (four miles for local government), and including exploration, exploitation, conservation and management of the sea, administrative affairs and law enforcement, with traditional fishing rights remaining unrestricted by the regional territorial sea delineation. Since 2001, these new laws have begun to be implemented and all of the 30 provinces and 200 of the 270 districts now have fishery service officers whose function is to develop fisheries in their areas (Nikijuluw, 2002). A COREMAP-proposed article for coral reef management and protection is to be included for the first time in the new governmental coastal plan (Dahuri, personal communication).

2.3 Coral Reef Fisheries and Destruction

The vast majority (95% of the total catch) of Indonesian fishing activity is conducted by small boat (*perahu*) fishermen, with increasing numbers of fishermen attempting to exploit the same areas of open-access fisheries using increasingly destructive practices in an attempt to get an economic advantage.

Migrating populations, combined with these new practices, are destroying even remote reefs and fisheries, resulting in collapses (Reefbase, 2002). The problems with these small-scale or artisanal fishers is that because of the intense effort and the often-destructive techniques that they use, many sites end up over-fished, resulting in diversity loss and coral settlement being replaced by algal growth over the reefs.

Of particular note are the ethnic groups of Bajau, Bugis and Makassarese of Sulawesi and the diffuse Butonese and Madurese, who travel over thousands of miles in search of under-exploited resources. Thus, problems are not confined to specific national sovereign waters. Rather, a more generic problem across the region is revealed by recent reports of illegal fishing for grouper, sharks and lobsters by Indonesian fishers in protected areas of Australia (Agence France Presse, 2002; BBC Worldwide Monitoring, 2002; Courier Mail, 2002). Even those fishing specifically for species such as lobster have resulted in severe by-catch of other and juvenile species; net sizes are set but not enforced and add to the degradation already caused by destructive methods (Reefbase, 2002).

The influence of the Asian Financial Crisis of the late 1990s cannot be ignored. Known as *Krismon (krisis moneter)* in Indonesia, the situation resulted in devaluation of the Rupiah, lower prices in Indonesia but higher returns for exporters. Thus many new fishers from closing industries and existing traditional domestic fishers entered the export-oriented fishing industry, where income was in dollars and remained stable or even increased. Hence, fishing using cyanide for live reef fish and ornamentals, targeting lobsters, shark fins, sea cucumbers and tunas, and more competitive aggressive fishing, became common (Chou, 2000; Erdmann and Pet, 1999). Lack of funding of regulatory and fishery enforcement bodies also led to reduced patrols, the targeting of spawning areas, and more bribery, further compromising stocks.

As a consequence of the above, many remote reefs are in a worse state than those closer to main population centers and fishers do not see for themselves the devastation they can cause. Moreover, many fishers are actually high-income earners and use destructive measures as a first choice rather than for subsistence (Reefbase, 2002). However, the reverse is also true in many groups, presenting a diverse range of livelihoods to be considered when addressing the issue of reef destruction. The disappearing reefs are already leading to a dramatic decline in the productivity of coastal fisheries and to increasing turf wars among fishermen for the remaining spoils. On the positive side, Indonesian fishermen are reportedly capable of responding quickly to changing market forces and can rapidly adopt new fishing techniques as they become more profitable (Reefbase, 2002).

Analyses of Indonesian coral reef conditions by LIPI (Science Foundation of Indonesia) in 1995 and COREMAP in 2001, revealed that 5-6% were in satisfactory, 21-23% good, 28-35% average and 40-43% in bad condition. (Satisfactory is living corals covering >75%, good 50-75%, average 25-50% and bad <25%).

Wilkenson et al. (1994) stated that all the reefs in Indonesia are either under critical condition (would disappear within 10-20 years) or under threatened condition (would disappear within 20-40 years). He estimated that 40% were in poor condition and only 29% either good or satisfactory. There are indications that the proportion of degraded reefs in Indonesia has increased from 10 to 50% within the last 50 years, particularly in the more accessible western areas (Chou, 2000; WRI, 2002) (See Figure 1).

There are 646 Marine Protected Areas in Southeast Asia, but of the 332 whose management status could be determined, only 14% were rated as effectively managed (<3% in Indonesia) by WRI (2002). Originally Indonesia planned to have 85 Marine Protected Areas covering ten million hectare by 1990, and 50 million hectare by 2000. However, in 2000, Indonesia actually had just 51 Marine Protected Areas that included coral reefs (131 in total), covering about 6.2 million hectare or just 9% of the country's total reef area (WRI, 2002).

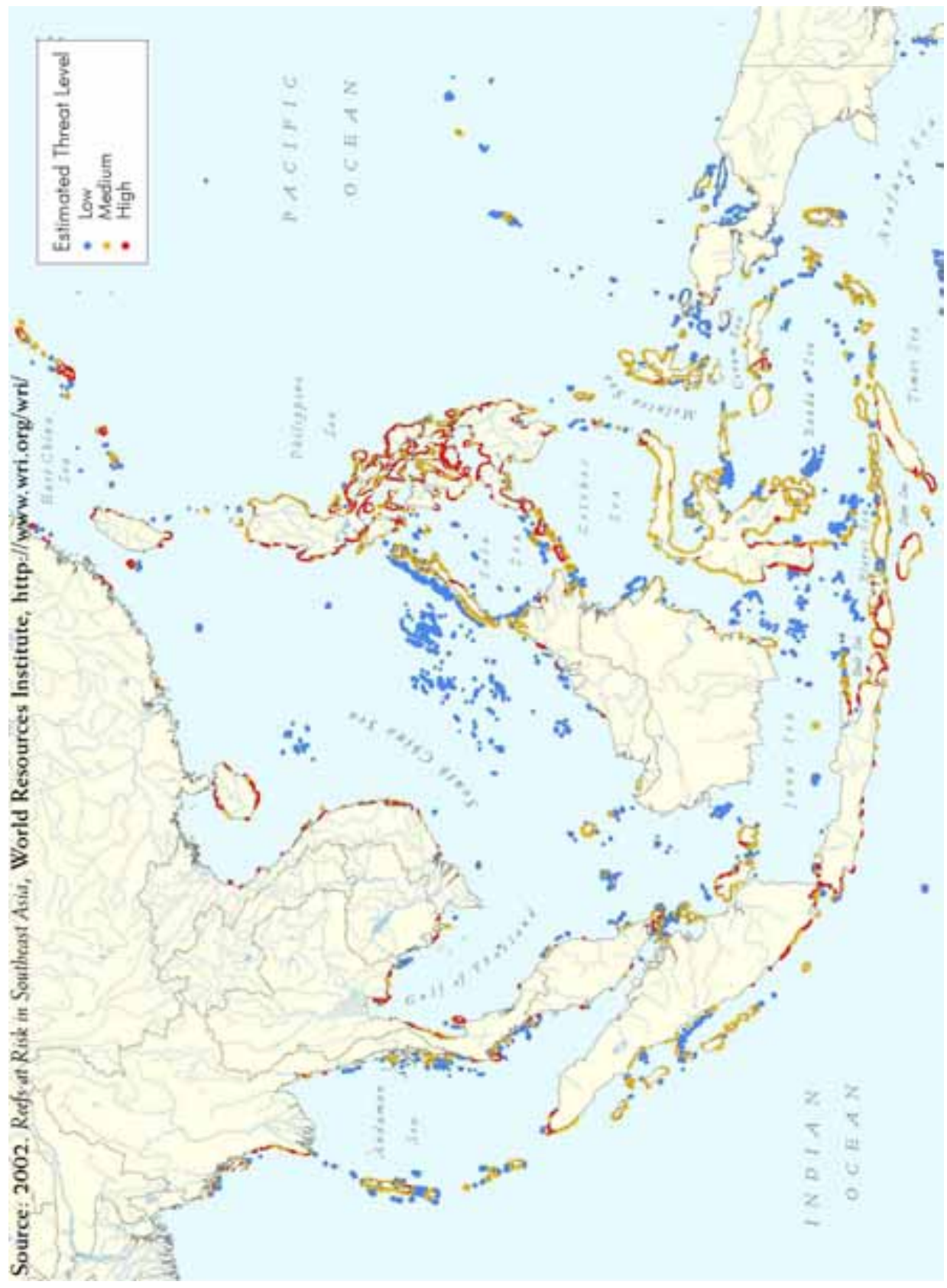


Figure 1 Estimated Threat to Southeast Asian Coral Reefs from Human Activities

The available evidence suggests a tale of a pristine, biologically-diverse resource rapidly being extinguished, in the face of economic decline in the region in the late 1990s. The loss of coral reefs will be devastating. To demonstrate the purely economical effects, it can be translated into a direct financial loss of just one of the goods and services that the reef provides: the assimilation of carbon from the atmosphere. From this alone, it is estimated that reefs are worth US\$ 240/ha/year (Chou, 2000). Add to this the value of fisheries, coastal protection, research for drugs and chemicals and tourist potential, and the immense value and current economic loss being inflicted becomes increasingly apparent and alarming.

From a resources management point of view, Cesar et al. (1997) estimated the economic profit or loss to the community and nation, which was caused by exploitation of reef fishery resources. For cyanide fishing he showed that it could generate US\$ 33,000/km² within a certain period of time, but that the loss caused by the degradation of the resource could be as much as US\$ 476,000/km² (largely owed to tourism and fisheries). For dynamite fishing, the balance was even worse, the activity generating just US\$ 15,000/km², but resulting in losses of up to US\$ 761,000/km² (largely due to tourism, fisheries and beach protection).

The recently released report – *Reefs at Risk in Southeast Asia* – published by the World Resources Institute (WRI, 2002), reported that 88% of Southeast Asia's reefs (86% in Indonesia) were severely threatened by human activity. They estimated that the sustainable value of Southeast Asian reef fisheries was US\$ 2.4 billion/year (excluding tourism and shoreline protection). The total economic value for Indonesia alone (the largest coral reef system in the region) was estimated at US\$ 1.6 billion/year, with a net present value of US\$ 14 billion.

3. DESTRUCTIVE FISHING PRACTICES

Most of the reef fishery exploitation in Indonesia uses cyanide and explosives, since they are perceived as being effective, quick and relatively cheap, and it is easy to handle the capture, despite the human dangers involved. WRI (2002) estimate that more than 53% of Indonesia's coral reefs are threatened by destructive fishing practices (See Figure 2). Since these techniques have been used for more than one generation, many fishermen know no other means for fish capture. Aw (1996) estimated that if these techniques continue unabated, by 2020 all coral reefs in the Asia-Pacific area will be totally destroyed.

Trawlers ripping up reefs with their nets are another serious threat to most of the reefs in the region. Trawler boats are big business and despite government legislation on the areas, numbers and exclusion zones, they are still taking excessive amounts of fish of all sizes and destroying coral reefs when fishing inside the four-mile zone allocated by the government for traditional fisherfolk.

Coral extraction, either for the live aquarium trade or for building materials is also widespread. To get 10 x 10 cm² of live coral, often up to 1 m³ of coral reef will be destroyed. Coral extraction for building materials is suspected to be a serious threat, but is difficult to document since it is not for export purposes.

Other destructive fishery practices include the artisanal use of fine mesh nets, taking fish before they can reproduce, the actual digging up of the reef for abalone (leaving behind 100% coral rubble), the collection of sea cucumbers and other invertebrates which used to be conducted at low tide (but now can be conducted in permanently submerged areas due to the use of dive gear and air compressors), and the use of coral to conceal fish traps and weighted fish traps destroying coral as they descend (Komodo, 2002).

3.1 Over-fishing

Prime amongst unsustainable fishing practices are the multiple facets of what is termed over-fishing; that is the removal of the fish themselves irrespective of the actual methods employed in conducting this activity. Throughout the region reef fish diversity and abundance are threatened by a combination of natural and human powered reef degradation and by destructive fishing practices.

Particularly in Indonesia, this was exacerbated by the economic collapse and devaluation of the Rupiah in the late 1990s, which promoted the over-fishing (usually by destructive practices, especially cyanide) of high-value coral reef species for the lucrative, foreign exchange-earning live reef fish trade. One of the peculiarities of this trade is that rarity increases the price paid to a level where it is economically beneficial to catch almost every individual. Together with the biological characteristics of groupers and wrasses – including aggregations of spawners, long life and size-dependant sex changes – the stocks of these fish are even more vulnerable to over-exploitation. Recent indications from the trade of these organisms through Hong Kong suggest a collapse from a high in 1997 by as much as 44% by 2000 (Graham, 2001).

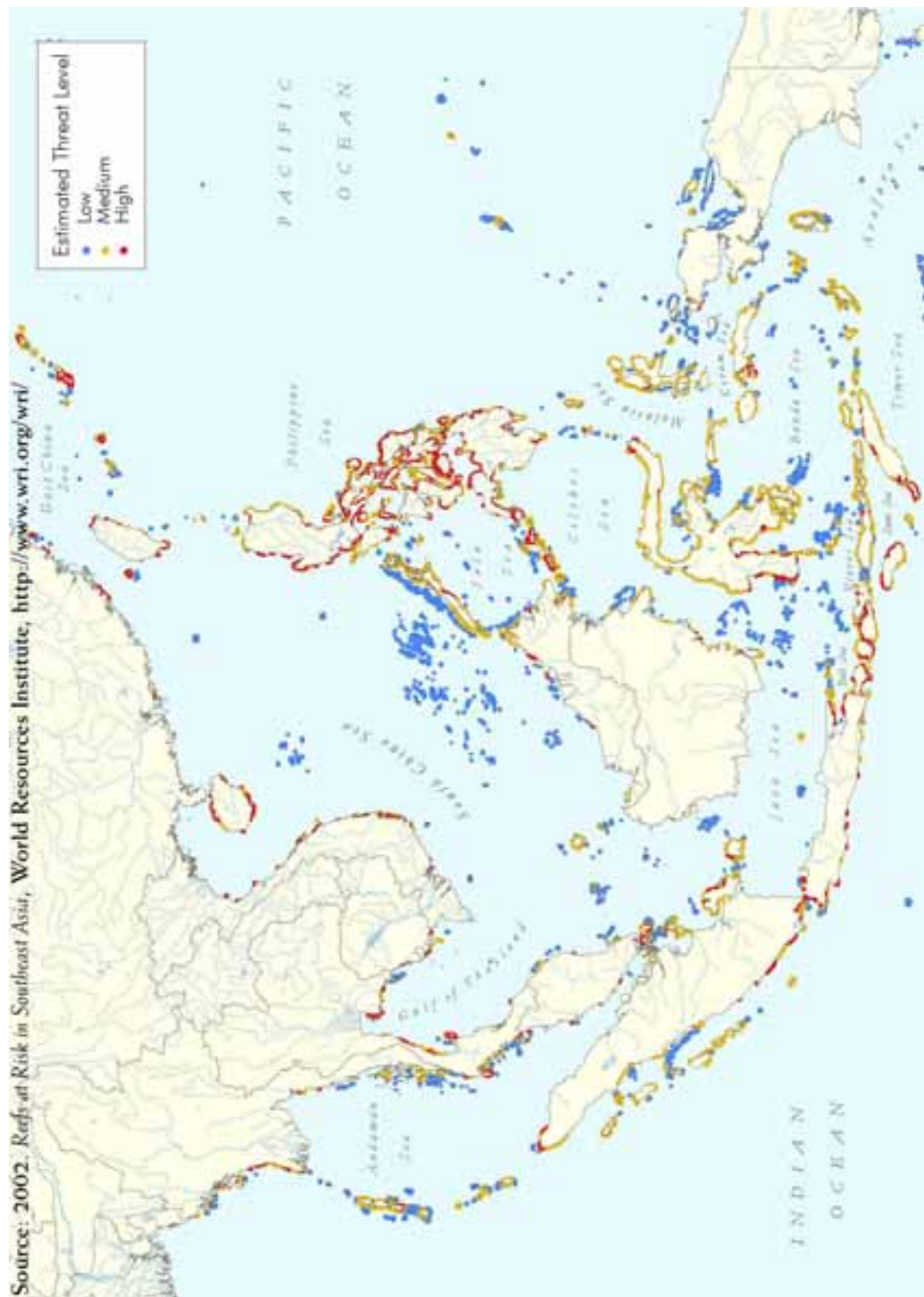


Figure 2 Estimated Threat to Southeast Asian Coral Reefs from Destructive Fishing Activities

In Indonesia, fishing sustainably can generate as much as US\$ 63,000/km² more over a 20 year period than over-fishing on healthy reefs. Although a healthy coral reef might provide an average sustainable fisheries yield of 20 mt/year, the yield of a reef damaged by destructive fishing practices may be more than <5 mt/year (WRI, 2002). WRI (2002) state that in Indonesia (with more than 32,000 km² of over-fished coral reefs), over-fishing is the major threat to the reefs, threatening 65% and accounting for an estimated loss of about US\$ 1.9 billion over the next 20 years (See Figure 3).

3.2 Dynamite or Blast Fishing

Blast fishing has been outlawed by all Southeast Asian countries, but is still practiced regularly in most countries as it is an efficient, short-term method of fishing a reef (Hodgson and Liebeler, 2002); hunting specifically for schooling fish to maximize impact, fishers dive after the explosion to collect dead and stunned fish. Blast fishing is used for food fish, since it bursts the swim bladder and kills the fish. The dead fish are then harvested, but unfortunately many of both the target and non-target species sink and are lost.

After the Second World War, explosives left over by Japan and the allied powers were used to blast coral reefs to get lime for building materials. Fishermen also used them to help them catch fish by stunning and later also adapted dynamite and grenades to catch fish. Today, other materials such as TNT and cheaper and easily obtained artificial fertilizers (such as urea, ammonium and potassium nitrate) are mixed with kerosene in a bottle and ignited using waterproof fuses (Komodo, 2002).

It has been estimated that up to 15% of the fishers in some villages fishing the Spermonde archipelago in South Sulawesi are blast fishermen, with their catches supplying 10-40% of the total landings for the 16,000 km² fishery (Pet-Soede and Erdmann, 1998).

Bombs can cost US\$ 1-2 to make but may bring in a catch with a market value of US\$ 15-40. The effects of blast fishing can be devastating to both reefs and people. Prematurely exploding bombs have led to lost limbs and lives; bombs as big as a soda bottle can destroy 10-20 m² of reef (Komodo, 2002). The explosives are relatively easy to obtain and are therefore freely used. Often smaller bombs will be thrown to kill small fish, which attracts bigger fish, which are then caught using bigger bombs.

Regularly bombed reefs frequently exhibit 50-80% coral mortality (Chou, 2000; WRI, 2002), and blast fishing has been estimated to account for losses of 3.75 m² per 100 m² of reef per year in Indonesia (Pet-Soede et al., 1999). Additionally, reefs subjected to blasting, however, need a longer recovery period compared to those affected by cyanide, perhaps 50 years to regain 50% of the original coral cover and become productive again (Moka, 2002; WRI, 2002). Of course, if the reefs are not left to recover, but are fished repeatedly to meet the needs of the local fishermen, this will never occur (Djohani, 1996).

The WRI (2002) report estimated that the net economic loss to Indonesia from blast fishing over the next 20 years would amount to at least US\$ 570 million.

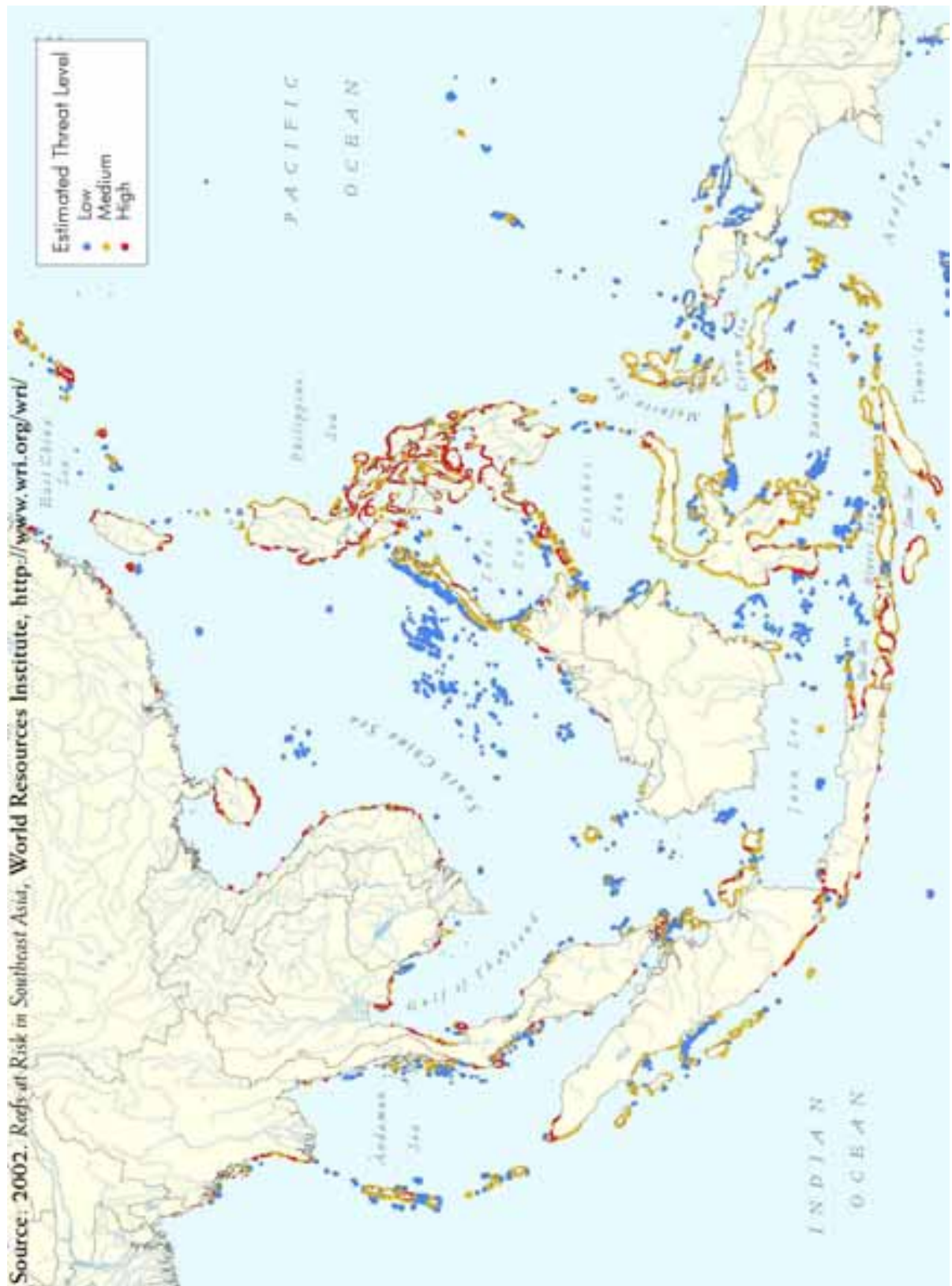


Figure 3 Estimated Threat to Southeast Asian Coral Reefs from Over-fishing

3.3 Cyanide Fishing

The use of cyanide salts to stun fish around and within coral reefs is currently the method of choice around Southeast Asia to supply high-value fish to the lucrative live fish trade. This practice began in the mid 1980s to satisfy the demand of rich Chinese in Hong Kong and spread to Indonesia by the late 1980s (Johannes and Riepen, 1995).

