IMPROVING COASTAL LIVELIHOODS THROUGH SUSTAINABLE AQUACULTURE PRACTICES

A REPORT TO THE COLLABORATIVE APEC GROUPER RESEARCH AND DEVELOPMENT NETWORK (FWG/01/2001)

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Haylor G, Briggs M R P, Pet-Soede L, Tung H, Yen N T H, Adrien B, O'Callaghan B, Gow C, DeVantier L, Cheung C, Santos R, Pador E, de la Torre M, Bulcock, P and Savage W

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The STREAM Initiative
Network of Aquaculture Centres in Asia-Pacific (NACA)
Suraswadi Bldg, DOF Complex
Kasetsart University Campus
Ladyao, Jatujak
Bangkok 10900 Thailand

Tel +66-2-940-5457
Fax +66-2-561-1727
Switchboard +66-2-561-1728-9 ext 108
E-mail ghaylor@loxinfo.co.th
Website http://www.streaminitiative.org

438 Alexander Road
#14-01/04 Alexander Point
Singapore 119958

Tel +65-276-1880
Fax +65-276-1775
E-mail info@mail.apecsec.org.sg
Website http://www.apecsec.org.sg

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ACRONYMS

AARM	Aquaculture and Aquatic Resources Management Program (AIT)
ACIAR	Australian Council for International Agriculture Research
AICC	Agriculture Information and Communication Centre (Nepal)
AIT	Asian Institute of Technology
BFAR	Bureau of Fisheries and Aquatic Resources (Philippines)
BATFCA	Batasan Tropical Fish Collectors Association
CBFM	Community Based Fisheries Management
CBNRM	Community Based Natural Resources Management
CBRMP	Community Based Resource Management Project
CLUP	Comprehensive Land Use Plan
CRM	Coastal Resources Management
CRMP	Coastal Resource Management Programme
CSO	Civil Society Organization
CY	Calendar Year
DFID	Department for International Development (UK)
DG	Director General
DOF	Department of Fisheries
DOFD	Department of Fisheries Development (Nepal)
EIRFP	East India Rain Fed Farming Project
FAO	Food and Agriculture Organization
FARMC	Fisheries and Aquatic Resource Management Council
FGD	Focus Group Discussion
FNRI	Food and Nutrition Research Institute
FRMP	Fisheries Resource Management Programme
FTC	Feed the Children
GTZ	Gesellshaft fur Technichezusaminarbeit (Germany)
ha	Hectare
HLURB	Housing and Land Use Regulatory Board
ICAR	Indian Council for Agricultural Research
IDRC	International Development Research Centre
IUCN	International Union for Conservation of Nature
ICLARM	"The World Fish Centre"
IMA	International Marine Alliance
INCODEV	EU research program on development
INTERFISH	Integrated Rice Fish Production Strategies Projects in Bangladesh
IRR	Internal Rate of Return
km	Kilometre
LGU	Local Government Unit
LHC	Live Hard Coral
LOGODEF	Local Government Development Foundation
MAC	Marine Aquarium Council
MAO	Municipal Agricultural Office
MARD	Ministry of Agriculture and Rural Development (Vietnam)
MDC	Municipal Development Council
MFARMC	Municipal Fisheries and Aquatic Resource Management Council
MOFI	Ministry of Fisheries (Vietnam)

MOLISA	Ministry of Labour, Invalids and Social Affairs (Vietnam)
MPDC	Municipal Planning and Development Coordinator
MPDO	Municipal Planning and Development Office
MPI	Ministry of Planning and Investment (Vietnam)
MRAG	Marine Resources Assessment Group, Imperial College London
MRC	Mekong River Commission
mt	Metric tonne
NACA	Network of Aquaculture Centres in Asia-Pacific
NFEP	Northwest Fisheries Extension Project (Bangladesh)
NGO	Non-governmental Organization
NZODA	New Zealand Overseas Development Administration
PCRA	Participatory Coastal Resource Assessment
PLA	Participatory Learning and Action
PNP	Philippine National Police
PRA	Participatory Rural Appraisal
RDC	Regional Development Committee (Lao PDR)
RIA	Research Institute for Aquaculture (Vietnam)
SAPA	Sustainable Aquaculture for Poverty Alleviation Strategy
SCALE	Cambodian NGO
SEAFDEC	South East Asia Fisheries Development Extension Centre
SPARK	Sharing and Promotion of Awareness and Regional Knowledge
SSI	Semi-structured Interview
STREAM	Support to Regional Aquatic Resources Management
SUML	Silliman University Marine Laboratory
SWOC	Strengths, Weaknesses, Opportunities and Constraints
UK	United Kingdom
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
USPC	United States Peace Corps
VSO	Voluntary Service Overseas
VWU	Vietnam Women's Union
WWW	World Wide Web