Free cyanide bonds with metals such as sodium or potassium to create salts that are relatively harmless until combined with acid compounds. These then react and liberate hydrogen cyanide gas that is highly toxic and can cause rapid asphyxiation.

Cyanide not only stuns the larger, higher-value target fish destined for restaurants throughout the region, but also kills small fish and marine biota including the coral polyps and symbiotic algae in the surrounding area. According to reports from the WWF, over 6,000 divers squirt an estimated 150,000 kg of cyanide on 33 million coral heads annually worldwide. One spray (approximately 20 ml) can kill an area of 1-5 m² of coral reef. Recent research has proven that cyanide concentrations hundreds of thousands of times lower than those used can kill coral rapidly (Dr Richmond of Guam University, quoted in Johannes and Riepen, 1995). Cyanide is also occasionally used for food fish or when times are hard, in 55-gallon oil drum quantities spread across the whole reef, resulting in widespread mortality (Johannes and Riepen, 1995).

Based on the observations that one bottle (0.5-1 liter) of cyanide solution is used to catch one fish (Pet and Pet-Soede, 1999), and that this kills 1 m² of live coral by poisoning and physical destruction, it is thought that due to the degrading properties of cyanide fishing alone, Indonesia is losing approximately 0.05-0.06 m² per 100 m² of reef per year (Mous et al., 2000). Although this level of reef destruction is 75 times lower than that attributed to blast fishing, additional incalculable “collateral” damages suffered to other reef-dwelling organisms suggest that cyanide fishing is a major threat to coral reefs.

It is estimated that 85% of the world’s traded aquarium fish, worth US\$ 200 million annually (Hodgson and Liebeler, 2002; MAC, personal communication), have been caught using cyanide mostly from Indonesia and the Philippines (Licuanan and Gomez, 2000). The financial rewards for the live reef fish trade can be lucrative with species such as the Humpback Grouper (*Cromileptes altivelis*) and the Humphead Wrasse (*Chelinus undulates*), retailing at as much as US\$ 150-180/kg in 1997 before the economic crisis, but still US\$ 100-110/kg by 2000 (Hodgson, 1999; Johannes and Riepen, 1995; McGilvray and Chan, 2002) (See Table 6 in section 7.1.1).

Recent estimates suggest that the world’s live fish trade has a value of US\$ 1 billion/year, of which 40% is through Hong Kong, who imported 17-26,000 mt in 2000 (FAO 2000, 2002b; WRI, 2002). However, this estimate is based on official statistics and local fishing vessels do not have to make trade declarations. Therefore, it is thought that the actual imports to Hong Kong were 30-35,000 mt in 1999 and possibly 37-44,000 mt in 2000 (based on extrapolations from trade from January-June), of which 50% comprised groupers and coral trout (McGilvray and Chan, 2002). If the figure of 40% of the world trade going through Hong Kong is correct (with 17% through Korea and 16% through Japan), this extrapolates to a worldwide industry worth US\$ 1.4-1.7 billion in 2000.

Estimates put approximately 50-70% of the total trade as coming from the wild, with the remainder, increasingly, coming from cultured fish, of which 10% is hatchery reared and 20-40% is from wild seed (Graham, 2001; TNC, 2000). In terms of total production, the relative contribution of wild fish may now be less since China may now produce as much as 150,000 mt (Graham, 2001). Hong Kong is increasingly serving as an air-based distribution center for fish passing through to China (55-60% of total Hong Kong imports). With the increasing wealth of the Chinese population, the demand for live fish is likely to increase significantly (McGilvray and Chan, 2002; Traffic, 1999).

The industry originated with foreign vessels and crew, but the use of local fishermen (trained in the use of cyanide by foreigners) proved a more cost-effective strategy, using first live fish transport vessels and then air freight, which opened up the further-afield markets such as China.

In Sulawesi, Aw (1996) found that the divers comprised boys from local tribes and sea gypsies. From small collection centers scattered among remote islands, each of these outposts gathered an average of 250 mt of Humphead Wrasse and grouper in 1996 to meet the demands of the middlemen in Makassar and Manado, who then shipped the live fish to cities around the region. Later, bigger businesses arrived with bigger boats manned with more crew, capable of fishing less-exploited reefs further out, adding to the destruction of the resources. Recently there has been a move away from direct cyanide fishing for live reef food fish due to declining stocks and increased costs. Estimates from 1998 suggested that 55% of fish for export from South Sulawesi were caught using traps (often baited with cyanide-tainted fish), 15% by hook and line and 30% by cyanide divers (Pet-Soede and Erdmann, 1998).

Since the late 1990s, the economic crash and increased fishing effort, the stocks of high-value live reef fish around Sulawesi, and Indonesia and Southeast Asia in general, appear to have plummeted dramatically. A synthesis of available data suggests live fish imports from Indonesia (accounting for 50-60% of the Southeast Asian trade in 1995, but only 10% by 2000) rose from 300-400 mt in 1989 to approximately 4,000 mt (of the 40-50,000 mt total regional trade), worth more than US\$ 350 million at its peak in 1995-97. Subsequently, there appears to have been a 40-50% decline to a total of only 2,000 mt (of the 22-28,000 mt regional total and 37-44,000 mt global trade) in 2000. However, data from Asian countries on imports of live groupers and seabass presented to FAO suggest the industry is still growing and reached nearly 62,000 mt in 2000 (Anon, 2001; Bentley, 1999; FAO, 2000; Graham, 2001; Johannes and Riepen, 1995; Lau and Parry-Jones, 1999; McGilvray and Chan, 2002; TNC, 2002; Traffic, 1999, 2002b).

Like a wave, the industry has spread throughout Indonesia with live fish exports rising for three to four years and then falling as the stocks are progressively depleted. Fish buyers estimate that by 2006, most of Indonesia will be fished out of groupers and wrasse (TNC, 2002).

However, the almost completely unregulated and unmonitored methods used in data collection in Indonesia, the fact that the industry wants to undervalue for tax purposes (and because it is illegal), together with unknown rates of domestic consumption and high transport mortality rates (30-80%), mean that the actual volume of fish caught is actually far higher than is shown in the importation figures to the major markets. For example, in South Sulawesi, Hasanuddin Fish Quarantine figures show that the export volume of live reef fish

rose from 39,000 to 155,000 mt between 1998 and 2000, with the official fisheries agency giving figures of 87,480 in 1999, but only 33,400 mt between January and October 2000 (IMA field report, quoted in Graham, 2001).

Data provided to the FAO from Indonesian authorities suggest that from a regional total of 185,000 mt, Indonesia caught 25% or 46,000 mt of groupers in 2000, increasing gradually from the less-than 16,000 mt captured in 1990 (FAO, 2002b). Government statistics on the marine fishery of South Sulawesi suggest that 6,000 mt of groupers and seabass (mainstays of the live reef fish trade) were captured in 2001 (Dinas Perikanan, 2001) (See Table 1 in section 4.3). This may signify further reductions in high-value reef fish stocks in South Sulawesi, although these data probably do not include fish that were caught illegally and smuggled out of Sulawesi on live fish transport vessels. Anecdotal evidence does suggest that the Spermonde archipelago close to Makassar has been virtually fished out and South Sulawesi fishermen are having to travel ever further (for example to Taka Bonerate Atoll and even the Moluccas and Raja Ampat) to maintain their catches (Johannes and Riepen, 1995).

The mortality rate for fish captured with cyanide is high – 50% for food fish and above 80% for ornamentals – and even those that do survive (although the cyanide is eventually excreted), usually die 4-6 weeks after capture. The aquarium industry (particularly the Marine Aquarium Council) and aid agencies have worked hard to try and educate collectors about this problem.

The inevitable over-exploitation that has ensued (due to open access to the resource and high prices) has been exacerbated by the poverty of many coastal communities in the region. A fisherman's consideration of the long-term sustainability of the resource is often over-ridden by the need to feed his family. The use of this technique has also lead to jealousies and conflicts with other fishermen using less destructive, and crucially, lower-income methods (Halim, 2002).

Cyanide is an industrial chemical, which is generally used in gold mining, electroplating and steel refining. The Indonesian government has limited the import quota for cyanide to 33 mt/year. However, the actual import volume can reach more than 7,000 mt/year. Cyanide is traded freely on the Indonesian market (no permit needed) with a current price of just US\$ 4-5/kg, which works out at approximately US\$ 0.33 per squirt bottle or US\$ 0.11 per fish caught (Johannes and Riepen, 1995).

The WRI (2002) report – *Reefs at Risk in Southeast Asia* – estimates that the net economic loss to Indonesia from cyanide fishing was US\$ 46 million annually.

4. SULAWESI

4.1 Current Coral Reef Status

Sulawesi (See Figure 4), with its coastline of 4,750 km, probably has the largest coral reef area in Indonesia, with a high proportion of its coast and islands being fringed with reefs up to 200 m wide (Tomascik et al., 1997). Sulawesi also has 34 individual barrier reefs around its islands (2,084 km total length), 27 atolls and 27 oceanic platform reefs, as well as a number of submerged and open water reefs. Few of these reefs have been the subjects of scientific study. The reefs of Tomini Bay (at 165 km long, Sulawesi's longest barrier reef) are some of the most biodiverse in the world, with an estimated 77 species of *Acropora* coral alone.

A report by the Center for Applied Biodiversity Science at Conservation International stated that, behind the Philippines and West Africa's Gulf of Guinea, the Sunda Islands of Indonesia were the third most threatened coral reefs in the world. According to data from WRI (2002), South Sulawesi is one of the two areas most threatened in Southeast Asia (together with the Philippines) by human activities. This is particularly true for over-fishing and most notably destructive fishing practices, with southeast Sulawesi having the largest area of reefs under high pressure from such practices in the entire region (See Figures 1, 2 and 3).

In North Sulawesi, the northern islands of Tamako, Talise and Bangka, conditions here are described as variable, with 50% coral cover in Tamako and 43-82% in Talise and Kinabokuten; little bomb damage was evident but the area is over-fished. In Manado, national park area reefs are described as fair at best. On the north coast of Sulawesi, sites range in cover from 20-50% and dead coral up to 75%. Bleaching and the evidence of blast fishing are evident throughout this area despite its national park status.

In Central Sulawesi, data evidence suggests that the reefs in this area are in better condition than elsewhere, although some sites show less than 25% coral cover. Surveys taken seven and five years ago, however, in the Malenge Islands suggest a rate of depletion of 22% over two years as a result of destructive fishing practices in the Southeast Asian economic slowdown.

In South Sulawesi, the Spermonde Archipelago, covering 400,000 ha of coastal waters including coral reefs and providing food income and protection to 6,500 households, shows a decline in cover from outer to inner reefs, although in the 1990s, areas with 100% cover could still be found. Bomb craters are present although young coral indicates rapid recruitment. Bleaching is now present and a decline in cover is indicated, for instance, a decrease from 46.5 to 42% in Barang reef over the period 1997-98. The Sembilan Islands, once regarded as being relatively undisturbed, all show evidence of crown of thorns starfish attack and blast fishing, especially the systems of P Kambuno, P Burung Loe and P Batang Lampe (Reefbase, 2002; Tomascik et al., 1997).



Figure 4 South Sulawesi Case Study Area within Indonesia

Willem Moka of the Maritime Biology and Research Center for Coral Reefs in South Sulawesi reported that the widespread use of cyanide and explosives has seriously damaged 60-80% of the coral reefs in the Spermonde Archipelago and on the west coast of South Sulawesi (Moka, personal communication). The area around the 500 ha Marine Protected Area (since 1998) of Kapoposang is the only one to remain relatively undisturbed. This park only permits traditional fishing and although there is no permanent presence, there are patrol boats and one NGO involved with protection of the park, which also serves as a major diving tourist attraction for Makassar. Moka suggested that traditional fishing methods are ineffective due to the strong winds and waves and the difficulty of extricating the coral fish from their reefs. The local fishermen thus turned to cyanide and dynamite, unaware of the damage that these methods can do to the reefs.

Within Sulawesi, the few reefs which are given nominal protection include Bunaken-Manado Tua in the north, the Kepulauan and Kapoposang Islands in the south and the Spermonde Archipelago, and Taka Bonerate Atoll in the southern Flores Sea (since 1995) and Kepulauan Wakatobi in southeast Sulawesi. Here the reefs are thought to be the closest to the perceived global center of marine biodiversity or, in effect, the evolutionary nursery of many global species. However, even in these supposedly protected areas, destructive practices occur – for instance, 40% of the income in the Spermonde Archipelago is reported to come from dynamite and cyanide fishing (Pet-Soede and Erdmann, 1998; Reefbase, 2002). The coast guard has recently been getting stricter, which is pushing illegal fishermen further out into surrounding unprotected islands, augmenting the destruction.

In general, although total fishery landings have actually increased due to higher effort (Dinas Perikanan, 2002), the average size of fish landed has reduced significantly. One important facet of fishing practices is that the local fishermen own the fewer fish that they catch using hook and line, while cyanide and bombing are controlled and financed by middlemen who thus get most of the profits, leaving local fishermen with less money for more catches.

4.2 Previous and Current Projects

The Indonesian Government's Coral Reef Rehabilitation and Management Program (COREMAP) are responsible for the new national policy and strategy on coral reef management, under the Ministry of Marine Affairs and Fisheries. Since 1998 they have been conducting a potential 15-year project sponsored by the World Bank, ADB, AUSAID and the Indonesian Government, looking into coral reef management in Indonesia, under the slogan – “let's work together to save coral reefs now”.

This was split into various inter-related components including:

1. Community-Based Management (CBM), including a coral reef management plan (CRMP) incorporating zonation, community rights and regulation, and alternative income-generation incorporating types (e.g., aquaculture, community cooperatives and handicrafts), feasibility, training and financial assistance, including a revolving fund (seed money) to help communities develop economic activities and then money is revolved to others
2. Research, Information and Training networking
3. Monitoring, Control and Surveillance (MCS), including community reef surveys, provision of infrastructure, training operators (450 people trained in SCUBA and

reef monitoring techniques so far), patrolling and prosecution involving the navy, police, local community reef watch and island patrol

4. Public Communication, in every form possible, and
5. Institutional Development.

The program was split into three phases:

- Phase 1: Setting up infrastructural framework and capability-building in four provinces around Indonesia (Biak in Irian Jaya, Taka Bonerate in South Sulawesi, Riau and Flores) for management of coral reef ecosystems, for a duration of three years.
- Phase 2: Enlargement and expansion of the area in Phase 1 and replication into other provinces, for a duration of six years.
- Phase 3: Institutionalization of the provinces so regional government could manage their own projects, for six years.

They have completed the initial coral reef surveys together with LIPI (scientific advisors) and the national aeronautics institute using remote sensing and ground-based confirmation. They have also collaborated with universities and used Australian and ASEAN standardized methods to conduct transects for routine coral surveys in more than 400 stations throughout Indonesia, with a summary in the four categories of coral reef status.

In Sulawesi, the Center for Coral Reef Studies (CCRS) of the Marine Science Department of Hasanuddin University, Makassar, conducted the study for COREMAP on Taka Bonerate atoll in the south of Selayar (1998), the Sembilan Islands off Sinjai (2000) and the Spermonde Archipelago off Makassar (2001) (Jompa, personal communication).

COREMAP have produced documents on coral reef management after regional discussions and handed them to Rokhmin Dahuri and a team of experts from the MMAF, on which to base new legal regulations, since, until now, there were no regulations specifically regarding coral reef management.

Phase 1 was due to finish in 2003-04, but mid-term independent and donor evaluators criticized the project and over the last two years, Johns Hopkins University has helped publicize the state of the reef resources. They have also involved the government on all levels, NGOs, artists, singers, leading locals, religions, school teachers, TV, radio, parents and games. Two surveys conducted 18 months apart have now shown a significant, although debatable, increase in public awareness of coral reefs and their problems in Indonesia. Also AUSAID will not be funding a second phase beyond 2004 in their region of Flores due to changes in their priorities toward education and health.

The Japanese government has given most of a US\$ 41.25 million grant over six years to the World Bank to design and oversee the second phase due to the lack of progress made with the first phase. The planning phase is starting in late 2002 and the second phase will begin in 2003. The stated development goals of this project are twofold: 1) coastal community empowerment to sustainably manage, protect and rehabilitate coral reef and associated ecosystems, and 2) lower incidence of poverty in coastal fisheries.

They will focus on four regional centers in central-eastern Indonesia in combination with the government COREMAP and local NGOs already established in the four areas, which are:

1. Irian Jaya in Raja Ampat
2. North Irian Jaya around Biak Island
3. Southeast Sulawesi around Wakatobe, and
4. South Sulawesi including the Spermonde Archipelago and Selayar Island.

The ADB in turn will be responsible for similar programs in western Indonesia around Sumatera and AUSAID was slated for areas further east, but have recently pulled out.

However, it is still unclear whether Indonesia will want to borrow more money and go further into debt and complete Phases 2 and 3 or not. There is also confusion about whether central or regional (already has 85% of the funds distributed) government will be responsible for the loan repayment since this was not established during the recent decentralization. This should be decided in early 2003.

USAID, TNC and CRC, together with the Indonesian government, started providing funding in 1997 (continuing to 2003) to an Indonesian NGO, Proyek Pesisir (Indonesian Coastal Resources Management Project, or CRMP) to help with “decentralized and strengthened coastal resources planning and management”. A number of initiatives were started in three north Sulawesi villages to abandon cyanide and blast fishing and turn 20% of 300 ha of damaged coral reefs in front of their villages into a marine sanctuary. Here they also stopped quarrying coral for construction purposes, and banned fishing, swimming and boating. The rest of the reef is fishable, but only using hand-lines, small nets or spears. They also mount 24-hour reef-watch patrols to ensure compliance.

They have already seen results from this approach, noting an increase in the size of fish schools and improved coral cover soon after stopping reef bombing. The project has also helped develop alternative and supplemental livelihoods through community group revolving funds (improved fishing with purchase of engines and seaweed farm development). Furthermore, achievements at the provincial and regency level have included a highly successful public education strategy and increased support among key agencies for community-based management and budget allocation from local government.

The project now hopes to expand its initiatives to 20 other north Sulawesi coastal communities. TNC is also promoting community-awareness programs, such as a traveling puppet show for school children, and is pushing for enforcement of the national law against reef bombing and the use of cyanide.

To persuade villagers to stop blast and cyanide fishing and to stay off the reefs, TNC and other environmental groups have come up with various alternative livelihood strategies for the local fishermen. These include FADs (fish aggregation devices), cage culture of grouper and sea bass, and floating seaweed farms. All of these initiatives have led to a positive change in attitude among local fishermen, who are learning to appreciate the value of their local resources and are prepared to fight for their protection, rather than destroy them using harmful fishing practices.

This project is widely regarded as being the most successful of its type in Indonesia. Although they deal with only a few communities, it does provide a useful model for future projects.

The International Marinelife Alliance (IMA) is an NGO charged with protecting the marine environment with the live reef fish trade as their entry point. They rely on partnerships and connections with government, other NGOs and businesses, and networking. They are in charge of a one-year 46,000 Euro study – funded by the European Community (EC), Asian Regional Council for Biodiversity and Conservation (ARCBC) and ASEAN – into marine diversity loss in the Spermonde Islands in South Sulawesi, assessing the capacity and impacts of destructive fishing practices. This project has completed its surveys and is now in the process of being written up.

They conducted surveys of loss-perception among locals and found that 50-60% of locals now no longer fish here, but have to go further afield due to habitat degradation and diversity loss. They were most concerned with the level of indebtedness of small-scale fishermen to middlemen involved in live fish, coral and aquarium fish trading. The local fisherfolk also indicated that for the live fish trade, cyanide use was quicker, it was easier to handle the caught fish and they were not concerned with fish quality. Dynamite was also perceived as the dominant and most effective method for catching fish to eat. The local people were aware of non-destructive techniques, but they were considered ineffective, and middlemen supplied the cyanide and explosives for the existing techniques. Another problem was with the local fishermen, who were often Bugis (semi-nomads) who had no tenure of the fishing grounds and therefore had no incentive towards conservation and protection. IMA consider that more funding is necessary to assist community organization and technical assistance (Wicaksono, personal communication).

In Taka Bonerate National Sea Park off Selayar Island, the South Sulawesi-based Research Institution for Coastal Villages and Community (LP3M) is helping the rehabilitation of coral reefs and providing guidance for local people. The director of LP3M, Hermanto Aziz, said that local fishermen were being guided through the community-based management pattern, namely, building the participation of fishermen in cultivating the sea and determining conservation areas. The serious damage to the reefs during the 1980s and 90s has now been reduced by improving locals' understanding of the need to maintain the condition of the reefs, by government deployment of sea rangers, control by security apparatuses and involvement of NGOs. However, there still exist differences in perception, as some fishermen want to maintain maximum productivity at whatever cost.

The CORAL program of the Coral Reef Alliance (CRA) awarded a US\$ 5,000 grant to a local environment education center (PPLH-Puntondo) to help protect the reef of Puntondo, a small village in southwest Sulawesi. PPLH is helping local fishermen to give up their use of cyanide and bombing by offering snorkeling and coral education classes so the fishermen can actually see the damage inflicted on the reefs. They also conduct surveys with the fishermen to assess the health of the local reefs. In this way, they hope to initiate a community-led management plan which might include seasonal or permanent protected fishing areas, fishing regulations and artificial reefs. However, they see the need to have the community make their own decisions based on direct observation and knowledge, not through regulations (Christiang, personal communication).