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EXECUTIVE SUMMARY

Wild-harvest fisheries for live reef fish are largely over-exploited or unsustainable because of over-fishing and the widespread use of destructive fishing practices such as blast and cyanide fishing. Sustainable aquaculture – such as that of groupers – is one option for meeting the strong demand for reef fish, as well as potentially maintaining or improving the livelihoods of coastal communities. This report from a short study by the STREAM Initiative draws on secondary literature, media sources and four diverse case studies from at-risk reef fisheries, to frame a strategy for encouraging sustainable aquaculture as an alternative to destructive fishing practices. It was undertaken as a component of the APEC-funded project Collaborative Grouper Research and Development Network (FWG/01/2001) to better understand how recent technical advances in grouper culture and other complementary work – including that of the Asia-Pacific Marine Finfish Aquaculture Network (APMFAN) hosted by NACA – could better support the livelihoods of poor coastal communities.

A wealth of marine diversity is found throughout Southeast Asia, although more than three-quarters of the region's reefs, including those most at-risk, are found in Indonesia and the Philippines, which along with Vietnam form the main focus of this report. The use of explosives to kill fish (so-called *blast fishing*) and cyanide to stun and capture fish for the live food and aquarium trades are widespread, illegal and destructive, yet lucrative livelihood opportunities for people from coastal communities with neighboring coral reefs. The main instruments to control destructive fishing are a combination of regulation and enforcement, and the identification and promotion of alternative sustainable livelihoods. Through an assessment of a still limited number of studies of coastal livelihoods, of projects and programs in support of alternatives to destructive fishing, and associated literature and media, insights are gained into factors that influence the ability to adopt sustainable sea farming technology. These can be categorized and described as below as technical, environmental planning and management, economic, and social issues.

Technical Issues

- Successful technical research and outreach is an essential pre-requisite to the development of livelihood options based on aquaculture. The Gondol Research Institute for Mariculture has been instrumental in the establishment and spread of grouper seed production in Indonesia. This technology has been spread to other countries, including Thailand and Vietnam, through grouper hatchery training courses operated by APMFAN. SEAFDEC AQD also provides training in marine finfish hatchery technology, including grouper production in the Philippines.
- Lucrative destructive practices (such as the use of cyanide in the live reef fish trade) should be discouraged through improving enforcement and patrol. Alternative livelihood options must be sustainable and sufficiently lucrative to compete with destructive practices. Options for local communities might include components of the sustainable rearing of grouper, seahorses, lobsters and especially low-input seaweed culture.
- The availability of a sustainable supply of fingerlings is necessary to empower responsible agencies to support aquaculture, to facilitate supplier-community relations, to support effective, efficient, responsible and sustainable management. A sustainable supply of fingerlings can be achieved through sustainable harvest of wild fingerlings

(current wild fry/fingerling supply appears to be unsustainable), or through the development of hatcheries.

- A realistic technical assessment of the status of production technology needs to be undertaken prior to the promotion of aquaculture species. For example, there are still significant technical limitations to the hatchery production of many high-value marine finfish species, including some groupers and wrasse as well as lobsters.
- To support the development of aquaculture for species for which there is no established hatchery technology (e.g., lobster), there is a need to develop sustainable harvest strategies.
- Selecting suitable locations in terms of space, facilities and biological criteria is key to the technical success of sustainable aquaculture, and opportunities to raise more than one species can reduce vulnerability to environmental and market perturbations.
- The hatchery component of the culture of all reef organisms is complex, risk-prone and unlikely to be an immediate option for resource-poor people. Hatcheries to support grow-out systems suitable for poorer entrepreneurs might be developed by support organizations (e.g., TNC), which in the medium term could be taken over by the private sector. In the longer term, as the technology becomes more robust and less capital intensive, it may become attractive to small-scale operators.