4.3 Marine Fisheries

Indonesian capture fishery production reached 5.5 million mt, while aquaculture production reached 1 million mt (from nearly 600,000 ha) for the first time in 2001 (Dahuri, personal communication). Dinas Perikanan (fishery and marine services) of South Sulawesi Province gives these data for 2001 (Dinas Perikanan, 2001): 450,000 mt worth US\$ 320 million of which 306,000 mt (US\$ 133 m @ US\$ 0.43/kg) was from marine capture fisheries and 112,000 mt (US\$ 169 m @ US\$ 1.5/kg) from brackishwater aquaculture (largely shrimp and milkfish around Maros and Pinrang) and 27,000 mt (US\$ 13 m @ US\$ 0.48/kg) from inland open water fisheries.

Fish catches from South Sulawesi's seas increased gradually from 227,000 mt in 1990 to 280,000 mt in 1999, but then jumped rapidly to 310,000 mt in 2000 and 450,000 mt in 2001, as more fishermen got involved in the industry following the economic crisis – up from 31,000 in 1990 to 47,000 in 2000 and nearly 60,000 in 2001 (Dinas Perikanan, 2001, 2002).

The marine fishery of South Sulawesi includes the capture of numerous species with aquaculture potential as shown in Table 1.

Table 1 South Sulawesi Marine Fishery Production and Value (2001)

Species	Production (mt)	Value (US\$ million)	Value (US\$/kg)
Seaweed Spp.	23,397	1.3	0.06
<i>Penaeus merguensis</i>	3,928	5.7	1.45
Grouper Spp.	3,510	2.6	0.74
Seabass	2,270	1.5	0.66
<i>Penaeus monodon</i>	1,142	3.9	3.42
Lobsters	692	3.4	4.91
Other shrimp Spp.	564	0.4	0.71
Sea Cucumber Spp.	327	0.4	1.22
<i>Metapenaeus Spp.</i>	240	0.3	1.25
Total	306,115	133.0	0.43

Source: Dinas Perikanan, Makassar, South Sulawesi (2001)

4.4 Aquaculture

The Indonesian government prioritized aquaculture to help economic growth, increase exports and supply food for its people. To this end, they earmarked shrimp, grouper and seaweed for export and earning foreign exchange, and tilapia and milkfish for local food security (Daihuri, personal communication). To help accomplish this, they set up the central Research Center for Aquaculture, under the MMAF, headed by Ketut Sugama.

Numerous governmental institutions in South Sulawesi are involved with aquaculture, but with seemingly little cooperation among them and even competition for government funding. The institutions, each of who have independent programs for grouper culture, for example, include:

1. Research Institute for Coastal Fisheries and Aquaculture (Balit Kantor), Maros
2. Fisheries Department (Dinas Perikanan), Makassar
3. Brackishwater Aquaculture Development Institute (BBAP), Takalar

4. Environmental Impact Management Agency (BAPEDA), Makassar
5. Hasanuddin University Marine Science Department, Makassar

South Sulawesi also has a large marine-brackishwater aquaculture industry producing 112,000 mt worth US\$ 169 million in 2001. The industry is dependant mainly on the semi-intensive pond-based production of shrimp (primarily *Penaeus monodon*), and milkfish (*Chanos chanos*) (Dinas Perikanan, 2001) (See Table 2).

Table 2 South Sulawesi Marine and Brackishwater Aquaculture Production and Value (2001)

Species	Production (mt)	Value (US\$ million)	Value (US\$/kg)
Milkfish	56,055	55.8	1.00
<i>Gracilaria Spp.</i>	19,158	1.6	0.08
<i>Penaeus monodon</i>	15,056	100.5	6.68
Other fish	8,918	2.1	0.23
Seabass	3,459	1.4	0.40
Mud Crab	2,305	2.9	1.24
<i>Tilapia Spp.</i>	1,846	0.7	0.40
<i>Metapenaeus Spp.</i>	1,424	1.2	0.83
<i>Penaeus merguensis</i>	1,289	1.7	1.34
Mullet Spp.	1,255	0.5	0.39
Swimming Crab	743	0.2	0.31
<i>Mysis Spp.</i>	62	0.1	1.31
Total	111,558	168.7	1.51

Source: Dinas Perikanan, Makassar, South Sulawesi (2001)

In 2001, South Sulawesi had 86,888 net hectare of brackishwater fish and shrimp ponds, including 33,675 ponds, mostly less than 5 ha in area, owned by 32,691 households (8,500 involved with milkfish, 6,000 with shrimp monoculture and 18,000 with milkfish-shrimp polyculture). Seed use was 600 million milkfish fry and 2.4 billion *P. monodon* post-larvae in 2001, with the majority of both seeded in the Pangkep regency 40 km north of Makassar (See Figure 4).

The trends in aquaculture production over the past 12 years have been gradually upward until 2000. However, from 2001 the area and hence production has declined, due largely to higher disease incidence and lower market value of shrimp, although yield has continued to increase gradually (see Table 3).

Table 3 Marine and Brackishwater Aquaculture Production in South Sulawesi Over Time

Year	Area (ha)	Production (mt)	Yield (mt/ha)
1990	74,887	65,488	0.87
1995	84,735	81,499	0.96
2000	98,191	124,845	1.27
2001	86,888	111,558	1.51

Source: Dinas Perikanan, Makassar, South Sulawesi (2001, 2002)

4.4.1 Grouper

Grouper culture in cages started in the late 1990s in Indonesia and now has grown to an industry producing approximately 3,000 mt worth more than US\$ 20 million per year. However, up-to-date figures on cultured grouper production are unavailable. The latest data from FAO (2000, 2002b) suggested that Indonesia produced 1,800 mt in 1999 and in 2000, 1,159 mt worth more than US\$ 7 million (at US\$ 6.4/kg), or just 12% of world production (not including mainland China). Taiwan produced 50% of the world's cultured grouper in 2000, with 5,000 mt from a total of 9,321 mt worth US\$ 64 million (FAO, 2000, 2002b). However, it is suspected that China may now have a large culture industry (Graham, 2001).

The impetus for the fledgling grouper culture industry in Indonesia resulted primarily from the government-, JICA- and ACIAR-funded Gondol Research Institute for Mariculture (GRIM) established in 1994 in Bali. GRIM managed to achieve (from 1996) and recently extend (from 2001) mass seed production of groupers and other species in their Backyard Multispecies Hatchery System (BMHS). This permitted the proliferation of backyard hatcheries and cage farm on-growing sites around Indonesia. Since that time, local and private investors have been expanding the industry and numerous government institutions around Indonesia and Sulawesi have continued research and extension.

Grouper farming in South Sulawesi is currently limited to 40 research and approximately 50 commercial cages in Barru and Sinjai, which have only been operational over the last year and hence do not show in the figures for mariculture production from the Fisheries Department for 2001.

In the central Research Center for Aquaculture, grouper production is currently the number one priority. Through GRIM in Bali (to answer the number one problem: lack of seed), they have developed grouper hatchery rearing (Sim et al., 2002; Sugama, personal communication; Sugama et al., 2002). This has involved primarily Tiger Grouper (*Epinephelus fuscogatus*) (medium value) and Humpbacked Grouper (*Cromileptes altivelis*) (high value), but also estuarine or Orange-spotted Grouper (*Epinephelus coioides*) which has a low market value. They have demonstrated and extended (including initially free eggs and appropriate diets) small-scale, low-tech grouper hatchery technology, which has led to the establishment of 2,000 backyard grouper and milkfish hatcheries in Bali alone.

Of these 2,000, only 180 are active continually and the others work with grouper and/or milkfish and occasionally nothing depending upon local demand and to satisfy the 30-60 million milkfish seed/month export market to the Philippines. Only 24 of these backyard hatcheries have grouper broodstock (Tiger only) and they, in addition to GRIM, sell eggs (US\$ 0.31/thousand for Humpback and US\$ 0.12/thousand for Tiger Grouper) to many of the other hatcheries (Sim et al., 2002; Sugama, personal communication).

There are also six grouper hatcheries in Lampung Province, one in Komodo run by TNC, 12 in East Java and only two in Sulawesi, including one planned in Sinjai, South Sulawesi, in cooperation with Dinas Perikanan and a 17-year loan from DANIDA (two years' construction, five years' rest and ten years' payback). For the Sinjai hatchery, the site selection is completed and a feasibility study is currently being conducted. This hatchery will use central and local government funding for construction; DANIDA will provide technical assistance and training will be the responsibility of GRIM. This should be a pivotal project and will be used as a training facility for local people and to provide seed for local growers.

They have a projected capacity of 1-2 million 5 cm fingerlings/year. However, this hatchery may never be built due to potential problems paying back the loan and inappropriate technology. The second Sulawesi grouper hatchery has just been set up and belongs to a private commercial company with some local government funding in Muna, Likang district in North Sulawesi (Marsden, personal communication).

Although GRIM itself is capable of producing more than 5 million/year, they produced 3-4 million Humpback and Tiger Grouper fry in 2001, with an additional 2.1 million from backyard hatcheries in the area. These fry were produced mostly to satisfy local demand, although this is seasonally insufficient for the Indonesian industry as a whole. In larval rearing, GRIM is now averaging 35% survival (7-20% average for backyard hatcheries) for Tiger and Humpback Grouper after two months to a size of 2.5-3 cm. They are then sold to the three to five pond or tank-based nursery growers in Bali who on-grow them to 5-10 cm, when they are ready to be moved to the on-growing cages. However, nurseries are not currently popular due to the expense involved with feeding these fingerlings and the current uncertain demand (Siar et al., 2002; Sugama, personal communication).

In GRIM, the cost of production of 2-cm humpback grouper fry is US\$ 0.09 each, while the selling price is US\$ 0.22 (US\$ 0.11/cm). Hatchery-gate value of 5-cm fingerlings are US\$ 0.25-0.88 each for Tiger Grouper while Humpback Grouper are valued higher at US\$ 0.50-1.26 each, with 5-cm wild-caught grouper fingerlings being worth US\$ 0.56-0.78 each, largely depending on season. After nursing, at 10-12 cm in length, Humpback Grouper are valued at US\$ 1.5-1.8 and Tiger Grouper US\$ 1.0-1.3 each. Prices for all categories are usually higher for export than for the domestic market (Siar et al., 2002; Sugama, personal communication).

The small-scale grouper hatchery industry is currently highly lucrative, although seasonal, generating an average of US\$ 2,000-5,000 per tank annually with IRRs (Internal Rate of Returns) generally over 100% and payback periods commonly under one year. These hatcheries also provide employment for many people (at least two full-time per hatchery earning US\$ 65-75/month and temporary staff, including many women for grading (US\$ 5/day) and distributing the fingerlings (Siar et al., 2002). However, to continue at this level of profitability, the nursing and on-growing industry in cages and/or ponds will have to expand to absorb the increasing hatchery production.

Indonesian grouper farmers have thus just recently acquired the technology to produce most of their own grouper seed economically and no longer need to fish exclusively for wild juveniles in destructive ways. Fishing practices for seed in Indonesia are currently unregulated and use a wide range of gears. These include the year-round, relatively selective and non-destructive hook and line and fish trap methods (taking mostly larger than 100-g juveniles), to seasonal push and scoop nets which take smaller fingerlings (2.5-5 cm) with little by-catch, but which by dragging can destroy large areas of seagrass beds (e.g., 50 ha lost in Banten Bay, Java between 1989-93), which are important nurseries for many fish species (Sadovy, 2000). Cyanide is also used to take juvenile or sub-adult fish destined for on-growing cages in Sulawesi, another highly destructive practice.

All of these practices, combined with over-fishing for both adults and seed, and coastal reclamation, development and pollution, have conspired to reduce Indonesian fry harvests by at least five-fold between the 1980s and the 90s (Sadovy, 2000). The capture of green or

estuarine grouper juveniles in Banten Bay was also reported by Nurai to cause an 80% reduction in wild stock (quoted in Halim, 2002).

Perhaps the most important problem with the capture of wild seed is that they are normally captured at 2-15 cm (range 1-25 cm), at immediately post-settlement to one year of age (Sadovy, 2000). This signifies that they will all be juveniles since sexual maturity does not occur until 25 cm total length, and hence will be removed from the population before having had a chance to spawn.

What little is known about natural fry mortality rates suggests that juveniles a few months old (>6 cm) may reasonably be expected to survive to adulthood. Thus, the current removal of this size of fish could have a significant impact on adult stock and should be considered a capture fishery and thus regulated (Sadovy, 2000). For example, fishermen could be allowed to take smaller fish, which have less chance of becoming adult, and forbidden from the capture of larger juveniles.

Although there are no reliable figures for fry capture or export, 1999 import figures from Hong Kong recorded US\$ 0.2 million worth of marine fry (mostly groupers) from Indonesia by air (no data from ship transport) (Sadovy, 2000). The world trade in grouper fry is now probably numbered in the hundreds or thousands of millions per year (Sadovy, 2000).

The production capacity of the GRIM hatchery alone would stock 5-6,000 cages capable of generating US\$ 12-19 million in 2001. This equates to 800-1,000 mt/year of cultured grouper, equaling the official import levels of live reef fish from Indonesia to Hong Kong in 2000 (Anon, 2001).

Most of the current grouper cage culture is in Aceh, Nias and Sibolga and the Batam Islands in North Sumatera (close to the Singapore live market) and Lampung Province (1,120 cages), the Riau and Bangka Islands in West Java, the Karimunjawa Islands in Central Java, Teluk Saleh in Western Nusa Tenggara, and some in Kendari Southeast, Barru Southwest, and the Togian Islands, North Sulawesi (Muhariadji, personal communication; Ramelan, 2002; Simangiah, personal communication). Many of these operations started with milkfish in cages, but most converted to grouper beginning in 2000.

One of the biggest private grouper cage farms is in Lampung Province, South Sumatera, with 300 cages altogether. The cages are mostly 3x3x3 m in size and are stocked with 500 5cm+ fish, with a total of 80,000 stocked per year, of which 80% are of hatchery origin, the rest coming from the wild during the off-season for the hatcheries. Each cage yields 250 kg in eight months for Tiger and Estuarine Grouper or 18 months for Humpback Grouper. This farm began operations in 1996 in cooperation with International Marinelife Alliance (IMA) using Humpback Grouper. Soon after this, many local small-scale businesses started and got involved with protecting the reefs in the area (Simangiah, personal communication).

The live grouper are marketed in Hong Kong. Two to three mt of fish are harvested and the live fish transporter vessel comes to take them to Hong Kong. Airfreight (since there are no direct flights) is still too expensive and so is still rarely used from Lampung.

Although Humpback Grouper are worth US\$ 28-38/kg live farm gate (US\$ 50/kg for hardier wild-caught fish), Tiger Grouper are worth less (\$10-12/kg), but have a cycle time of only

eight months (a more attractive proposition as an alternative livelihood), but are still less profitable currently (See Table 5).

The Lampung farm with 300 cages produces an average of 40 mt/year, with approximately 100 mt/year produced by all of the cages in Lampung Province. The culture industry in this area is worth US\$ 4 million/year and expanding. Real cost data generated from a Humpback Grouper cage farm are shown in Table 4.

Table 4 Real Data Analysis of Costs (US\$) for Humpback Grouper Cage Farm of 4*4 Cage Units

Item	Value (US\$)
Capital costs	22,346
Debt repayment	11,732
Operational costs	34,413
Total costs	68,492
Production (4 mt @ US\$ 28/kg)	112,000
Profit Cycle 1 (18 months)	43,240
Profit cycle 2 (12 months)	65,587

Source: Ketut Sugama (personal communication)

A government-run hatchery in Aceh (North Sumatera – their natural spawning site) has recently succeeded in the spawning and larval rearing of Giant Grouper (*Epinephelus lanceolatus*) (Sugama, personal communication). Gondol have the ability to do the larval rearing of this fish, but have not done so yet due to the scarcity of local broodstock. A commercial company in southern Taiwan also spawned this species successfully in 2000 using 500 broodstock (Sadovy, 2000). From this spawning, two million fry were sold to Hainan, Hong Kong, Malaysia and Vietnam. The National Institute of Coastal Aquaculture (NICA) in southern Thailand has also reported some success with this species (Sadovy, 2000).

Culture of the Giant Grouper has potential as an alternative livelihood since it will grow to 0.6-1 kg in only 4-6 months, a much more attractive payback period for small-scale farmers. A report prepared by TNC on the prospects for Indonesian coastal fishermen to use grouper culture as an alternative source of livelihood, suggested that despite a high willingness of fishermen (74%) and middlemen (95%) to adopt grouper culture, their major preoccupation involved the long time-delay in receiving financial reward from such activity (Halim, 2002; Wicaksono, personal communication).

Since 1999, GRIM has been working on developing grouper grow-out feeds on an ACIAR-funded project. Early achievements allowed Humpback Grouper to be grown from 10-cm stocking size to 470 g in 15 months, feeding only pellets at an FCR of 1.4:1. GRIM are now collaborating with the private sector (CP and Comfeed) to produce their formulations (38-40% protein for bigger sizes and less than 46% protein for small), which cost US\$ 0.7/kg to produce and sell for US\$ 1-1.1/kg. They are addressing the problem of fishmeal use by partially replacing fishmeal with soybean and other plant meals and snail meal (Siar et al., 2002; Sugama, personal communication).

GRIM is helping to stimulate private individuals and companies by running regular training courses on hatchery and grow-out technology with students free-of-charge and private participants paying fees. Although GRIM are not investigating pond culture technology, the DGF in Jepara is currently conducting research into this aspect. This could generate an

alternative use for the thousands of hectare of currently unused or unprofitable shrimp and milkfish ponds around Sulawesi (and Indonesia in general).

Future species for production research in GRIM include red snapper, coral trout, mud and swimming crabs and Humphead or Napoleon Wrasse (*Cheilinus undulates*). This last species has received some interest and spawning is possible, but larval survival is still low. Current investigations are focusing on egg quality issues with this species.

In Sulawesi, the Research Institute for Coastal Fisheries (Balit Kantor), a technical unit of the Central Research Institute for Aquaculture funded by government and Australian ACIAR money, is involved with research programs to produce adaptive and ecologically sustainable aquaculture and capture fisheries in South Sulawesi. The institute is conducting research and extension into grouper culture, principally using Tiger and Humpback Groupers but also Mud Groupers, Humphead Wrasse and milkfish.

They have no hatchery but are using seed from Gondol and on-growing grouper and milkfish in net cages around Parepare and Barru on the west coast and Sinjai in the east of South Sulawesi. They started cage culture demonstrations in 1999, currently have 32 cages (10 for grouper and 22 for milkfish), and have already sparked the interest of local entrepreneurs who have 50 cages around South Sulawesi. Real data from these operations are shown in Table 5.

Table 5 Cage Culture Details for Grouper and Milkfish in South Sulawesi (2002)

Parameter	Tiger Grouper	Humpback Grouper	Milkfish
Cage size (m)	2*2*2	2*2*2	2*2*2
Cage cost (US\$)	89	89	89
Cage life (years)	5-6	5-6	5-6
Net cost (US\$)	34	34	34
Net life (years)	2	2	2
Market	Live export	Live export	Local
Market size (g)	700	700	500-600
Grow-out (months)	8	18-20	5
Seed supply	Hatchery 5 cm	Hatchery 5 cm	Hatchery 50 g
Seed cost (US\$)	0.89	1.12	0.11-0.17
Harvest density (no/cage)	200-300	200-300	500
Survival rate (%)	60-70	60-70	95
Feed	Trash fish	Pellets	Pellets
FCR	8-10:1	3.5:1	1.7-2.2:1
Diseases	VNN, Vibrio	Cryptocarium	?
Farmer class	Mid-rich	Mid-rich	Low-mid
Market value cage (US\$/kg)	10-12	28-38	1.7-2.0
Market value pond (US\$/kg)	?	?	1.0-1.1
Profit margin cage (US\$/kg)	2.23	22.34	0.45-0.67

Source: Research Institute for Coastal Aquaculture, Maros (2002)

In another form of culture, a group of nine coral reef fish traders involving 450 fishers and 450 cages (5x5x5 m) established themselves in South Sulawesi around the Spermonde Archipelago in the late 1990s to raise primarily cyanide-caught, sub-adult fish to market size for the live fish trade, feeding with trash fish (Moka, personal communication; Sadovy, 2000).

The government Fisheries Department (Dinas Perikanan) of South Sulawesi, in making aquaculture a priority to replace destructive fishing practices, are researching small-scale cage culture of groupers in Barru Province, and want to scale up with groupers and coral reef fish. Their current constraint is seed supply and they are hoping that BBAP can help develop their hatchery for high-value species. They are currently relying on seed from government facilities in BBAP, a private hatchery in Lampung and GRIM.

The BBAP hatchery in Takalar has so far concentrated on Tiger Grouper, producing two runs so far at 0.1% and then 20% survival to 45 days. They also have other grouper broodstock (Humpback, Mud and Humphead Wrasse) as well as seabass, but have not so far managed to spawn them. They send their staff to Gondol for training in grouper rearing. BBAP have also been working with grouper in cages in Barru and Sinjai using their own seed and those from Gondol. They have also tried grouper cages around Takalar, but this area offers no protection in wet season, limiting them to the 8-month dry season. Thus, in 2003 they want to start researching grouper (Tiger and Mud) culture in ponds. They run training courses for locals three times per year in hatchery, grow-out and disease. They also have a functioning histology lab and will get a full PCR lab by 2003.

4.4.2 Shrimp

The most valuable aquaculture species produced in Sulawesi is the Black Tiger Shrimp (*Penaeus monodon*). There are more than 60,000 ha of brackishwater ponds in South Sulawesi alone, producing *P. monodon* in semi-intensive monoculture (25%) or polyculture with milkfish (75%). This industry generated 15,000 mt worth more than US\$ 100 million in 2001 (more than 25 times the value of the marine fishery for this species) (Dinas Perikanan, 2001, See Table 2).

However, the Fisheries Department of South Sulawesi report that the industry is now suffering due to low market price, disease problems (principally white spot virus) and the cost (US\$ 34-56/female and US\$ 4/male), scarcity (most from Aceh and East Java) and perhaps loss of genetic diversity of broodstock leading to low growth and survival rates. Thus, there may be up to 8,000 ha of currently unused shrimp ponds, and 30 of the 35 large shrimp hatcheries are now closed, but perhaps only temporarily for the wet season (Ibrahim, personal communication).

The Fisheries Department is currently conducting demonstrations of semi-intensive *P. monodon* culture techniques in 10 ha of ponds in each of Pinrang and Polmas districts. They are also trying to secure financing from banks for shrimp farmers.

BBAP have a *P. monodon* hatchery producing seed for sale to local farmers and to stock their own research ponds. They also have a *Macrobrachium* hatchery selling seed to local farmers under stimulus from the Governor's office.

There is also some culture of *P. merguensis* and other *Metapenaeid* shrimp in extensive, tidal fed and seeded ponds producing 2,713 mt worth 2.9 million in 2001 (Dinas Perikanan, 2001, See Table 2).

Additionally, two commercial companies have experimented with the alien *P. vannamei* in Pinrang and Bone. Both obtained post-larvae from a commercial hatchery owned by Patango Banuwangi in Surabaya, East Java. Although the initial trials were not successful, some

companies are still trying with this species in Java. P T SAU in Bone stocked two 0.5-ha ponds at 15-20/m² and produced 2 t/ha at 10 g, but encountered problems selling the shrimp produced to a market used to *P. monodon*. Dewindoo in Barru stocked one 1-ha pond at 10/m² and harvested just 0.8 t/ha at 12-14 g. They obtained a market price of just US\$ 3.4/kg locally and US\$ 3.9/kg in Java, only 50% of the value of cultured *P. monodon* (See Table 2).

4.4.3 Milkfish

The traditional milkfish (*Chanos chanos*) culture industry has been in brackishwater ponds either in monoculture (60%) or in polyculture with *P. monodon* (40%). This industry in South Sulawesi produced 56,000 mt worth almost US\$ 56 million in 2001 (Dinas Perikanan, 2001, See Table 2). However, as with the shrimp industry, recent problems supposedly associated with the feed and seed quality of milkfish have resulted in lower growth rates. In 1999, the fish grew to 400-500 g in four months, while the culture period is currently 5-6 months for the same sized fish (Muhariadji, personal communication).

Despite these problems, some shrimp farmers are culturing milkfish in their shrimp ponds, and are buying fry cheaply from the wild or from the two commercial hatcheries in Barru (at US\$ 9-11/thousand) or preferably from GRIM or the GRIM-inspired backyard hatcheries of Bali (at US\$ 4/thousand).

Backyard milkfish hatcheries in Bali began producing in 1993 and were encouraged and supported by GRIM (through free training, technical support and fertilized egg distribution) such that their numbers increased from 10-20 in 1993 to 214 in 1997. From there, they were also extended to other areas of Indonesia including Sulawesi (Siar et al., 2002).

The collection of wild milkfish fry for on-growing is a major livelihood among Indonesian coastal dwellers. However, with the development of successful hatcheries, wild collectors can no longer compete on price and are forced to either become hatchery or pond/cage farmers or seek alternative employment. In Bali, the adoption of milkfish hatcheries by small farmers created new livelihoods with more profit than from agriculture or catching wild seed, but their production is seasonal and now they are converting to grouper due to its higher potential profitability (Siar et al., 2002).

There is some diversification, with tank-and pond-based nursery operators who raise the fry to 50 g for sale to cage farms. BBAP have been working with milkfish in both hatchery and extensive pond culture, where they stock 3-5 fish/m² and use only fertilizers to increase natural productivity in an attempt to improve the economics of milkfish culture.

There have also been some investigations of milkfish in cages for local consumption and tuna bait. However, the local farmers are just barely breaking even and are generally more inclined towards grouper as it is perceived as being more profitable (See Table 5).

4.4.4 Seaweed

Extensive industries for both the capture and culture of seaweed exist in South Sulawesi. The capture of mostly *Eucheuma Spp.*, largely around Takalar, amounted to nearly 24,000 mt worth US\$ 1.3 million in 2001, while the culture industry around Sinjai and Takalar produced nearly 20,000 mt of pond-cultured *Gracilaria Spp.*, worth US\$ 1.6 million in 2001 (Dinas Perikanan, 2001, See Tables 1 and 2).

There is also culture of *Gracilaria* in ponds in the Palopo area, with some help from NGOs in culture techniques and marketing. Women working part-time over a 60-90 day culture cycle mostly carry this out.

Current research work in Sulawesi includes a German PhD student studying the aquaculture potential of seaweed through the Marine Science Department of Hasanuddin University and BBAP, Takalar, who are starting work on seeding techniques for *Eucheuma* and *Gracilaria* in 2003.

Since 1999 there has been culture of *Eucheuma* seaweed on ropes and bamboo stakes in the sea around Tanekeke Island off Takalar, Sinjai, Kapoposang in the Spermonde Archipelago and Taka Bonerate in the south. But some conflicts with cyanide fishermen have surfaced since seaweed downstream of reefs where cyanide is being used is dying (Johannes and Riepen, 1995; Moka and Ibrahim, personal communication).

Most seaweed currently produced is sun dried and sold at US\$ 0.23-0.28/kg to middlemen who then sell to the one existing processing plant, Bantimurung Indah in Maros (the first in Indonesia). However, there are some problems with quality due to poor drying techniques.

The government is helping build a processing plant (opening in 2003) with cooperation with a Japanese company in Takalar for *Eucheuma cottonii*, *Eucheuma spinosum* (new name *Kappaphycus alvarezii*), *Gracilaria verrucosa* and *Gellidium Sp.* to help stabilize prices. Nearly all the seaweed processed is exported, with the current plant either selling the product dried, half-processed and chopped or as a fine powder.

4.4.5 Seabass

South Sulawesi had a marine fishery for seabass (*Lates calcarifer*) amounting to 2,270 mt, worth US\$ 1.5 million in 2001, and a pond- and cage-based aquaculture industry, almost entirely around Bone on the east coast, producing 3,500 mt worth US\$ 1.4 million in 2001 (Dinas Perikanan, 2001, See Tables 1 and 2).

More recently, however, seabass have been losing favor with aquaculturists due to their low value (US \$ 0.4/kg, See Table 2), especially compared to grouper, and to the unavailability of seed. BBAP in Takalar have broodstock seabass but have as yet not been able to spawn them efficiently.

4.4.6 Lobsters

There is a fishery for *Palinurus Spp.* lobsters off South Sulawesi of 692 mt worth US\$ 3.4 million in 2001, with most being sold into the live fish trade overseas (Dinas Perikanan, 2001, See Table 1). Recently, however, there has been interest in the culture of these organisms to augment this trade.

The Fisheries Department of South Sulawesi is researching lobster farming in cages in the Sembilan Islands off Sinjai using wild-caught juveniles. However, the lobsters take longer to grow than groupers, the feed is expensive and their culture is not as profitable as grouper. Also, the taking of all the juvenile lobsters from the reefs before they have had the chance to spawn is probably unsustainable (without protected zones to allow recruitment) and hence the industry is not considered viable.

4.4.7 Giant Clams and Other Mollusks

There is no fishery for or commercial aquaculture of giant clams (*Tridachna Spp.*) currently in South Sulawesi, but recent advances in their aquaculture, principally in Australia, have led to interest in their culture here.

Under the Marine Science Department of Hasanuddin University in South Sulawesi, there is a group headed by Aspari Rachman and Mr Syafiuddin called the Marine Ecosystem Conservation and Rehabilitation Unit. They are working with two private Indonesian companies (CV Dinar and CV Marina Aquarium) to research the culture of grouper, clownfish, milkfish and giant clams for aquarium use. They have a small lab in the university and a research station on Balanglombo Island in the Spermonde Archipelago off Makassar for fish, seaweed and clams, which is just going commercial, and another in Bali. This hatchery has been doing restocking and sale of clams since 1990, but only work to order (they are currently producing for companies in the Molucca Islands).

The Marine Biology Department of Hasanuddin University is also trying to get outside funding for research into abalone, pearl oyster and *Trochus* culture. Some research projects have also looked into culturing abalone and pearl oysters in Lombok and Bali under Aspari Rahman, and pearl oysters in north Sulawesi under Proyek Pesisir. Rahman also had a research project in 1996 involving the culture and restocking of giant clams in the Spermonde Islands and Taka Bonerate Atoll with consultants from JCU, Townsville, Australia. After this restocking project, fishing for clams was prohibited, the populations have recovered and now locals are pushing to reopen the fishery for them (Littay, personal communication).

Sulawesi has no pearl oyster culture as yet, although in other areas of Indonesia this is practiced, such that 118 private companies produced 103 mt with a value of US\$ 20 million in 1994 (Ramelan, 2002). The main limitation currently is the lack of hatcheries and hence seed stock, since there are indications that the wild stock is depleted.

4.4.8 Tilapia

There is an aquaculture industry for *Tilapia Spp.* in South Sulawesi that produced nearly 2,000 mt worth US\$ 700,000 in 2001 (Dinas Perikanan, 2001, See Table 2). Most of this culture was in brackishwater ponds around Maros on the west coast, although the Fisheries Department is promoting tilapia for culture in Sulawesi's freshwater lakes.

4.4.9 Siganids

There is no commercial industry for rabbit fish (*Siganus Spp.*) in Sulawesi. However, there is a project set up by an NGO on Condon Bali Island near Kapoposang to culture this species, since they have a good local price and the larvae are easy to produce in the hatchery (Jompa, personal communication).

4.4.10 Coral Reef Organisms for Aquarium Trade

After the live reef fish trade for high-value groupers and wrasses, ornamental fish (more than 280 species) and corals (70 species) for the aquarium trade are the most exploited reef fisheries commodity in Indonesia, with some species already becoming scarce (Anon, 2001). These organisms (except the corals) are also fished for predominantly using cyanide, often with even more devastating effects than for food fish. This is because there are many more target species and hence more cyanide is used. There is thus considerable need and demand for alternative supplies of these organisms and aquaculture is a possibility.

There are two possibilities for the culture of coral reef organisms to satisfy the aquarium trade and reduce pressure on wild stocks – either wild capture and on-growing of seed, or the complete hatchery-based rearing of these organisms.

Some research work has already been done in New Zealand, Australia and French Polynesia, and under an ACIAR-funded project in the Solomon Islands, to develop fisheries based on the capture and culture of post-larval coral reef fish (Hair, 2002; Trakakis, personal communication). The project in the Solomons used light traps and crest nets to catch recently settled fish of high-value species (including groupers), which were presumed to have a high mortality immediately post-settlement on the reef. They then worked on methods of on-growing suitable for extension to local fishermen as an alternative livelihood (Hair, 2002).

The other alternative is to establish hatcheries for species of interest to the aquarists. There are currently five existing world-wide hatcheries producing coral reef fish on a commercial scale:

1. Reef Propagations Inc, Illinois, USA, Joe Lichtenbert
2. C-Quest, Puerto Rico, Bill Addison
3. Oceans, Reefs and Aquariums, Harbor Brach, Fort Pierce, Florida, Jeff Turner
4. Mangrove Tropicals, Hawaii, Richard Masse
5. TMC, USA, Paul West and Daniel Stokes

Most of these companies concentrate on clownfish and other fish species, but the hatchery technology is capital intensive, secretive and risky such that all of the other previous companies have gone bankrupt.

5. SPECIAL CASE: TRADITIONAL INDONESIAN FISHING IN THE MOU BOX, NORTHWEST AUSTRALIA

5.1 Introduction

This section deals with the problems involved with Indonesian fishermen fishing for *trochus*, sea cucumbers and sharks and other fish within the MOU Box. The MOU Box is an area of the Australian Fishing Zone off the northwest Australian coast where Australia has agreed (under a 1974 Memorandum of Understanding) not to enforce its fisheries laws against traditional Indonesian fishermen. Many of the original fishermen originated from South Sulawesi and some still do, but the majority now comes from the islands of Rote, Raas and Madura. Nevertheless, some of the recommendations made in this report for alternative livelihood possibilities within a community-based coastal resources management plan for South Sulawesi, may also be applied to these fishermen.

5.2 Background on the Traditional Fishing Grounds of the MOU Box

Maritime boundary negotiations between Australia and Indonesia took place in the early 1970s. In this context and in recognition of the history of Indonesian fishing in the area, Australia and Indonesia signed the “Memorandum of Understanding between the Government of Australia and the Government of the Republic of Indonesia Regarding the Operations of Indonesian Traditional Fishermen in Areas of the Australian Exclusive Fishing Zone and Continental Shelf (MOU)” on 7 November 1974. The MOU provided a basis for traditional Indonesian fishing access to defined areas within Australia’s northwestern Exclusive Economic Zone (EEZ). Specifically, Australia agreed to refrain from applying its fisheries laws against traditional fishermen who conduct their operations in accordance with the MOU.

Australia shares 2,000 km of its maritime border with Indonesia and the establishment in 1979 of the 200 nautical mile Australian Fishing Zone (AFZ) and in 1980 of the 200-mile Indonesian Exclusive Economic Zone created areas with overlapping fishery rights between the two countries. Hence, under the 1982 “Provisional Fisheries Surveillance and Enforcement Arrangement” lines were drawn but, as outlined in the 1974 MOU, traditional fishing by Indonesian fishers was still allowed in key areas (CSIRO, 1999; Fox et al., 2002).

The permitted areas of access under the 1974 MOU included the continental shelf adjacent to Ashmore Reef, Cartier Island, Browse Island and Scott and Seringapatam Reefs. Australia and Indonesia met in 1989 to produce practical guidelines for the effective implementation of the MOU, and to discuss other developments since 1974¹. Australia proposed the establishment of a wider “Box” area of permitted access, which enclosed the reefs mentioned in the MOU. This proposal was agreed, and the area has since been referred to as the “MOU Box”. The 1989 Practical Guidelines also further define the term “traditional fishing” in the MOU as being:

¹ This included the declaration of 200 nautical mile zones by both countries and the agreement to a provisional fisheries surveillance and enforcement line (PFSEL) between Australia and Indonesia in 1981.

limited to Indonesian traditional fishermen using traditional methods and traditional vessels consistent with the tradition over decades of time, which does not include fishing methods or vessels utilizing motors or engines.

At the 1989 talks, Indonesia indicated its willingness to prevent breaches of the MOU and both countries also agreed to cooperate in developing alternative livelihood projects in eastern Indonesia for traditional fishermen utilizing the MOU Box.

The largest reef in the MOU Box is the Ashmore Reef, which forms part of the 560 km² of shallow reefs and 1,226 km² of shoals within the MOU Box (CSIRO, 1999). Here “traditional” fishers were allowed to take *trochus*, sea cucumber, abalone, green snail, sponges and all seabed mollusks, as well as fin-fish and reef sharks. Ashmore Reef was proclaimed as a National Nature Reserve (583 km² in extent) in 1983. In 1988 the majority of the Reserve was closed to access and fishing. This measure had the effect of shifting fishing emphasis to nearby Cartier Island, Browse Island and Scott and Seringapatam Reefs, the other fishable areas within the MOU Box (See Figure 5). In 1985 a camp was established for caretakers and in 1986, a chartered vessel was stationed at Ashmore to oversee the reserve.

In 2000, the Cartier Island Marine Reserve (extending over a four nautical mile radius from Cartier Island, and 167 km² in total) was established to protect its natural resources and act as a seed reef to help repopulate other areas in the southerly-flowing current passing this reserve. The Reserve was closed to Indonesian fishing in 2002, with this closure to be enforced from July 2003. Since Cartier Island and the surrounding area within a 10-km radius is a former Defence Practice Area, the whole site is currently completely closed for all shipping, except for emergencies and essential management and research activities under permit (Commonwealth of Australia, 2002).

Since 2000, there has been an Australian Custom Service vessel stationed at Ashmore, largely in response to increased transit of illegal immigrants passing through this area. However, the vessel and crew also conduct reserve management duties, replacing the Environment Australia (2002) vessel and crew who were stationed there for over a decade.

Both Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve have been placed under the jurisdiction of the Commonwealth of Australia, who published the current management plan for these reserves in 2002, confirming the above restrictions (Commonwealth of Australia, 2002). The intention is that these plans and regulations will be in force until 2009, but will be reviewed in 2007, taking into account ongoing performance assessments.

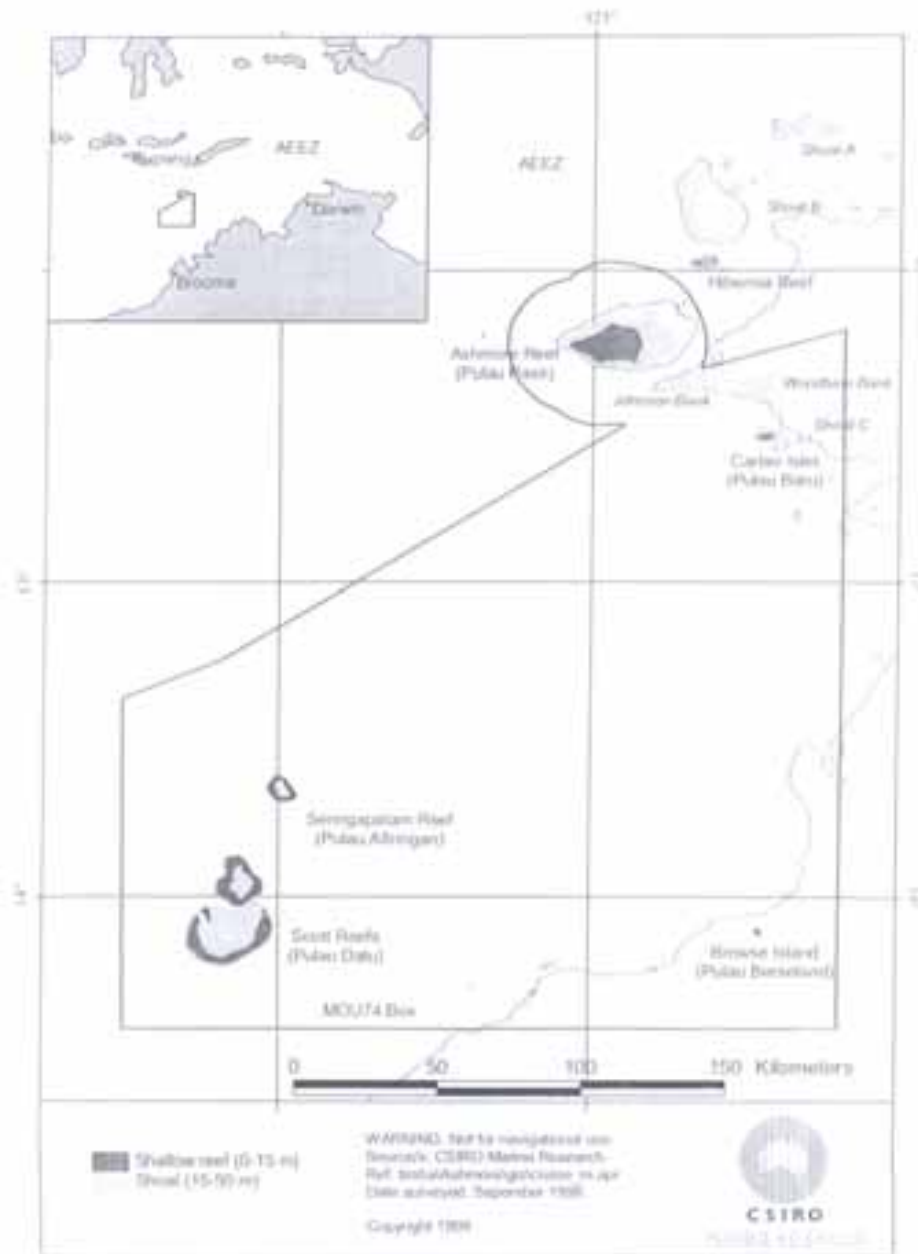


Figure 5 The MOU Box and Relative Positions of Indonesia, Australia and the Australian Fishing Zone (AEEZ)

5.3 Traditional Fishing Practices

The fact that Ashmore Reef is closer to Indonesia's southernmost Islands, including Rote (110 km due north), Timor and Sumba, than it is to Australia (600 km to the south), and that it has fresh water, has made it an important fishing and staging area for Indonesian fishermen (who call it Sand Island) for a long time. The historical evidence suggests that it has been used by Indonesian fishermen from Sulawesi for more than 250 years to supply the Chinese demand for sea cucumbers (Commonwealth of Australia, 2002; CSIRO, 1999; Fox et al., 2002).

Currently, some fishermen from Sulawesi – including the nomadic fishing and sailing populations of Makassarese, Bugis and Bajau – still fish these areas, but the majority are from branches of these peoples now based in Nusa Tenggara Timor (89%), including Rote, Raas, Madura, Timor, Flores and the Moluccas, the Madurese from Madura, and the Butonese from Buton. Makassar in South Sulawesi was traditionally, and remains today, the major trade center for *trochus*, sea cucumbers and shark fins for the whole of eastern Indonesia (Fox et al., 2002).

Although fishing effort data are rare, estimates have suggested that until the early 1900s, 200 *perahus* (fishing vessels) and 8,000 fishers per year fished the MOU Box area. More recently, due probably to higher product prices, the depletion of Indonesian reefs and Indonesia's economic problems, the effort has increased significantly, both for traditional and illegal fishing in and outside the MOU Box (CSIRO, 1999).

Data on the catches and profits obtained from traditional sedentary *trochus* and sea cucumber fishing, and the more modern long lining for sharks within and around the MOU Box, are patchy and incomplete. However, some indications can be given (Fox et al., 2002). Previously high catches of sea cucumbers in the peak seasons from October to December between 1995 and 1997, fell (with a slight peak in May-June 1998) even in the peak season, probably due to over-fishing of first high and then medium-low-value species leading to over-fishing. Median catches averaged 100 kg of dry product per vessel (with peaks up to 1,000 kg). *Trochus* catches are even harder to document, but median catches (1995-99) averaged 14 kg per vessel (maximum 1,000 kg), but with fewer trips being made each year.

Traditional Indonesian fishers who travel to the MOU Box (usually for four-month trips) to fish for *trochus* and sea cucumbers, typically make US\$ 150-320 per month, although the over-fishing of high-value species may now be reducing the profitability of these trips. However, comparisons suggested that these figures are from 60-240% more than the earnings of local fishers working in Raas, showing a clear financial incentive to continue exploiting the MOU Box, at least for the time being (Fox et al., 2002).

Shark fishing around Australia began to assume dominance among Indonesian fishermen in the 1990s due largely to a six-fold increase in product value for the new export market to Hong Kong. Other factors were the shorter duration and hence greater number of trips that could be made with this type of fishing, and the over-exploitation of *trochus* and sea cucumber resources. In addition, the over-fishing of shark in Indonesian waters meant that higher-value fins from larger shark could only be obtained from Australian waters (Fox et al., 2002).

Shark fishing data is more complete, but only reflective of fishing in the MOU Box. The data are probably an underestimate of total fishing effort that is carried out more successfully (and illegally) in the AFZ, but outside the MOU Box where the shark resources are less depleted. Mean catches were 5-6 kg of dried shark fins per vessel between 1997-99 (maximum 16 kg), worth typically around US\$ 500. The current value of shark fin in Indonesia varies depending on size from US\$ 5-10/kg for the smallest, US\$ 20-25 for medium and up to US\$ 50-100/kg for the biggest, first-class fins (Fox et al., 2002).

Shark fishermen may typically earn anywhere between US\$ 40-230 per trip (usually 15 days in duration). However, some trips earn much more and sometimes so little that the fishermen become indebted to their bosses for the losses incurred (repayment of the cost of outfitting the boat). The vessel owners (often owning multiple boats) and bosses (who give credit to finance the trips) stand to make much higher profits, especially since they buy the fins cheaply from fishermen bound to them by debt.

Although the practice is risky – since the Australians will confiscate boats caught fishing illegally – due to the high profits possible, the bosses (who assume responsibility for the boat, but not the equipment) can cover the cost of a lost second-hand boat with only one to two successful trips (Fox et al., 2002). Loss of the fishing equipment (for example, from a confiscated boat) is shared among the captain and crew and thus creates much of the fishermen's indebtedness. The limited bargaining power of the boat crews against boat owners has resulted in increased indebtedness of poor fishermen. The widening economic gap between crews and the middlemen or boat-owning bosses and the Australian Government apprehension policy as the most effective deterrent to illegal activity does not auger well for the livelihoods of these fishers and will likely prove a financial disincentive.

Whatever form of fishing is done, journeys to fish around the MOU Box are seasonal, depending largely on the weather conditions, rather than resource availability or fishing season. Many Indonesian fishermen therefore have to supplement their fishing activities in Australian waters with local fishing or trade within Indonesia. They are thus not wholly dependent on fishing in the MOU Box and are somewhat open to the idea of fishing for other species or changing livelihood if necessary (Fox et al., 2002). Some form of alternative livelihood based on their own islands could thus be expected to be adopted without substantial problems if it were to prove economically viable (See section 8).

5.4 Problems with Traditional Fishing Practices

Over the years, problems have arisen with the MOU, including the definition of what “traditional” fishing means, how to regulate access to the areas open to these fishers, and underlying both, definition of who has the traditional claims to fish these waters. In addition, although the Australian government manages the marine resources of the area, little is known of the real catches of the Indonesian fishermen and there is increasing concern over the unsustainability of the current fishing practices (CSIRO, 1999).

According to recent surveys of the MOU Box area conducted by CSIRO in 1998 (CSIRO, 1999), there has been significant over-fishing and stock depletion. This has occurred principally because the MOU does not provide an effective and regulated basis for traditional fishing access. Over-fishing is also leading to a loss of livelihood for traditional fishers gathering sea cucumbers and *trochus*. This, together with more industrialized fishing methods

since the early 1990s has led to a switch towards motorized boats, long-lining for shark in the MOU Box and other areas of the AFZ (often using the MOU Box area as a staging point for illegal activity). As a result, many traditional Indonesian fishermen who used this area in the past under the terms of the MOU are increasingly finding themselves involved in a competitive and often illegal fishery.

Of the apprehensions between 1988 and 2001 within the MOU Box (operating outside the scope of the MOU), most were boats from South Sulawesi fishing for sea cucumbers in the mid-1990s. This type of fishing and hence apprehensions has declined markedly since 1995 due largely to over-exploited resources and boat destruction, and perhaps due to the switch to shark long-line fishing (Fox et al., 2002).

Thus, recently, the vast majority of vessels apprehended illegally fishing in the AFZ (outside the MOU Box) have been targeting shark and this appears to be on the increase. For example, in 1988, approximately 52% of all apprehended Indonesian vessels targeted shark. By 2002, this had risen to approximately 90%. Overall, Indonesian vessel apprehensions (95% of the total) have increased from an average of 36 per year between 1988 and 1993, to 90 per year between 1994 and 2002, with an additional 33 gear or catch seizures per year since 2000 (AFFA, personal communication).

The 1998 CSIRO survey revealed that over all of the shallow reefs (except perhaps within the Ashmore Reef National Park) there were severe depletions of *trochus* (*T. niloticus*) and the high-value sea cucumber (*Holothuria Spp.*), and that fishing had switched to the medium-low-value species, which were also becoming depleted. The deeper (>20 m) shoal areas were less depleted, probably due to the lower-value species and more difficult fishing conditions.

Finfish stocks were abundant in the shallow reefs and showed no signs of over-fishing, probably because finfish have not been targeted extensively by the Indonesian fishermen.

Low estimates of shark abundance and biomass on the reefs and shoals throughout the MOU Box were recorded from as early as 1994 and in the 1998 survey. This suggested that the current fishing effort (particularly with long lines) was seriously depleting the shark resources of the area (CSIRO, 1999).

5.5 Possibilities for the Resolution of Problems

It seems impossible to believe that either the Australian or Indonesian governments could reestablish a traditional fishery to resolve the problems encountered currently in the MOU Box. Instead, it has been suggested by the Australians that, to protect the resources of this area and provide assistance to Indonesian fishermen, the fishery, for the high-value species at least, should be closed for a minimum of three years, with accompanying planning and monitoring requirements (CSIRO, 1999). Additionally, some form of multi-focused, site-specific, long-term, alternative livelihood generation, requiring cooperation between both governments and the people involved, will be required (Fox et al., 2002).

In light of the 1998 CSIRO study and the resulting decline of livelihoods for traditional Indonesian fishers in the MOU Box, Australia and Indonesia met in April 2002 and resolved to form a joint MOU Box Management Committee. Closure of the MOU Box is not considered prudent given the importance of the area to traditional fishers and the significance

the Indonesian Government places on the 1974 MOU. However, both countries agreed to develop and implement a joint management strategy to conserve MOU Box resources while observing the needs of traditional fishers. A framework for this strategy was agreed in March 2003. It contains four elements:

- Management measures (such as identification of “traditional” fishers and regulation of effort)
- Research (for example, on shark abundance, regeneration of sedentary stocks, appropriate aquaculture alternatives)
- Alternative livelihoods (pilot project is currently underway), and
- Education and training (to ensure all elements occur in consultation with fishers and their communities).

The management plans for Ashmore and Cartier marine reserves (Commonwealth of Australia, 2002) outline a number of strategies concerned with protecting the reserves and minimizing the impact of traditional fishers operating legally in the area. These include:

1. Bans on fishing and access as detailed above
2. Cooperative management and protection initiatives
3. Study of the socio-economics of traditional fishers from Indonesia
4. Development and support of cooperative projects with Indonesia to facilitate alternative livelihoods for traditional fishers
5. Education of Indonesian fishermen regarding the latest restrictions and conservation aims of the reserves, and
6. Maintenance of a management and surveillance presence to help protect the reserves.

For their part, the Indonesian-government Ministry of Marine Affairs and Fisheries (MMAF) are trying to cooperate with the Australians and the Indonesian Ministry of Environment and Forestry, and have agreed that the Indonesian Government should do three things to specifically address this problem (Dahuri, personal communication):

1. Extension, education and training of Indonesian fishermen such that they should respect the Australian regulations, together with negotiations with Australia on catch limits.
2. Work with Australian Government grants to help fund research into alternative livelihood studies for the displaced fishermen (already initiated), and
3. Enforce the existing laws to reduce or eliminate illegal fishing by Indonesians in Australian waters.

The reorganization of the Indonesian-government Fisheries Department in 1999, with the formation of the MMAF, and their refocusing of emphasis towards empowerment of coastal communities within an integrated coastal management plan, was aimed at breaking indebtedness and generating alternative livelihoods for coastal fisherfolk.

The MMAF have also identified five critical factors relevant to the success of alternative livelihood initiatives within a community-based coastal management plan (Fox et al., 2002):

1. Local people should objectively identify the target group and beneficiaries
2. Local youth should be recruited to work as mediators, catalysts and extension agents
3. Local management consultants should be hired by the project to help people during, and prepare them to run their businesses, after the project ends
4. Formal and informal leaders should head an advisory group at village level to voluntarily help people during and after the project, and
5. Micro-finance institutions, totally owned by the beneficiaries, should be established with the flexibility to account for different needs in different places.

In the past there have been limited possibilities for formal credit for local fishermen in eastern Indonesia (bank interest rates are 18% per annum, with virtually impossible conditions), and they instead must rely on money-lending middlemen and vessel owners who often charge 60% annual interest. They also have the option to buy the fishermen's products at lower than market value. This has created the relationships of indebtedness that characterize Indonesian fishermen, often for life.

In 1992, in order to alleviate these problems, a cooperative, KUD (*Mina Sepakat*) was established in Pepela on Rote Island to provide for the needs of fishermen and their families. Although 121 fishermen joined the co-op, it failed due to conflicts of interest with the boat-owning management board, whose interests were in perpetuating the indebtedness of the fishermen (Fox et al., 2002).

The MMAF is currently again trying to establish credit facilities for local fishermen to help break indebtedness, despite past failures throughout Indonesia with *Mina* co-op schemes in the 1970s due to poor money management. Such initiatives should be lauded, but care must be taken in educating the recipients of such loans, and preventing corruption, for them to have any chance of success.

The total number of beneficiaries of the new government programs was reportedly 5,843 families in 2000 and 23,649 families in 2001 throughout Indonesia (Nikijuluw, quoted in Fox et al., 2002). Some of these have included fisherfolk involved in fishing the MOU Box, although in many of these areas (e.g., Rote and Raas) natural resources, and hence potential alternative livelihoods, are limited.

Numerous alternative livelihood projects have been proposed for Pepela on Rote island, mostly involved with aquaculture of seaweed, pearl oysters, milkfish and sponges in the clean waters of Pepela bay, although no projects have been successful to date. Seaweed farming, however, is a growing industry on Rote and is already tempting some fishers away from fishing. Nearby Kupang on Timor Island now has a processing plant to assist with marketing the products (Fox et al., 2002).

A grant totaling nearly US\$ 13,000 was given to a program in Madura between 2000 and 2001 involving 166 families to promote fishing for groupers and anchovies, and build a processing plant for the anchovies caught. Profits from the plant went into a revolving fund to increase the number of beneficiaries. There were also attempts to promote grouper farming and other aquaculture, but these never taken up (Fox et al., 2002).

Specific alternatives outlined for the migratory fishers of Raas were aquaculture, including seaweed, and the keeping or on-growing of live caught groupers and tourism, although due to the transient and scattered nature of communities throughout eastern Indonesia, detailed needs assessments are required (Fox et al., 2002).

Fishing activities therefore still dominate the areas from where fishermen using the MOU Box originate and attempts to provide alternative livelihoods have been limited in scope, scale and success. More coordination between Australian and Indonesian authorities, which has already been agreed to by both parties in principal, will be required in order to achieve this.

The introduction of aquaculture has yet to be successful, but may be possible with appropriate incentives and economic, technical, processing and marketing support. Alternative fishing methods, particularly with regard to the establishment of FADs and marine protected areas, and encouragement of marine-based eco-tourism, offer other possibilities, as they do for South Sulawesi (See section 7).

It is clear that whatever alternative livelihoods are considered, they will have to involve middlemen and vessel owners as well as poor fisherfolk, since they have a vested interest in continuing their current activities unless they can be convinced of the earning potential of alternative livelihoods. The various aquaculture and other options outlined in section 7 may present opportunities for such diverse and profitable livelihood aspirations.

Indonesian fishermen should require little convincing of the need to change livelihood. They are already acutely aware of the problems involving illegal fishing, loss of equipment, boats and money, over-fishing of high-value species, declining catches and profits, incursions into prohibited waters, and increased indebtedness. These problems have already led to the switch to shark fishing from *trochus* and sea cucumber gathering, and in some cases the exit from fishing entirely.

The problem has always been and still remains a lack of alternative opportunities. Education and economic empowerment of local people through well-organized micro-financing schemes, as a way of breaking indebtedness, keeping them out of fishing and broadening their horizons, and assistance in the generation of alternative livelihoods, is where coordinated efforts from both governments as well as NGOs and other agencies should now be the focus.

6. CONTROL OF DESTRUCTIVE FISHING AND COMMUNITY-BASED COASTAL RESOURCES MANAGEMENT

A tighter control of destructive fishing is needed through traditional as well as newer methods, for example, international satellite monitoring of fishing boat movements. The Indonesian MMAF has reported that around 7,000 foreign fishing vessels are operating illegally within the country's EEZ, incurring estimated annual losses to Indonesia of US\$ 1.4-4 billion (Dahuri, personal communication).

Cyanide use in the live reef fish trade has drawn a lot of concern from many parties in recent years. This practice entails limited destruction of coral reef structures, but perhaps more importantly, is an insidious form of over-fishing of high-profile, high-value species that in turn has potentially deleterious effects on coral reef communities. There are strong indications that the fishery is unsustainable and is now on (or perhaps beyond) the point of collapse in many areas of Indonesia and Southeast Asia in general.

It is currently difficult to control the trade in live reef fish because many of the live fish boats entering Indonesia from Hong Kong are registered as cargo boats and their cargo is not considered as food, and thus not under the control of the Indonesian Directorate General of Fisheries (Djohani, 1996). In any case, it is difficult to arrest boats that have holding tanks, but no fishing gear, especially since the high value of their cargoes permits large bribes.

What is needed is to convince regional government regulatory agencies that the live food fish trade is a distinctive form of fishery requiring its own legislation and management. Bearing this in mind, many recommendations have been made as to how to best combat this destructive and unsustainable fishery and these may be grouped into the following strategies (Graham, 2001):

1. *Fisheries and site-based management*: for transforming the fishery through legislation, policies and controls, and development of alternative enterprises and incentives
2. *Demand-side controls*: for controlling the import and trade in consumer countries
3. *Industry development*: to transform practices through fishing methods, mariculture, handling, transport and marketing, and industry standards
4. *Research and monitoring*: to collect and analyze all the information required to sustain the industry, and
5. *Communication and outreach*: To enhance the flow of information among the industry participants and the public.

A consensus of the specific problems, solutions and requirements associated with the live reef fish industry are shown in Box 1.

Blast or dynamite fishing is usually conducted for the harvest of food fish for local people, but can be many times more destructive of coral reef structures than cyanide fishing, and has ancillary effects on non-target marine organisms, which are also killed or displaced through bombing. Although blast fishing is officially illegal, its components are so readily available

and easy to obtain, and monitoring and enforcement so lax, that it appears extremely difficult to limit.

Although the vast majority (85%) of respondents from surveys of coastal communities around Sulawesi appeared aware that bombing damaged the ocean, they still sometimes used the technique since it was considered highly efficient and profitable (Crawford et al., 1998). They appeared unaware that their activities threatened their own existence, believing that there were plenty of undamaged reefs further out (Pet-Soede et al., 1999).

To enhance the control of this form of destructive fishing, attention should be focused on:

1. Banning the only potentially controllable item in the arsenal of the blast fisherman – waterproof fuses
2. Initiating and managing local marine tenure systems to give ownership and protection rights of the resources to the fishermen
3. Education of local fishermen as to the highly destructive capacity of blast fishing to their own resources and instruction in alternative fishing methods
4. Rigorous enforcement of the laws against blast fishing and the control of corruption
5. Locally-managed credit systems to free local fishermen from indebtedness to middlemen, and
6. Promotion of alternative livelihoods that can generate substantial income to compete with blast fishing.

Basic over-fishing, including but not limited to the two most obvious forms of destructive fishing, is even more pervasive and harder to control. Nevertheless, within an integrated community-based coastal management plan, limitations on all forms of destructive fishing will inevitably require relocation of the current participants into alternative livelihoods.

The staggering loss to fisheries, coral reefs and their communities (both aquatic and human), biodiversity, coastal protection and alternative livelihood potential of other forms of fishing and tourism due to destructive fishing practices, has recently been accounted for by the World Resources Institute's study on Southeast Asian coral reefs (WRI, 2002). The total economic value of Indonesia's coral reefs was estimated at US\$ 1.6 million/year, with a net present value of US\$ 14 billion. The net economic loss to Indonesia over the next 20 years (largely due to coastal protection, tourism and fisheries) was estimated at US\$ 95 million/year from over-fishing, US\$ 46 million/year from cyanide fishing, and US\$ 28.5 million/year from blast fishing.

Cesar et al. (1997) also calculated the economic losses to Indonesia where cyanide fishing is being conducted as US\$ 443,000/km² and for blast fishing up to US\$ 746,000/km². An analysis by Pet-Soede et al. (1999) suggested a more conservative net loss after 20 years due to blast fishing of US\$ 33,900-306,800/km² of blasted coral reef, depending on the potential value for tourism and coastal protection. The total loss for the world's coral reefs over the next 25 years was estimated at US\$ 1.2 billion/year (Cesar et al., 1997).

Box 1 Recommendations for Combating Problems with Live Reef Fish Trade in Indonesia

Problem	Solution	Requirements
Lack of common knowledge of problem	Dissemination of environmental and human problems of trade to all affected parties	Publicity campaigns aimed all affected parties in every conceivable medium to publicise problems with trade
Lack of quotas leading to unrestricted fishing	Legislate regional export quotas for each species with size limits; formation of an association of traders as a forum for legislation	Monitoring and enforcement of fish catches; research into stock assessments and maximum sustainable yields; collaboration between relevant parties for establishment of association
Lack of accurate data on quantities of fish taken	Specific legislation directed at certification, control and management of trade; improve data collection and handling mechanisms; obligatory reporting of all captures and exports to Fisheries Ministry	Specific regulations and coordination between central and regional/district government fishery departments, exporters, middlemen and fishermen; provision of resources for more effective monitoring and management of fishery
Use of cyanide and other destructive techniques	Stricter legislation and control of licences, sale and possession of cyanide; ban hookah compressors; establish labs for cyanide testing; training courses in non-destructive fishing techniques; public education and eco-certification of fish caught without cyanide; investigate possibilities of using clove oil to replace cyanide as fish anesthetic	Enhanced monitoring of fishery; training and empowerment of fishers in non-destructive techniques; establishment of cyanide testing labs in countries of origin and destination; enforce use of alternatives to cyanide for legitimate industrial uses; raise public awareness of cyanide issue to enhance marketing opportunities; research into effects and efficacy of clove oil
Over-fishing, especially of spawning aggregations	Seasonal or areal closed seasons; complete ban on fishing over known spawning aggregations; establishment of marine protected areas (including spawning and nursing areas) to serve as source reefs; permitting, access and impact fees and other restrictions of fishery	Research and collaboration with locals into location of spawning aggregations, source reefs and seasonality of spawning; education of fishers and government officials of problems with over-fishing; decentralisation of management responsibility and costs and empowerment of local communities for their own resources
Endangered status of some species	Use of CITES as framework for monitoring and enforcing regulations; enforce bans on fishing for endangered species	Coordination at every level with CITES protocols; provide resources for monitoring and control of illegal fishing for banned species
Transport mortality, especially mature females	Enforce bans of cyanide use; ban fishing on spawning sites and in spawning seasons; research and extend better handling and transportation techniques; restrict and centralize distribution routes	Tougher penalties for cyanide use; research and dissemination of results of handling and transport-induced mortality of live fish; coordination between importers and exporters on modes and routes of transport and feasibility of centralized distribution and monitoring systems
Reliance on Wild-caught fish	Development of aquaculture systems for main species, including laws, policies and incentives specific to the aquaculture industry	Research into techniques for hatchery, nursery and on-growing various species; government legislation and incentives for fishers to start aquaculture
Illegal large-scale fishing by foreign vessels	Decentralise and empower management and monitoring of coral reef areas to local communities; tougher government enforcement of EEZs and restrictions on foreign fishermen	Decentralization of the power and economic resources necessary to enable local communities and municipalities to own and manage their own resources; tougher anti-corruption laws.

Box 1 Recommendations for Combating Problems with Live Reef Fish Trade in Indonesia (continued)

Problem	Solution	Requirements
Strong demand for rare, wild fish species	Education of consumers into unsustainability of current practices and merits of aquacultured fish	Educational campaigns aimed at consumer nations regarding cyanide use and merits of aquaculture
High value of live fish trade limiting options of fishermen	Develop alternative fishing methods (i.e. FADs) and livelihoods (i.e. aquaculture) which are sufficiently lucrative to gain converts from destructive fishing methods	Thorough analysis of alternative livelihood options in consultation with local communities and empowerment of poor fishers to break indebtedness and adopt such livelihoods
Capture of aquarium organisms using unsustainable methods	Stricter control of cyanide; retrain fishers using non-destructive methods; adopt MAC codes of practice for fishers, middlemen, exporters and importers	International collaboration and education to promote eco-certified aquarium organisms; research into aquaculture of aquarium organisms

Sources: Anon (2001), Bentley (1999), Djohani (1996), Erdmann and Pet (1999), Graham (2001), Johannes (1997a), Johannes and Riepen (1995), MAC (2002), McGilvray and Chan (2002), MOU et al. (2000, 2002), Pet and Pet-Soede (1999), Pet-Soede and Erdmann (1998), Pet-Soede et al. (1999), TNC (2002), WRI (2002)

Clearly, through political will, concerted action must be taken to tackle the huge and complex environmental, social and political problems associated with destructive fishing. The time for action is now, since social scientists argue that fishery-dependent communities are much more difficult to rebuild once their fishery has collapsed (Rice, 2002). The new Indonesian government, under the newly formed MMAF, headed first by Sarwono Kusumaatmadja and recently by Rokhmin Dahuri, has recently taken the first few steps down the path to sustainability, drawing heavily on the successes of Proyek Pesisir's community-based coastal management projects in Indonesia.

What remain unfulfilled are further examples of integrated, community-based coastal resources management aimed at combating the previous lack of integration of development plans and regulatory systems between sectors and tiers of government and industry. This has resulted in competition for the same resources and hence their over-exploitation and loss (Dahuri and Dutton, 2000). For example, most fringing reefs are clearly within the jurisdiction of local governments. However, few have as yet recognized or are ready to assume that responsibility, and their increased development activity without effective management could further worsen the situation (Dutton et al., 2001).

Other problems which still exist within the new Ministry and which require resolution include:

1. Confusion and ambiguities of definition and terminology in fisheries management indicating clouded vision in the management process
2. Extant acts and laws from previous government ministries not directly focused on coastal issues which are centralistic, product-oriented and unsystematic
3. Despite initiation of decentralization of management of fisheries, there is still no act for community tenureship and management of the sea (only for land area), or for regulation of the fishermen's economic, environmental, social and cultural human rights

4. Confusion as to who is responsible for conservation and rehabilitation of the marine environment, since conservation is not under the remit of the Fisheries Department
5. No specific regulations aimed at the management of coral reef fisheries or the live fish trade as apart from marine fisheries in general, resulting in a lack of monitoring, data, reporting and control of the size and scope of the trade, and
6. The suspicion that law enforcement officials have economic interests in the exploitation and trade of marine and coastal resources (Anon, 2001).

Additionally, the costs of government enforcement, especially over the 86,000 km² of Indonesian coral reefs, are prohibitive. There is little outside funding available for coastal management projects and even the loans available must be closely evaluated by the Indonesian government due to their already huge debt repayment commitments (Dahuri, personal communication).

Despite the high penalties for destructive fishing (up to ten years in jail and/or US\$ 12,000 fine), the high profits obtained often ensures that through bribery, key officials in the field (often receiving low salaries) ignore or participate in illegal fishing (Johannes and Riepen, 1995). Few cases of cyanide fishing are brought to court, and usually the offenders are released after payment of a “fine” (Pet and Pet-Soede, 1999).

It has been reported that for each export of live reef food fish from Indonesia, the exporters have to allocate a total of US\$ 8 for a formal export tax, documents and CITES certification and an informal security and bribery “levy”. This further exacerbates the inequitable distribution of rewards towards the actual fishermen shouldered with these taxes. The fishermen may actually receive between 10 and 30% of the final value of live food or aquarium fish (Anon, 2001).

Community-based management control would enable villagers to police their own waters and would provide them with an incentive they currently lack to conserve their own marine resources. Where governments have not done so, they should recognize and support traditional village fishing rights where they exist. An example of this is the so-called *sasi* (traditional resource ownership) system used for generations in some areas of Indonesia. In this system, areas are alternately opened and closed and there is management of who, when and where fishing is permitted, and systems for dispute resolution (Moka, personal communication). Only through direct control of their fishing grounds will coastal communities be empowered and encouraged to fish sustainably.

The local communities must be educated as to the importance of treating coral reefs and their fishery resources sustainably. That this is required was shown in the results of surveys conducted as part of the Indonesian COREMAP program (Dutton et al., 2001). These surveys indicated that in South Sulawesi for example, only just over half of coastal residents (much less urbanites) were either aware of the term “coral reefs” or concerned for their local reefs, but that the vast majority of coastal residents were aware of the importance of protecting, learning about, strengthening laws about and having control over their local reefs. Similar findings resulted from a survey done under Proyek Pesisir in north Sulawesi (Crawford et al., 1998). The lack of perceived threat in resource depletion must be tackled through public education programs (as demonstrated in Proyek Pesisir) in order to aid the successful implementation of community-based management programs.

A consensus of the steps and measures required for development community-based coastal resources management programs is shown in Box 2.

The current government development plan has changed Indonesia's strategy towards the management of marine and coastal resources based on partnerships between community, government and industry – community participation being facilitated by the strengthening of provincial planning capabilities through their agencies. These Provincial Development Planning Agencies are intended to play a key role in the formulation of sectoral agency programs at provincial level.

Box 2 Framework for the Development of a Community-based Sustainable Coastal Resources Management Project in Indonesia

Operation	Specifications
Agreement of need	In intimate dialogue with local community (who can set their own criteria for needs and success and provide first-hand knowledge of their environment) and all levels of government and NGOs
Selection of Site	In consultation with local communities, scientists and planners, including marine reserve location and marking if desired
Capacity building	Education and organization of local communities into core-management and advisory committees with full-time professionals; provision of logistics and credit required for project; clarification and enforcement of legal issues pertaining to tenure of project site
Profiling of site	Strategic research and information collection and dissemination including environmental, socio-economic, legal, institutional elements to give a picture of the current status of the resources, including watershed areas
Developing collaborative management plan	Including local communities and government, national government agencies, trade and industry and scientists; clarification of priority issues, minimum performance standards, possible conflicts of interest and formalisation of responsibility and authority
Consultation	With National, provincial and district government, NGOs, local communities and other successful examples of coastal management to learn from their successes and failures
Feasibility studies	For possible alternative livelihoods and non-destructive fishing methods
Personnel training	For all elements of local communities and government and other associated parties in environmental issues, non-destructive fishing practices, monitoring and rule enforcement, community projects and alternative livelihoods
Implementation of pilot project	Ensuring that local communities, government and NGOs assume responsibility for the project and that the planning agency supplies technical and financial support where required
Enforcement and monitoring	Continued assistance, financial and logistical to assure that all parties are maintaining laws and standards pertaining to project and that the results are monitored to demonstrate benefits obtained
Evaluation and adjustment of management plan and dissemination	Refining target goals based on experiences and coordinated feedback from local community; demonstrating sustainable financial and social benefits and other improvements to resource base; broadening implementation through extension and dissemination of results; assistance with certification, handling, processing and marketing of new products
Institutional planning and implementation	Periodic review and refinement of arrangements for implementation and coordination across ministries/sectors and between provinces, tailored to match institutional and organizational capacity; economic analyses of resources to aid development of management policy

Sources: APEC/NACA/BOBP/GOI (2002), Crawford et al. (1998, 2000), Dahuri and Dutton (2000), Dutton (2001), Dutton et al. (2001), Knight (2000), Nikijuluw (2002), Rice (2002), White (1997), WRI (2002)

7. ALTERNATIVE LIVELIHOOD POTENTIAL

This section considers the various options for alternative livelihood generation for fishermen engaged in destructive fishing practices. As has been mentioned, alternative livelihood generation can form only a part of an integrated coastal management plan, but, as such, is of critical importance in maintaining or enhancing the lives of coastal fisherfolk deprived of their current livelihoods. The type of alternative livelihoods suitable will vary depending on the socio-economic and cultural character of the fishing community and on other factors such as the available natural resources and infrastructure (Pet-Soede et al., 1999).

Fishermen can gain high wages using destructive fishing practices. It has been estimated that in South Sulawesi, fishermen catching groupers and wrasse for the live reef trade (primarily using cyanide) can earn US\$ 100-200/month for small-scale operations, up to US\$ 800/month for medium-large-scale workers, while the owners of large-scale boats employing up to ten fishers can earn as much as US\$ 35,000 per month. Similarly, monthly earnings of blast fishermen in South Sulawesi are estimated to range from US\$ 50 for one man operations, US\$ 150 for workers and US\$ 400 for owners of medium-scale operations, and up to US\$ 200 for fishers and US\$ 1,100 for the owner of large-scale operations (See Box 3) (Pet and Pet-Soede, 1999; Pet-Soede and Erdmann, 1998; Pet-Soede et al., 1999).

Research on Indonesian fishermen who travel into Australian waters to fish around the MOU Box area (See section 5) reveals that shark fishermen may typically earn anywhere between US\$ 40-230 per trip (usually 15 days in duration). However, some trips earn much more and sometimes so little that the fishermen become indebted to their bosses for the losses incurred. The vessel owners (often owning multiple boats) stand to make much higher profits, but the practice is risky since the Australians will confiscate boats caught fishing illegally (Fox et al., 2002).

More traditional fishers who travel to the same area (usually for four-month trips) to fish for *trochus* and sea cucumbers, typically make US\$ 150-320 per month, although the over-fishing of high-value species may now be reducing the profitability of these trips (Fox et al., 2002).

These figures belie the commonly-held belief that all local small-scale fishermen are always poor. These salaries are many times above the US\$ 30/month poverty line and the earnings of artisanal fishermen using non-destructive techniques, and even of university professors. In Indonesia, the driving force behind the use of destructive fishing methods may well be greed rather than need (Pet-Soede and Erdmann, 1998). Thus, any alternative livelihood requires the capacity to earn significant returns if it is to entice these fishers away from their trade (while there are still sufficient fish to be caught).

Box 3 shows a comparison of the profits obtainable from destructive and non-destructive fishing compared with salaries reported from real examples of alternative livelihoods (particularly aquaculture) around Indonesia.

Box 3 Comparison of Profits Obtainable for Alternative Livelihoods in Indonesia

Livelihood	Location	Scale	Net Profit US\$/month	Comments	Reference
Poverty Line	Indonesia		30/indiv.	Minimal salary	TNC, 2000
Average coastal fisherman	Indonesia	Small-scale	10/indiv.	US\$ 40/mo divided by 4 in household	Nikijuluw (2002)
University Lecturer	Indonesia		150/indiv.	Average salary	Pet-Soede and Erdmann (1998)
Cyanide Fishing	Indonesia	Small-med. scale	150-500 /indiv.	For live fish trade	Pet-Soede and Erdmann (1998)
	Komodo	Small scale	63/indiv.	For live fish trade	TNC (2000)
	South Sulawesi	Small scale	100-200 /indiv.	Using squirt bottles	Pet-Soede and Erdmann (1998), Pet and Pet-Soede (1999)
	South Sulawesi	Medium scale	252-800 /indiv.	Using baited traps and bottles	Pet-Soede and Erdmann (1998), Pet and Pet-Soede (1999)
	Indonesia	Large scale	400/indiv.	Using traps and bottles	Pet and Pet-Soede (1999)
	Indonesia	Small scale	100/owner	Owner of boat	Pet and Pet-Soede (1999)
	Indonesia	Medium scale	413/owner	Owner of boat	Pet and Pet-Soede (1999)
	Indonesia	Large scale	35,000/ owner	Owner of boat	Pet and Pet-Soede (1999)
Blast Fishing	South Sulawesi	Small scale	55/indiv.	4m canoe, 1 person	Pet-Soede et al. (1999)
	South Sulawesi	Medium scale	146/indiv.	8-10m boats, 5 crew	Pet-Soede et al. (1999)
	South Sulawesi	Large Scale	197/indiv.	10-15m boats, 15-20 crew	Pet-Soede et al. (1999)
	South Sulawesi	Small scale	55/owner	Owner of boat	Pet-Soede et al. (1999)
	South Sulawesi	Medium scale	393/owner	Owner of boat	Pet-Soede et al. (1999)
	South Sulawesi	Large Scale	1,100/owner	Owner of boat	Pet-Soede et al. (1999)
Shark Fin Fishing	MOU Box, Australia	Large scale, Long-line	40-230/indiv.	Average for 15 day trip (one/mo)	Fox et al. (2002)
Trochus and Sea Cucumber Fishing	MOU Box, Australia	Large scale	150-320 /indiv.	Average for 4 month trip catching high value species	Fox et al. (2002)
Artisanal Fishing	South Sulawesi	Small scale	50/indiv.	Hook and line	Pet-Soede and Erdmann (1998)
	South Sulawesi	Small scale	25-40/indiv.	Scare nets	Pet-Soede and Erdmann (1998)
Grouper Fry Fishing	Java	Seasonally large	Up to 6,000-13,000/indiv.	Scoopnets	Sadovy (2000)
Grouper Fry Fishing	Indonesia	Seasonally large	Up to 420/indiv.	Traps	Sadovy (2000)
Grouper Hatchery	Bali	Technician	65-75/indiv.	Seasonal	Siar et al. (2002)
	Bali	Female graders	20/indiv.	Temporary 4d/mo	Siar et al. (2002)
	Bali	Owner	167-417/tank		Siar et al. (2002)

Box 3 Comparison of Profits Obtainable for Alternative Livelihoods in Indonesia (continued)

Livelihood	Location	Scale	Net Profit US\$/month	Comments	Reference
Grouper Cage Farm	South Sulawesi	Small- Medium scale	49/cage	Tiger, 4 cages/unit	Muharijadi (personal communication)
	South Sulawesi	Small- Medium scale	206/cage	Humpback, 4 cages/unit	Muharijadi (personal communication)
	Indonesia	Large scale	150-342 /cage	Humpback, 16 cages/unit	Muharijadi (personal communication)
Milkfish Hatchery	Bali	Technician	63/indiv.	Seasonal	Siar et al. (2002)
	Bali	Owner	100-200 /owner	Seasonal	Siar et al. (2002)
Milkfish Broker	Bali	Often women	25/indiv.	Seasonal	Siar et al. (2002)
Milkfish Cage Farm	South Sulawesi	Small- Medium scale	28/cage	4 cages/unit	Muharijadi (personal communication)
Seaweed Farm	Komodo	Family-based	40/family	300-400 m2 each	Sofianto et al. (2002)
	Komodo	Group-based	250/group	Larger areas	Sofianto et al. (2002)
FAD	Komodo	10 boats/FAD	72/indiv.	8 days/mo fishing	TNC (2000)

7.1 Aquaculture

Aquaculture is playing an increasingly important role in supplying food fish and a source of trade to the rapidly increasing populations of Asia (Kongkeo and Phillips, 2002). As an alternative livelihood to destructive fishing, although promising, aquaculture has specific issues that must be addressed before implementing any new activities. These issues vary for each type of aquaculture activity planned and must be considered case by case. However, they typically include:

1. The often high capital cost and skill levels required
2. Correct focusing of projects to answer the needs of specific tiers, genders and ages of the population and to integrate with other aspects of coastal management
3. The willingness and ability of fishermen to change occupation
4. The ability of farmed products to replace wild-caught counterparts (marketing)
5. The footprint of the aquaculture operation (including such things as environmental pollution, land-use conflicts, requirements for fishery products and waste treatment facilities)
6. Seed and broodstock source and supply, and
7. Often unproven economic, technical and environmental sustainability factors.

The benefits and drawbacks of various aquaculture operations with relation to their ability to act as alternative livelihoods for fishermen currently using destructive fishing practices are summarized in Box 4.

Box 4 The Benefits and Drawbacks of Sustainable Fishing and Aquaculture Operations as Replacements for Destructive Fishing Practices in South Sulawesi

Livelihood	Benefits	Drawbacks
Destructive fishing		
Fishing using cyanide and bombs	High profitability; suitable for all levels of society	Coral reef destruction; unsustainable; dangerous; over-fishing of existing stocks; collateral damage to other reef organisms; lost tourism potential
Wild grouper seed collection	High seasonal profitability; suitable for fisherfolk	Threatens stocks of high value species; habitat destruction; by-catch losses
Sustainable fishing		
Fishing using nets, traps, hook and line	Profitable; suitable for all levels of society; legal; safe; sustainable	Not as profitable as destructive fishing
Fishing using fish attracting devices (FADs)	Reduces destructive fishing; high profits possible; low tech; sustainable	Handling and marketing deficiencies; not as profitable as destructive fishing; retraining and constant surveillance required
Harvesting of aquarium organisms using nets	Reduces destructive fishing; high profits possible; foreign exchange generation	Possibilities for overexploitation of wild stocks; training required; certification and control mechanisms not yet established
Aquaculture		
Grouper hatchery	High demand, job creation; reduce dependence on wild seed; profitability	High tech; risky; disease problems; unknown techniques for some species; seasonality; unavailability of broodstock; long grow-out; part-time employment may not prevent fishing
Grouper nursery	Necessity for industry; potential profits	Unknown economics; capital intensive
Grouper grow-out	High profitability; reduces reliance on wild fish; foreign exchange generation; human health benefits	Undeveloped technology; high tech; capital intensive; risky; perhaps unsuitable for fisherfolk; current dependence on trash fish and fish-meal based diets; shortage of grow-out sites
Shrimp hatchery	High job creation for all levels; established demand	Seasonal; current problems in industry reducing profitability
Shrimp grow-out	High job creation for all levels; high potential profits; foreign exchange generation	Current problems in industry reducing profitability; effluent discharge pollution problems
Milkfish hatchery	Low tech; suitable for fisherfolk	Falling prices creating high competition
Milkfish grow-out	Produces food for local people; relatively low tech	Low market price makes unattractive

Box 4 The Benefits and Drawbacks of Sustainable Fishing and Aquaculture Operations as Replacements for Destructive Fishing Practices in South Sulawesi (continued)

Livelihood	Benefits	Drawbacks
Aquaculture		
Seaweed farms	Low-tech; sustainable; low impact; low capital investment; suitable for entire families	Relatively low income generation; only part-time allowing continued destructive fishing; underdeveloped processing and marketing; may involve destruction of seagrass beds
Seabass culture	Reduced reliance of wild fish; known technology	Relatively risky and capital intensive; not as profitable as grouper culture
Lobster culture	Reduced reliance on wild lobsters; Potential high profits; High demand; foreign exchange generation	Seed production techniques unknown; wild seed collection could threaten wild stocks; not as profitable as grouper culture
Giant clam and mollusc culture	Low impact; low tech; known technology; high demand; produces food and products for local people and export, suitable for fisherfolk	Limited experience in Sulawesi with hatchery and grow-out techniques; low-mid level income generation; possible conflicts of interest with fisherfolk; current seed shortages
Tilapia culture	Produces food for local people; suitable for fisherfolk; compatible in polyculture with shrimp	Low profitability; high land requirements unless used in polyculture
Siganid culture	Produces food for local people	Seed production techniques unknown; low profitability
Aquarium organism culture	Reduced dependence on and exploitation of wild stocks; high profits possible, foreign exchange generation	High capital investment; high risk; high tech and skill requirements; lack of experience in Sulawesi

Sources: APEC/NACA/BOBP/GOI (2002), Friend and Funge-Smith (2002), Hair (2002), Halim (2002), Kongkeo and Phillips (2002), Mac (Website, 2002), MOU et al. (2002), Muhariadji (personal communication), Ramelan (2002), Sadovy (2000), Sadovy and Pet (1998), Siar et al. (2002), Sofianto et al. (2001, 2002), Sugama et al. (2002), Sugama (personal communication), Svennevig (2002), TNC (2000)

Recent research in Southeast Asia indicates that fishermen like their occupation and sometimes are bound to it through indebtedness. Hence, only a minority would or could change to another occupation, with similar income, if it were available (Pollnac et al., 2000). Even if they did, there remains the probability that other people would fill their places once they made the change. However, although there was concern about the long pay-back period involved; grouper culture, for example, was looked on positively as an alternative livelihood by most fishermen and middlemen interviewed in a recent survey conducted in Indonesia (Halim, 2002).

Not only the content, but also the manner of communication of extending aquaculture to fishers, must be considered. The model of aquaculture extension used by GRIM has proven successful in promoting backyard milkfish and grouper hatcheries in Bali and hence the on-growing industries for milkfish in ponds and groupers in cages throughout Indonesia. Study of their methods thus provides models for uptake throughout Indonesia and beyond.

7.1.1 Grouper

Just as the wild fishery for groupers is collapsing, grouper aquaculture in Southeast Asia is progressing and may now already account for up to 30% (as much as 20,000 mt worth US\$ 150 million) of the trade in market-sized fish in Southeast Asia (FAO, 2000; Sadovy, 2000,

including Indonesian estimates for 2000; TNC, 2002). Grouper culture has been earmarked by the Indonesian government for commercial development for a number of reasons. These include to:

- Satisfy the high demand for high-value live reef food fish for the growing Southeast Asian market (particularly increasingly affluent southern China)
- Take the pressure off wild stocks
- Generate much-needed foreign exchange
- Reduce the use of destructive fishing practices (cyanide and bombing) traditionally used for the capture of these fish, and
- Provide a source of ciguatera toxin free food fish.

An integrated survey of consumers, stakeholders and restaurant owners conducted in Hong Kong in 1999 (Chan, 2000) revealed that demand for wild live reef food fish (mostly groupers) could be modified primarily through education of the parties involved, with most parties agreeing that conservation and eco-labeling schemes were good ideas. Eighty percent of respondents said they would change their consumption behavior when sufficiently informed of conservation and toxicity issues, which is not currently the case. For example, 50% had never heard of cyanide fishing, more than 80% were not aware of the destructive capacity of cyanide fishing, 50% did not know that cultured fish were ciguatera-free, and 70% were unaware of the endangered status of Humphead Wrasse or Giant Grouper (and still liked to eat these fish).

Hong Kong people like to eat live reef food fish due primarily to their freshness, good taste and texture. Sixty-seven percent of respondents said that they would eat cultured fish if they offered a significant price benefit (currently 30-40% lower wholesale price) and because of the lower risk of ciguatera poisoning. Forty percent of people said that they preferred wild over cultured fish, although 23% actually preferred cultured fish. The general consensus was that wild fish had better taste and texture, although blind taste tests conducted by TNC with Malabar Grouper revealed that most people actually preferred cultured fish (Chan, 2000). Thus, aquacultured grouper have the potential to replace wild fish in the live trade if sufficient marketing effort were to be applied.

The Directorate General of Fisheries of Indonesia has undertaken surveys throughout Indonesia and has identified south and southeast Sulawesi as areas with high potential for development of mariculture, particularly for groupers and sea cucumbers (Ramelan, 2002).

In recent years, largely thanks to the research and extension efforts of GRIM in Bali, the dependence of the Indonesian industry on wild-caught juveniles has been reduced. However, there remains a seasonal undersupply of hatchery-reared fry and fingerlings. With the undoubted expansion in on-growing groupers in the near future, it will be increasingly important to maintain the development of grouper hatcheries and nurseries for a variety of species. It will also be important to continue development of on-growing techniques and artificial feeds not based on fishmeal, as this also places heavy demands on fishery resources.

What remains unclear however is whether grouper aquaculture will really benefit the poorest segment of society in Indonesia. The reasons for this are outlined in Box 5.

Box 5 Constraints on Grouper Aquaculture from Benefiting Poor Indonesian Fisherfolk

- Under-developed culture technology, and the requirement for considerable knowledge and skill, not possessed by artisanal fisherfolk
- High-risk and capital intensive industry with no current financial back-up
- Long-term pay-back with no short-term profits
- Difficulty in breaking existing indebtedness relationships between fishermen and middlemen
- Reluctance of fisherfolk to change their mode of livelihood to an unknown activity
- Lack of tenureship of coastal areas and mechanisms for its enforcement
- Difficulty and expense of procuring and manipulating broodstock for egg production
- Development of hatcheries may affect the wild-caught fry fishery, a current source of livelihood for many small-scale fisherfolk
- Current seasonality of grouper hatcheries due to technical difficulties and low demand for on-growing
- Few sites suitable for current style of cage culture which could lead to problems with competition and environmental degradation
- Current reliance on trash fish for food which may serve as food for local fishermen, may lead to environmental degradation and the extraction of which may be unsustainable
- Probable reductions in market value on wide-scale adoption of grouper culture leading to oversupply of a limited and volatile market
- Current dominance of markets by live fish traders and wholesalers leading to unfair distribution of benefits to producers

Sources: APEC/NACA/BOBP/GOI (2002), Halim (2002), Kongkeo and Phillips (2002), Pollnac et al. (2000), Siar et al. (2002), Svennevig (2002)

It appears that grouper farming will inevitably continue to develop in Indonesia, such that it may become a large industry generating foreign exchange and many jobs. However, there are many obstacles to it becoming a suitable means of generating alternative livelihoods for poor fishermen currently engaged in destructive fishing practices.

Cage- or pond-based grouper farms and hatcheries are technologically under-developed and require considerable skill and investment are risky and have a long pay-back period, excluding most poor farmers without access or willingness to get credit. Even if small-scale, low-cost cage farms were attempted, there would be nothing to stop fishermen from continuing their destructive fishing practices as they were waiting for the 8-18 month culture cycle to deliver profit. Halim (2002) reported that the attitude of fishermen, although positive toward mariculture, perceived their investment in time as being short, so that they would be able to carry on fishing at the same time.

Additionally, although many small-scale backyard hatcheries have been developed in Bali (following the success of GRIM), with further advances in hatchery technology and expansion of the hatchery industry, the price for grouper seed will inevitably fall. This seems to be apparent already due to the currently relatively under-developed state of the Indonesian grouper on-growing industry (Siar et al., 2002). Other examples of this scenario are found with grouper hatcheries in Taiwan and with milkfish hatcheries of Bali. This will most likely result in only the bigger and more efficient hatcheries (with export capabilities) able to survive and the smaller, relatively expensive operations (those likely to be run by local fishermen) failing due to non-competitiveness. Poor fishermen will then have no role in either hatchery or wild-caught seed production.

Any regulation of wild seed collection (to stimulate hatcheries or conserve wild stocks) must be considered carefully, since wild seed collection provides livelihoods for tens of thousands of small-scale Southeast Asian fishermen. In peak seasons, daily scoop-net catches sometimes amount to 1,000-2,000 fry of 2.5 cm per fisher (worth US\$ 300-600), and trap fishermen can work year-round and take two to ten 50-200 g fish, worth up to US\$ 20 per day (Sadovy, 2000). If this source of livelihood were to be removed, it could therefore have serious negative consequences for coastal communities and surrounding coral reef resources (See Boxes 3-5).

An APEC-organized working group on coastal livelihoods and socio-economic issues suggested that due to these problems (at least over the next 5-10 years), perhaps broodstock holding, and egg and larval production of groupers, should be centralized and run through the government, but that small-scale nurseries could be promoted as alternative livelihoods for coastal fishers and their families (APEC/NACA/BOBP/GOI, 2002). However, as mentioned above, the nursing systems currently working are unpopular, unproven, risky and require substantial research and development prior to their promotion in this way.

A survey conducted recently in Indonesia showed that despite resistance to change, particularly involving the long time required to obtain profits, the vast majority of fishermen and particularly middlemen (with a higher resource base) were willing to adopt such grouper culture (either full- or part-time) as an alternative livelihood under the right conditions. This was particularly true for individual fishermen (traditionally using small boats on one day trips) who saw on-growing groupers as a way of making up their income differential with group- type grouper fishermen. Also, middlemen who already hold grouper in cages prior to export, saw grouper culture as a natural and compatible extension of their current activities (Halim, 2002).

It is also the case that grouper culture is currently one of the few possibilities for generating sufficient revenue to look attractive to fishermen and middlemen using cyanide in the live reef fish trade, who can earn US\$ 100-800/month at present (See Box 3). In Komodo Island, TNC are also promoting the larval rearing (using expertise from GRIM) and cage culture of grouper and sea bass, which they estimate could increase the income of local fishermen ten-fold.

The prices paid by retailers and wholesalers of groupers in Hong Kong in 2000 (McGilvray and Chan, 2002) are shown in Table 6. From this it can be seen that species selection is important on economic as well as technological grounds.

Table 6 Mean Wholesale and Retail Value of Various Wild Groupers in Hong Kong (2000)

Species	Wholesale value (US\$/kg)	Retail value (US\$/kg)
<i>C. undulates</i> (Humphead Wrasse)	55	108
<i>C. altivelius</i> (Humpback)	66	103
<i>P. leopardus</i> (Leopard Coral)	38	64
<i>E. lanceolatus</i> (Giant)	26	63
<i>E. fuscoguttatus</i> (Tiger)	24	49
<i>E. polyphkadion</i> (Flowery)	22	45
<i>E. coioides</i> (Estuarine, Orange-spotted)	13	28
<i>L. argentimaculatus</i> (Mangrove Red Snapper)	8	17

Source: McGilvray and Chan (2002)

Economically, Humpback Grouper and Giant Grouper (which has the added advantage of fast growth rate) appear to hold the most potential, until Humphead Wrasse culture becomes technologically viable. GRIM in Bali and Balit Kantor in South Sulawesi are already investigating this possibility. However, there are clear market preferences for the Leopard Coral Grouper (*Plectropomus leopardus*) and the Mangrove Red Snapper (*Lutjanus argentimaculatus*). Between them, these were the favourite species of 80% of people surveyed in Hong Kong in 1999 (Chan, 2000), indicating the potential for the cultivation (once the hatchery technology can be developed) and marketing of these species.

Currently, cultured fish receive 35-43% less on the market than wild fish, due to current consumer preferences. Marketing efforts directed at informing consumers and traders of the advantages of cultured fish should help to rectify this problem. Emphasis should be placed on the lack of ciguatera toxicity, environmental benefits related to non-destructive, sustainable culture methods and the lack of taste and/or texture differences.

The world market in 2000 for live groupers (dominated by Hong Kong and southern China) perhaps totaled 40-50,000 mt worth close to US\$ 0.7-0.9 billion, of which up to 30% was supplied by aquaculture. With the increased affluence of the Chinese, recent advances in culture technology and apparent collapses in the wild fishery, the production and sale of cultured grouper is set to increase substantially.

However, the market as it stands, only seems capable of absorbing a two- to three-fold increase in cultured grouper production. Additionally, the market is highly exclusive, volatile and controlled by wholesalers, who currently receive 50% of retail value (See Table 6), with farm gate prices typically only 25-30% of retail value.

A comprehensive strategy aimed at promoting the economically-, technologically- and environmentally-sustainable culture, and marketing of a wide range of grouper (and other) species, will be needed in order to maintain the growth and development of this fledgling industry. In the late 1990s, similar problems were faced and overcome in the cage-based culture of salmon, seabass and seabream in Europe, through technological advances and consolidations, increasing the efficiency of culture, and intensive marketing campaigns to broaden marketing opportunities (Svennevig, 2002).

In this regard, the exploitation of fresh, chilled and frozen grouper markets must be considered. FAO data from 2000 suggest a worldwide (90% to the USA) market for groupers,

snappers, croakers and drums of 17,000 mt worth US\$ 68 million (at US\$ 4/kg) for the fresh and chilled product and 71,000 mt worth US\$ 161 million (at US\$ 2.3/kg) for the frozen product (FAO, 2000).

The measures outlined in Box 6 could be considered by the Indonesian government to promote grouper culture as a means of providing alternative livelihoods to fisherfolk using destructive practices.

Box 6 Measures Required to Promote Grouper Culture as an Alternative Livelihood to Indonesian Fisherfolk Using Destructive Fishing Practices

- Study the needs, capabilities, cultural aspects and property rights of local communities to integrate aquaculture into the larger coastal management context and promote the livelihood of the people
- Develop clear objectives for grouper hatchery and on-growing culture and a plan to implement these objectives
- Declare and manage marine protected areas encompassing grouper spawning aggregations (to assist recruitment and broodstock availability) and seed settlement and nursery habitats (including mangroves and seagrass areas)
- Legislate for the Fisheries Ministry to monitor and control all trade in live food fish including “cargo” vessels from Hong Kong
- Develop and implement certification and cyanide detection systems to ensure quality and good practice
- Develop carrying capacity and site selection models and zonation and licensing plans for hatchery and on-growing systems to reduce clustering and negative environmental impacts and ensure sustainability
- Research and extend culture techniques for on-growing systems including low cost coastal and high-tech offshore cage- and land-based pond systems
- Develop sustainable technologies for the production of alternative grouper species including the Giant Grouper and perhaps the high-value Humphead Wrasse and Leopard Coral Grouper in order to reduce grow-out times and broaden marketing opportunities
- Provide closely-monitored incentives, low-interest loans or revolving funds aimed specifically at fishermen abandoning destructive methods with which to overcome indebtedness and initiate grouper culture projects
- Scale up education, training and extension to local fisherfolk of grouper (preferably multi-species) hatchery, nursery and on-growing culture techniques
- Prohibit import of grouper seed to stimulate the local seed industry, improve resource management and reduce disease transfer problems
- Study the wild seed industry to gain knowledge on which to base regulations and recommendations on destructive or wasteful captures and transport procedures and the over-utilization of juvenile fish

Box 6 Measures Required to Promote Grouper Culture as an Alternative Livelihood to Indonesian Fisherfolk Using Destructive Fishing Practices (continued)

- Develop low-tech, economic methods to nurse wild and hatchery-reared fry until ready for stocking (i.e., from 2 to 10 cm) to eliminate the current high wastage of grouper seed and provide more livelihood options
- Provide techniques and support for disease diagnosis, prevention and control (particularly for viral diseases) to the farmers
- Continue development of specific formulated feeds for each of the cultured species, with minimal use of fishmeal and other marine proteins, and designed to improve taste and other desirable market qualities
- Develop price and market information and diversification systems (including the harmonized system) to match supply and demand of each grouper species (connecting producers to markets), open new markets (e.g., fresh and chilled products) and promote eco-labeled and “ciguatera-free” cultured fish
- Identify alternative markets for excess grouper seed such as for the aquarium trade and export to other producing countries
- Encourage regional suppliers of hatchery and on-growing equipment and feeds

Sources: APEC/NACA/BOBP/GOI (2002), ASEAN/SEAFDEC (2001), Bentley (1999), Chan (2000), Graham (2001), Halim (2002), Kongkeo and Phillips (2002), Lau and Parry-Jones (1999), MOU et al. (2002), Pollnac et al. (2000), Roberts et al. (2001), Sadovy (2000), Sadovy and Pet (1998), Siar et al. (2002), Svennevig (2002), TNC (2000), WRI (2002)

One aspect of grouper culture, which is currently under-developed in Indonesia, is that of pond farming. Indonesian farmers have complained of a shortage of suitable ponds for both nursing fingerlings to a size suitable for stocking in cages and for on-growing juvenile fish (Sadovy, 2000; Siar et al., 2002). There already exist successful (although quite limited) examples of pond growing of grouper in China, southern Taiwan, the Philippines, Vietnam and Thailand using old shrimp ponds (Sadovy, 2000). For example, pond culture of the Malabar Grouper (*E. malabaricus*) in Taiwan utilizes small ponds of 0.2-0.3 ha, stocking densities of 3-4/m², trash fish-based feeds (7:1 FCR), high rates of water exchange and aeration, with production yields of 10-12 mt/ha and costs of US\$ 9/kg over the 12-18 month production cycle (Johannes and Riepen, 1995).

Due to the current problems with disease and low market value for shrimp in Indonesia, it appears quite feasible that some of the now-abandoned shrimp ponds could be used for grouper culture. More research will have to be done in defining and resolving the challenges with this form of culture, particularly the nursery phases, and the Indonesian government has until now left this area largely untouched, except for a small DGR project in pond farming techniques in Jepara, and a recently started attempt at nursing fry in cages by GRIM in Bali (Sugama, personal communication).

7.1.2 Shrimp

As in many areas of the world at present, shrimp farming in South Sulawesi is suffering problems largely due to market price and viral diseases. The industry in South Sulawesi is

still large and generated 15,000 mt worth more than US\$ 100 million from 87,000 ha in 2001 (Dinas Perikanan, 2001). Of equal importance, small-scale, semi-intensive shrimp farming (80% of ponds less than 5 ha in size) is a major employer of coastal people, many of whom were ex-fishermen before the shrimp farming boom of the late 1980s. Shrimp farming provided a livelihood to approximately 100,000 people, including more than 18,000 households using polyculture (with milkfish) and more than 6,000 households using monoculture (usually of the Black Tiger Shrimp, *Penaeus monodon*) in 2001 (Dinas Perikanan, 2001). It was not possible to find recent data on the economics of shrimp farming in Sulawesi.

With the current problems facing the industry, it is more a case of helping to prevent further collapses in the industry to safeguard the livelihoods of the people involved, rather than looking to shrimp farming to provide additional livelihoods. Government and private sector involvement is needed to help counter the current problems with shrimp farming techniques, diversify the overwhelming dependence on shrimp (and milkfish) pond culture, and prevent reversion of livelihoods towards destructive fishing practices.

This would require government incentives, research, education and training into sustainable techniques for the culture of shrimp (*P. monodon* and other species, such as *P. vannamei*) and other fish species. The Indonesian government has begun such work through the Fisheries Department and BBAP, but a much more coordinated effort will be required to produce any rapid, but permanent change.

There are more than 8,000 ha of currently-unused shrimp ponds in South Sulawesi which could be converted for the pond nursing and on-growing of grouper and possibly for polyculture of shrimp with milkfish and tilapia. Experience from elsewhere in the world indicates that polyculture of shrimp with non-carnivorous fish species can help to reduce the mortality of shrimp infected with the white spot virus. Similarly, with the right incentives and training idle shrimp hatcheries could be converted for the production of grouper, milkfish, seabass and/or tilapia seed.

7.1.3 Milkfish

From the early successes in milkfish seed production in Balinese hatcheries supported by GRIM from 1993, a flourishing, if seasonal, seed production industry was developed. This supported the on-growing industry in both ponds (monoculture and polyculture with shrimp) and cages.

The hatchery industry is most marked in Bali, but has extended to some degree throughout Indonesia. Although in Bali the production of cheap seed quickly displaced traditional wild fry collectors and ornamental fish catchers using cyanide, many of them became hatchery operators or owners and some even became involved in construction of these same hatcheries. A survey conducted by GRIM in 1997 suggested that there were 546 technicians working in 214 milkfish hatcheries surveyed earning about US\$ 63/month. There were also about 300 brokers earning approximately US\$ 25/month, dealing with the ten million fry produced daily from this area. Other part-time work (including for women) was also generated including fish packers and exporters. Additionally, total monthly income for a backyard hatchery is currently estimated at US\$ 250-500, equating to a monthly profit of US\$ 100-200 (Siar et al., 2002).

Despite more recent declines in the value of milkfish fry (of up to 90%) due to overproduction in Bali (Siar et al., 2002), there is still potential for the milkfish hatchery industry of Bali to be emulated elsewhere, including Sulawesi. This could have benefits including alternative livelihood generation for fishermen using destructive fishing methods, protection of wild seed stocks for the fishery and broodstock industries, and provision of cheap, high-quality seed to the on-growing industry.

The on-growing industry in South Sulawesi is large, producing 56,000 mt worth US\$ 56 million in 2001 (Dinas Perikanan, 2001). Virtually all of this production is from ponds, since early cage culture efforts with this species are being superseded by the higher-value grouper species. However, there is room for future expansion of pond-cultured milkfish. Pond culture can be done cheaply with low inputs, generates a local food fish crop, and is hence in many ways is more suitable for poorer fisherfolk than the high-risk, capital-intensive pond culture of shrimp or cage culture of groupers.

The Indonesian government, through BBAP in Sulawesi, is currently conducting research and extension of low-input milkfish culture in ponds to this end. There remains a need, however, to ensure high-quality seed and develop good feeds or fertilization regimes to optimize growth, and help marketing (of particularly pond-culture fish) both locally and for export.

7.1.4 Seaweed

The seaweed culture industry of Indonesia has grown from 157,000 mt in 1997 to 300,000 mt worth US\$ 24 million in 2001 (Ramelan, 2002; Sofianto et al., 2002). Of this total, 20,000 mt was from South Sulawesi, worth US\$ 1.6 million mainly from the pond culture of *Gracilaria Spp.* (Dinas Perikanan, 2001).

Both governmental and NGO, community-based assistance (in training, finance and processing) is now being offered to local fishermen currently using destructive practices to convert to seaweed farming as a more sustainable form of livelihood. Eastern Indonesia in particular has been earmarked by the government as suitable for seaweed culture (Ramelan, 2002). Seaweed culture involves the use of ponds for growing *Gracilaria Spp.*, and either floating structures or areas of seabed for the culture of *Kappaphycus (Eucheuma Spp.)* in Sulawesi, Komodo and elsewhere.

The Governmental Research Center for Aquaculture has recognized the capital-intensive and relatively high-tech nature of grouper farming and is trying to stimulate interest in seaweed (*Gracilaria*) farming to help the poorest coastal people. To this end, the director, Ketut Sugama, has developed a private company to initiate a community-based approach to growing *Gracilaria* in ponds, and help providing the necessary capital investment (Sugama, personal communication).

The USAID Proyek Pesisir in north Sulawesi included seaweed culture as a component at one of its sites. They set up a revolving fund and training courses for nine existing small-scale seaweed farmers to enable them to expand their operations. Data on the success of this project have not yet been published, but only a small percentage of farmers interviewed said that they reduced their fishing activities as a result of seaweed farming. Instead, their perceptions were that there was time for both and that fishing even improved due to the presence of the seaweed farms (Crawford et al., 2000).

The potential of seaweed culture has also been demonstrated through a TNC project aimed at providing alternative livelihoods to local fishermen using destructive practices. TNC started this work in 2000, confirming an increasing world market demand for seaweed-based products, local testing suggesting *Kappaphycus alvarezii* (*Eucheuma*) as the primary candidate, and a training program for 34 participants from 12 villages around the Komodo national park. The participants were also given materials and each started cultivating 100 m² plots in front of their villages in 2001 (Sofianto et al., 2002).

By early 2002, 100 families were each cultivating 300-400 m² plots, producing 0.75 kg of dry seaweed/m² worth US\$ 0.3-0.4/kg over a 45-day cycle, amounting to a total production of 200 mt/year. Due to the low capital cost required, a net income of US\$ 40 per month per family (involving part-time labor for men, women and children) is being obtained (Sofianto et al., 2002). Also in Kukusan, TNC have been promoting floating bamboo and rope seaweed farms which they estimate can earn the community US\$ 250 per month/farm.

The dried seaweed produced is largely destined to the growing export markets for agar-type products as well as some local consumption. Although the level of income obtainable cannot compete with the current income of cyanide or blast fishermen, and (since it is part-time) may not replace these activities, such culture is directly applicable to the poorest segments of society, providing jobs and income for whole families in a sustainable manner. It has additional positive characteristics for alternative livelihood generation in that it has low capital investment and skill-level needs, is environmentally sound and is a relatively (for aquaculture) low-risk enterprise.

Further development of the fledgling seaweed culture industry, particularly with regard to improved techniques, stabilization and promotion of prices through better and more processing facilities, and access to world markets, could be expected to result in a more lucrative industry in the future. A joint venture between a Japanese company and the Indonesian government is addressing this problem and plan on opening a processing plant in Takalar, South Sulawesi, in 2003. The recently formed Indonesian Seaweed Association (ARLI) may be a pathway through which such advances could be coordinated.

Such stimuli to the culture industry could also improve the economics of the capture industry that is another major employer of coastal fisherfolk in Indonesia. The fishery in South Sulawesi, for example, produced 24,000 mt of mostly *Eucheuma Spp.*, worth US\$ 1.3 million in 2001 (Dinas Perikanan, 2001).

7.1.5 Seabass

Seabass is farmed in both cages and ponds in South Sulawesi, in an industry that produced 3,500 mt worth US\$ 1.4 million in 2001 (Dinas Perikanan, 2001). Recently, however, seabass production has been losing favour, with the majority of farmers looking to grouper production due to the relatively low value of seabass (US\$ 0.40/kg) and problems obtaining sufficient seed.

Although traditional markets for Asian seabass are almost exclusively limited to within Asia (predominantly for the live food trade), there is great potential to market fresh and chilled seabass worldwide, particularly due to its low production cost (Svennevig, 2002). However, seabass (like grouper) are traditionally fed trash fish, so research into the development of

artificial diets is also required for this species to eliminate the undesirable qualities of wet feeds.

The new TNC hatchery in Komodo will produce seabass fingerlings in addition to three grouper species for distribution to local farmers to help maintain a broad production base and aid marketing of the final products (MOU et al., 2002). The BBAP hatchery in Takalar and the GRIM hatchery in Bali also have the potential to produce seabass fry (simpler than producing grouper), although neither is now doing so due primarily to lack of demand. The potential for expansion of seabass aquaculture is a possibility, once the technological and marketing problems can be resolved.

7.1.6 Lobsters

There are no current culture activities with lobsters in South Sulawesi, although the potential for supplying cultured lobsters to the lucrative live fish trade is a big incentive for developing an industry. The problem is that larval rearing techniques for lobsters have not yet been developed and research efforts have so far concentrated on the capture of wild juveniles for stocking cages. This has obvious sustainability issues, necessitating alternative strategies.

A local live fish trader has had the idea of cooperation with an experienced New Zealand company to take pre-settled post-larval lobsters (which have a naturally low survival) and on-grow them before putting them into cages (Trakakis, personal communication). Although this is an interesting idea, the removal of lobsters from the reefs, even at this age, has unknown sustainability issues, so should be approached with caution.

Hatchery production of lobsters is still a distant reality, so the culture of lobsters is not yet at a stage sufficiently advanced to offer any real sustainable livelihood options to local fishermen.

7.1.7 Giant Clams and Other Mollusks

There is currently little commercial activity, but a great potential, for mollusk culture around Sulawesi. However, the limited number of projects investigating this potential has as yet failed to produce sufficient incentive to be taken up by local people.

Some success of pearl farming (in terms of income generation and job creation) within the USAID-funded Proyek Pesisir in North Sulawesi were countered by the negative impacts of loss of traditional fishing grounds by local fishermen, resulting in negative perception and conflicts of interest (Crawford et al., 1998). Pearl oyster culture is, however, a US\$ 20 million industry around Indonesia and really only lacks demonstration, extension and a seed source to be adopted in Sulawesi.

Some small-scale projects involving pearl oysters, giant clams and abalone around Sulawesi have achieved some success, but there have not been any coordinated efforts to encourage mollusk culture of any kind in this area. Perhaps the first step would be in the establishment of hatcheries for some of the potential species and demonstrations and extension of the techniques required. One such facility, owned and run by Hasanuddin University, already exists and is on the point of going commercial, primarily to produce clam seed for export to other areas of Indonesia.

The advantages of mollusk culture are many and include low-skill, low-investment, but environmentally-friendly techniques which have the capacity to provide livelihoods for whole families and produce potentially valuable products. These include live products to the aquarium trade (giant clams and abalone) and for restocking the fishery (clams), food for the local market and export (mussels, clams, oysters and abalone) and for high-value specialty products like mother of pearl, shells and pearls (oysters and clams).

7.1.8 Tilapia

South Sulawesi had a 2,000 mt, US\$ 700,000, pond-based culture industry for tilapia in 2001 (Dinas Perikanan, 2001). There is considerable potential for the expansion and polyculture of tilapia with shrimp and milkfish. There are up to 8,000 ha of unused shrimp ponds and more than 80,000 ha of currently working shrimp and milkfish ponds which could potentially be converted to polyculture including tilapia.

Additionally, the Fisheries Department is promoting tilapia culture in the abundant natural freshwater lakes of South Sulawesi in cages and pens. This may be an activity suitable for poor fishermen since, although they are a low-value species (US\$ 0.4/kg), tilapias are low on the food chain, and cheap and easy to produce both in the hatchery and grow-out. They can also be grown in virtually every type of aquaculture system from tanks and ponds to cages, and in salinities from fresh to salt-water. Tilapia are thus adaptable to many types of culture activity and efforts to enhance marketing of the products would help provide a useful addition to alternative livelihood generation from aquaculture.

7.1.9 Siganids

Little is known about the culture possibilities of rabbit fish (*Siganus Spp.*). However, they do have good acceptance, with a fairly high price in the local market, are sometimes sold live for export, and are reputedly easy to produce in the hatchery.

There is one NGO project on Kapopsang Island in the Spermonde Archipelago that is now trying to culture this species, but no results are yet available on progress made. Rabbit fish thus remain just another possibility for culture and job creation.

7.1.10 Coral Reef Organisms for Aquarium Trade

Following a number of research projects, there has been some commercial interest in South Sulawesi of using lights at night to attract and catch post-larval coral reef fish and lobsters for on-growing (Trakakis and Jompa, personal communication). Although there is evidence to suggest that the mortality rate of settlement-stage lobsters and groupers declines rapidly, there is not yet enough known of natural mortality rates to safely target such young juveniles for capture and on-growing. Capture of specific species and minimizing “by-catch” losses are other areas of concern. More research is therefore needed before advocating the introduction of more potentially harmful fishing methods (Sadovy and Pet, 1998).

Closed-cycle hatchery production and on-growing of organisms for the aquarium trade is still probably too risky and capital intensive to offer any currently realistic livelihood options in Sulawesi. However, the Marine Science Department of Hasanuddin University in Makassar is working with two private Indonesian companies (CV Dinar and CV Marina Aquarium) to research the culture of grouper (especially humpback), clownfish, milkfish and giant clams

for aquarium use. The aquarium trade may, however, be a useful alternative market for grouper fingerlings produced in hatcheries since there is a high demand and hence price for 5-10 cm Humpback Grouper, which are worth US\$ 8-10 each in Singapore and Australia (Sugama et al., 2002).

Other possibilities exist, particularly for innovative species such as seahorses (*Hippocampus Spp.*) and holothurians, which also have markets as human medicines in Asia. Seahorses have a great culture potential due to advances in larval rearing and because they have recently (at the 13 November 2002 meeting of the UN in Chile) been included on the CITES list. This now requires that all catches and sales must be legalized. Indonesia is the major supplier of seahorses for the 70 mt/year Asian traditional medicine market and the European and US aquarium industries.

7.1.11 Other Fish Species

For the profitability and sustainability of aquaculture activities, it is important to maintain a high diversity of species cultured. This will help create more development opportunities, open markets limited in their capacity to absorb quantities of, and reduce dependence on, any single species, and match the species cultured to suit particular conditions and seed availability in each area. It is particularly important to consider the cultivation of fish species lower in the food chain (non-carnivores) as candidates for alternative livelihood generation because they tend to be less complicated to culture, have a higher potential for increased production efficiency, use cheaper feeds and often provide food for local people as well as acting as cash crops (APEC/NACA/BOBP/GOI, 2002; Kongkeo and Phillips, 2002; Svennevig, 2002).

Other species worthy of consideration for aquaculture in Sulawesi include mullets, snappers, seabreams, cobia, tuna and flounders, all of which are cultured around Southeast Asia, but not yet in Sulawesi.

7.2 Alternative Fishing Methods

There are possibilities to replace cyanide and blast fishing with traditional non-destructive methods, e.g., hook and line and fish traps (*bubu*), with sufficient training, incentives, regulation and enforcement. Hook and line fishing can be effective, especially in unexploited reefs and is still widely used throughout Indonesia. This includes the Spermonde Archipelago of South Sulawesi, incorporating techniques to stop the swim bladders of fish caught from deep exploding and killing the fish bound for the live fish trade. Traditional traps, although capable of causing physical damage to coral reefs, as well as being quite unselective and inefficient, are a useful, common and less destructive method than cyanide or bombs, unless they incorporate cyanide-adulterated baits, as is often the case in Sulawesi (Pet-Soede and Erdmann, 1998). According to fishermen, line fishing for groupers is more competitive with cyanide fishing in CPUE (catch per unit effort) when stock densities are high. It is not until stocks dwindle that cyanide catches decline less rapidly (Johannes and Riepen, 1995).

Other, non-traditional livelihood possibilities include catching organisms for the aquarium trade using certified, non-destructive methods, fish attracting devices (FADs) aimed at the hook and line harvest of marine pelagic fish and the setting up of Marine Protected Areas for

conservation and tourism-related livelihood generation. These options will be discussed in this section.

7.2.1 Certified or Eco-Labeled Aquarium Organisms Trade

It has been estimated that the total world trade of marine aquarium species approached US\$ 200 million by 2002 (Hodgson and Liebeler, 2002; MAC, personal communication). Aquaculture accounted for less than 2% of this trade and is suffering slow growth due to economic and biological constraints to culture of these organisms.

Most of the capture of marine organisms bound for the aquarium trade in Indonesia is conducted using cyanide to stun the fish and make them easier to catch. At present, there is a lack of alternatives proposed, just calls to ban bombs and cyanide. It has also been reported that up to 80% of ornamental fish captured using cyanide will die, exacerbating the problem by raising the price and encouraging capture of more fish to meet the market demand (Anon, 2001). Additionally, the damage done to coral reefs fishing with cyanide is probably greater for aquarium than for food fish since the number of target fish is higher and mechanical damage is more extensive (MOU et al., 2000). Changing the reliance on cyanide to less destructive fishing methods thus offers a more immediate solution to the problems created.

Various groups have developed retraining programs for fisherfolk currently using destructive practices. Prime among these is the Marine Aquarium Council (MAC), which is attempting to unite industry, hobbyists, environmentalists and governments to create a set of core standards that can be used to certify businesses that uphold sustainable practices. The aims of MAC are to certify and regulate the trade in marine aquarium organisms to provide jobs and income to local fishermen and hence provide incentives for them to protect their coastal resources. There may also be the possibility of incorporating cultured coral reef fish caught as post-larvae and then on-grown into such eco-labeling schemes (see section 7.1.10).

Although MAC does not yet have direct representation in Indonesia, Terangi and Telepak (two Indonesian NGOs) started working in 2001 with MAC and six experts in Jakarta and Bali. Their aims were to introduce a certification scheme for marine ornamentals to help protect reef resources, and increase product quality and price. The training is focused on catching fish with barrier and scoop nets and bookkeeping, handling and packaging fish for export. They are now using the Serribu Islands north of Jakarta as a case study, have already selected one operation and are in process of certification now.

The International Marinelife Alliance (IMA) is also working to get the MAC standards accepted by combining with communities to facilitate compliance and remove indebtedness. Although small communities may be unable to comply with all of the MAC standards, there is potential for the establishment of cooperatives. The IMA are already working in this way in Bali with an aquarium fish project in Las village with a community cooperative. IMA are also assisting with handling and marketing of fish directly to the USA.

Problems encountered to date include jealousy between net and cyanide users, but they say that this should ease as net use becomes prevalent. Unfortunately, there are still no cyanide testing facilities in Indonesia, meaning that it is impossible to determine which fish were caught illegally (Djohani, 1996). There is thus an urgent need for laboratories and monitoring procedures in Indonesia to control the live fish industries for both food and aquaria.

7.2.2 FADs

TNC and other environmental groups have developed various community-based, alternative livelihood strategies for local fishermen currently using destructive fishing methods. One of the alternative fishing methods is the use of fish aggregation devices (FADs). These are large buoyant bamboo structures anchored in 1,500-2,000 m of water, which become colonized by algae and other organisms, which, in turn, attract fish (mostly Spanish Mackerel, *Scomberomorus commerson* and tunas). The idea is that the FADs attract and then hold migrating pelagic fish which then, when caught, increase the overall catch rates from the area.

TNC started their project in the Komodo Island Marine Park in 1999, conducting feasibility studies, training in fishing, handling and post-harvest techniques and marketing, together with local communities, government, traders and fishermen. Currently, more than 100 boats, manned by more than 300 former reef fishermen from Komodo, fish the FADs using handlines, netting 10-15 tuna worth up to US\$ 10 daily per fisherman. This equates to a net income of US\$ 72 per month at eight days/month of fishing effort. This compares favorably to that gained using cyanide or blast fishing, estimated at US\$ 63/month in the same area and is well above the US\$ 30/person/month poverty line (Sofianto et al., 2001; TNC, 2000) (See Box 3).

Despite some problems with the pilot studies in Komodo, including destruction and over-fishing of the FADS by commercial purse seiners from Sulawesi, increased skill, better management and continuous guarding of the FADs have recently improved their feasibility and attracted private sector investment. Although the initial construction and management costs are quite high (US\$ 2,000/FAD, with a life-span of one year), this amount is economically feasible for groups of ten fishing boats, which practically can share one FAD among them. With the high incomes generated, replacement costs can quite easily be saved if the fishermen are made aware of such a necessity.

The reasons that this technique has so far not gained widespread attention include the high income possible and low likelihood of prosecution from using current destructive techniques, and the limited knowledge of and hence skill required in constructing the FADs and fishing them using this technique. Additionally, boat owners and middlemen can still earn more from destructive fishing, meaning that individual fishermen find it difficult to switch and the boat owners do not want to, unless forced.

However, a skills base for pelagic fisheries does exist in South Sulawesi (TNC, 2000). Hence, with further extension and promotion (especially regarding post-harvest and marketing skills), together with stricter enforcement of the bans on destructive fishing practices, and a way of breaking the indebtedness system, there seems to be a potential for further development of this technology around Sulawesi and elsewhere. Experience from the Philippines with FADs has also suggested that their use can stimulate a proprietary and protective interest in the surrounding fishing grounds, with a consequent decline in destructive fishing practices (Galvez, 1991, quoted in Johannes, 1997b).

7.3 Marine Protected Areas

Marine Protected Areas (MPAs) can serve a number of functions including fisheries management, tourism promotion, and conservation or the maintenance of biodiversity. However, most that are set up by governments around Southeast Asia fail due to lack of enforcement and local conflicts. Thus, the participation, information gathering, and education of local communities, as promoted now in Indonesia, is perhaps the best way forward in this region.

When marine reserves are established, there needs to be effective management to ensure that they function. Even when there is management-oriented staff in MPAs, they often lack adequate training and skills and are not provided with logistics resources. Problems also occur due to conflicting responsibilities, e.g., among fisheries, tourism and conservation, and lack of communication among the various agencies involved (Chou, 2000).

In 1999, an extensive, worldwide reef survey called Reef Check was conducted over 90 days on 300 reefs in 31 countries. Results showed that in the mean coral health reef index they developed, there were no significant differences between marine protected and non-protected sites, probably due to lack of management or insufficient elapsed time since their establishment (Hodgson, 1999). Indeed, the recent evaluation of the state of Southeast Asia's coral reefs conducted by the World Resources Institute suggested that less than 3% of Indonesia's 6.2 million ha of Marine Protected Areas were effectively managed (14% average for Southeast Asia) (WRI, 2002).

However, well-managed marine reserves (where fishing is completely banned) do exist and have long been known to lead to rapid increases in the biomass, abundance and average size of exploited organisms and to increased species diversity within the MPAs, for example, in the Ashmore Reef Natural Nature Reserve in the years between its establishment (1983) and enforcement (1989), and now (CSIRO, 1999, See section 7), and the well-managed and integrated approach taken for Apo Island marine sanctuary in the Philippines. This latter MPA has shown percentage increases in species richness, food fish abundance and total fish abundance of 7, 83 and 32% respectively, as well as improvements in coral reef structure between 1986 and 1992 within the MPA (White, 1997).

Additionally, MPAs in the Caribbean and Florida have recently (for the first time) been proven capable of enhancing adjacent fisheries. Roberts et al. (2001) showed that the creation of an 11-km section of protected coast in St Lucia constituting 35% of the island's coral reef fishing grounds, increased catches in nearby areas by 36-90%, mirroring a doubling of biomass compared to pre-reserve numbers within 3-5 years. The reserves were also appreciated and acknowledged by the local fishermen as contributing to their catches.

Clearly there is a need to develop more MPAs with better systems of protection and increased political commitment and coordination than exist currently. The Indonesian government recognized this when they stated their (failed) objective of 50 million ha by the year 2000 (WRI, 2002).

Laws for many MPAs have traditionally been extensions of those governing terrestrial parks and have not covered the respective ecological and economic management differences. Regardless of adequate administrative and legal frameworks, problems will still arise from lack of political will, corruption, lack of resources, lack of appreciation of the role of coral

reefs and lack of recognition of local community needs. These are all issues which need to be legislated for within the adoption of an integrated coastal management strategy (Chou, 2000).

Arguably, the best way of enabling this is to entrust the management of marine resources to coastal communities, as is the current stated aim of the Indonesian government (Dahuri, personal communication; Djohani, 1996). Thus, through education and government-assisted empowerment of local communities, they get a better sense of propriety and greater motivation to manage and protect the resources that they depend upon, and ultimately become the beneficiaries of.

In Indonesia, the TNC project in Komodo National Park (the subject of another of the case studies in this APEC program) and particularly the Proyek Pesisir-USAID CRMP project in north Sulawesi, has shown how this is possible and could be used as a model in future expansion. Data generated after the first three years of Proyek Pesisir indicated that despite some confusion within the community as to their purpose and rules, all three MPAs set up as part of the project were perceived by staff and local communities as being extremely successful and useful components of the project (Crawford et al., 2000).

Key concepts of the community-based approach developed in Proyek Pesisir, dovetailing with the recent decentralization of governance in coastal fisheries, include the idea that no single model is perfect for all coastal contexts, and that effective protection and management of coastal resources specifically requires that the public be empowered to make decisions based on local conditions and their commonly held values. The result of supporting these values is that the community assumes responsibility for enforcement of the local management plans (Dutton, 2001).

In Maluku, eastern Indonesia, the so-called *sasi* (traditional resource ownership) system has been developed in which an island is alternately isolated and then opened again. Under this system, locals are prohibited from fishing at particular times (Moka, 2002). This idea has potential throughout Indonesia in community-based management programs.

In north Sulawesi, the Bunaken National Marine Park has been developed into a dive-tourism-based, decentralized co-management success story based on yearly revenues of US\$ 80-100,000 (derived from a US\$ 10 levy for all international dive tourists). This self-financing has allowed a multi-stakeholder, co-management alliance of representatives of the 20,000 local residents, dive operators and local government. Conservation and development initiatives developed and financed under the scheme include mooring buoy programs, scholarships for local students, conservation awareness and education activities, handicraft training for local women and 24-hour joint patrols to tackle destructive and illegal fishing in the park (Dutton, 2001).

For larger areas, the co-management system approach may be more effective where management is shared between government agencies, local communities and NGOs (Chou, 2000).

The recent (1999) Indonesian government legislation regarding zonation of coastal resources and decentralization of the management (monitoring and enforcement) responsibilities is the first step in this direction. However, in order to realize its stated goals, this process (See Box 2) requires continued commitment, funding, education and training of both local communities

and municipal staff (to ensure local and national government objectives are harmonized), together with innovative measures to prevent corruption and indebtedness.

One of the major considerations is where to put such MPAs. This must be discussed in consultation with communities adjacent to the park sites, together with scientists, planners and local government. During this process, in order to make full use of the MPA, consideration should be given to a number of important biological criteria (in addition to the managerial aspects discussed above and tourism-related aspects discussed in section 7.4). Specifically, this involves attempting to include grouper spawning sites, source reefs (supplying larvae to other reefs in the area) and nursery areas, including seagrass beds and mangrove areas, within the boundaries of the MPAs.

7.3.1 Grouper Spawning Aggregations

Currently, there is little management of reef fish spawning aggregations globally, and, of that in place, few stated objectives or indications of the outcomes of management (TNC, 2002). Groupers are susceptible to over-fishing due to their habit of aggregating for spawning. Experienced local fishers can easily locate these fixed sites and decimate the area quickly. The situation becomes exacerbated with the advent of more sophisticated gears, including global positioning systems and spotter planes often used by the larger foreign fishing boats (Johannes, 1997a; Johannes and Riepen, 1995). Some of their own research revealed that fishing with handlines over a known grouper spawning aggregation resulted in a catch of 1,100 groupers in a single day (Johannes and Riepen, 1995). It has been reported that groupers have been virtually eliminated by over-fishing in at least five Pacific Island spawning aggregations (Johannes, 1997a).

Grouper spawning aggregations should thus be identified (often the local fishermen know exactly when and where they occur) and included in Marine Protected Areas. They should then be protected from all fishing since it is so easy to over-fish at such locations and since the fish caught are susceptible to high transport mortality. This is because the often-gravid females caught on such sites will usually release their eggs (promoted by the use of anesthetics) during transport, leading to oxygen starvation and gill clogging, and eventually death (Johannes, 1997a).

7.3.2 Source Reefs

Maintaining and/or restoring natural biodiversity to degraded reefs relies on the availability of new juveniles. Although most recruitment comes from the reef where the larvae were produced, the larval stages of many reef organisms can drift for long distances in ocean currents. Thus, conservation of reefs that are source reefs, responsible for repopulating other reefs downstream, is of vital importance. Problems with this approach are lack of knowledge and in some cases unfavorable current flow. For example, there is a divide on the Wallace line between Sulawesi and Kalimantan where currents flow north to south, but not east to west on either side of the Makassar straits. Thus reefs on one side of the strait cannot be relied upon to reseed those on the other side (WRI, 2002). Identification and inclusion of regional source reefs should thus be a priority during the planning of new MPAs.

7.3.3 Nursery Areas

Many species of marine organisms require specific nursery areas in which to settle once they come out of their planktonic life stages. Inclusion of such areas, which typically include seagrass beds and mangrove areas, into marine parks is therefore required to ensure that the chain of habitats used by such organisms remains unbroken. In this way, the organisms will have access to at least some areas where they are afforded protection throughout their lifetimes, so that conservation, biodiversity, as well as fishery, livelihood and tourism functions, can all be met.

In this last regard, suitable planning must accompany zoning efforts within MPAs to ensure that mutually incompatible activities do not adversely affect areas of the park designed for critical conservation issues. For example, seagrass beds might be adversely affected by eutrophication resulting from effluent discharge, destruction by the propellers of tourist motorboats, or by the siting of seaweed farms over such beds. Additionally, excessive boat traffic may disturb the normal courting behaviors of reef fish within spawning areas (TNC, 2002).

The marriage of MPAs and grouper spawning aggregations, source reefs and nursery areas may thus present the best chance of protecting these species from extinction at the hands of destructive fishers, while adding on benefits accruing from enhanced tourism potential, repopulation of surrounding reefs and maintenance of the livelihoods of local fisherfolk.

Unless action is taken quickly, the species particularly at-risk from the live reef food fish trade may be lost. An idea of their current status is given in the results of the worldwide Reef Check survey conducted in the late 1990s which showed that three of these species – Humpback Grouper, Bumphead Parrotfish and Humphead Wrasse – were missing from 95%, 89% and 88% of Indo-Pacific reefs respectively (UCLA News, 2002).

7.4 Tourism

Tourism presents an increasingly important opportunity for alternative livelihood generation, while sustaining the natural resources. As an idea of the size of the industry in Indonesia, an article in the 3 December 2002 edition of the *Jakarta Post* published figures of US\$ 7.7 billion from domestic and US\$ 5.5 billion from international tourism in 2001.

In 2000, the Indonesian government held a forum on marine tourism where it was agreed that local people should be directly involved in marine tourism, which must itself be capable of sustaining the functions of the marine ecosystem (Dahuri, personal communication). This arose after previous failures resulting from the top-down management approach. For example, in 1996, local resistance resulted from an ill-considered government initiative to move the indigenous community off LaiLai Island within the Spermonde Archipelago to make way for a tourist resort. Also within the Spermonde Islands, Kapoposang has been an MPA since 1996 under the Ministry of Forestry for conservation and tourism, but it has never enjoyed any real enforcement of its protected status. The WWF, together with a US private company, is now planning a marine tourist business there, but there are already conflicts with an existing dive tourism operation.

Reef-related tourism is becoming increasingly important in Indonesia. Tourism, especially related to dive tourism, is incompatible with destructive fishing since the larger, more spectacular species such as the groupers and wrasses targeted by cyanide fishermen are exactly the species that most divers will pay to see, and the incompatibility of blast fishing and diving hardly needs to be explained.

Often, dive resorts set up their own “house reefs” or MPAs, which are well preserved, with the resorts often providing fast boats and fuel to local agencies to improve surveillance. This then goes to ensure the financial self-sufficiency of the protected area. Dive tourism can thus play a direct and active role in conservation of resources, as well as providing jobs and foreign exchange earnings for the host country (Chou, 2000; Djohani, 1996).

Experience in the Philippines has also shown substantial increases in dive-related tourism, in addition to improved fish catches, after the establishment and management of MPAs, such as in Apo Island in Visayas Province (White, 1997). Additionally, it was shown that the financial benefits of selling souvenirs and transporting tourists to resort islands were substantial even to fishers using only their outrigger boats. Fishers’ benefits exceeded losses due to reduced catches and the presence of tourists made it harder for fishers to continue blasting with concomitant improvements in resources (Pet-Soede et al., 1999).

However, the development of tourist facilities has in some cases led to reef damage as a result of bad planning and construction of communal and recreational facilities such as jetties, seawall defenses and tourist resorts altering current patterns and sediment distribution. Tourists can also damage reefs with their fins while snorkeling, diving or walking on the reefs, indicating the necessity for proper monitoring and management practices.

Total potential annual economic net benefit per square kilometer of healthy coral reef in areas (with tourism potential) range from US\$ 23,100 to US\$ 270,000 in Indonesia and the Philippines. Without tourism this range drops to between US\$ 20,000 and US\$ 151,000 (WRI, 2002). In the long-term therefore, tourism (if well managed) provides a sustainable and economically beneficial alternative livelihood for local communities.

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