Environmental Planning and Management Issues

- It is fundamental that the central government should have a strong commitment to ending destructive fishing practices and to supporting coastal people's livelihoods.
- The introduction of sustainable aquaculture practices should be part of a coherent wider program of intervention in coastal resources management, involving the participation of resource users in the design of interventions, along with partnerships with relevant organizations. Adequate social preparation and technical support are necessary to ensure success, and programs should link aquaculture to responsible resource governance.
- Community-based coastal resources co-management with government and the private sector – aimed at combating the lack of integration of development plans and regulatory systems between sectors and tiers of government and industry – is vital.
- Well-managed Marine Protected Areas (MPAs) are internationally recognized as valuable approaches that also support the development of sustainable livelihoods, and may facilitate the shift from destructive fishing to aquaculture. However, currently only a small percentage of MPAs appear to be effectively managed. Improving the design and management of MPAs and local selling of the approach and controls are required.
- Aquaculture development should be promoted only after feed and seed availability is assured and where policies and enforcement mechanisms are in place to guide sustainable development and control unsustainable exploitation.
- Investment in the production of sustainable aquaculture inputs, e.g., local supply of good quality fingerlings produced in a hatchery and the availability of fish feed, is key to sustainable development and would benefit from collaboration with the private sector, perhaps mediated initially through service providers.
- Certification and regulation of sustainable wild collection, and of the aquaculture industry, could provide an incentive for applying best practices and hence safeguard jobs and income of local fishermen, and could support a market niche and or price premium

for properly collected and cultured reef fish. Cyanide detection opportunities may help with regulation.

- There is a need for environmental planning and management to reduce impacts. Clustering of grow-out cages is common in Asia, leading to localized pollution, and thus issues of carrying capacity need to be addressed.

Economic Issues

- Financial services provision to poor people is essential and should receive priority development support. In this regard, decentralized, flexible community-based savings, micro-credit and insurance schemes are of key importance.
- Being in debt is a constraint for many potential poorer adopters of new livelihood opportunities such as grouper culture, which should not be under-estimated.
- A grouper hatchery is capital-intensive and relatively high-tech for resource poor people. However, grow-out of grouper can be less capital intensive than species such as milkfish, and grow-out of fast-growing species such as Giant Grouper may offer shorter pay-back periods.

Social Issues

- A clear understanding of the livelihoods of people fishing destructively is essential to the design of enforcement and patrol as well as the participatory planning and development of service provision in support of alternative opportunities.
- A strategy to improve coastal livelihoods would be likely to deal with:
  - *Asset building*, i.e., building new skills, e.g., aquaculture (increasing human capital), encouraging group building and networking (increasing social capital), providing alternative credit (increasing financial capital), and securing entitlement to reef areas (increasing natural capital)
  - *Strengthening policies, institutions and processes*, i.e., formulating a clear policy with the participation of resource users, communicating this policy clearly, enforcement of the policy, and building the capacity of local governments for resource governance.
- Policies and institutional arrangements should support practices that are environmentally and economically sustainable, equitable and coherent, to promote aquaculture systems that are at a scale which is technically and economically feasible yet provide a return that is competitive with destructive fishing practices.
- Information services (technical, legal and financial) are essential and should receive priority development support. The use of mass communications approaches to complement traditional extension may make most effective use of resources.
- From the case studies, it appears that many fishers do not appreciate that fishing practices can be destructive or that marine resources are finite. There is a clear rationale for appropriate education on these issues.

A strategic planning framework is presented, comprising four stages:

- *Analysis* (so that plans are based on a comprehensive understanding of local institutions and policy, people's livelihoods, successful ways of working and communications opportunities)

- *Knowledge* (detailing policy, legislation, people's assets, objectives and influences, institutional relationships, funds and access to information types)
- *Constituency Building* (negotiating, partnerships, building awareness and consensus, networking), and
- *Action* (participatory selection, planning and implementation of development options).

The elements comprising each stage are deconstructed, drawing on case study partners' individual experiences with coastal communities and attempts to discourage destructive fishing practices and to encourage sustainable livelihoods.

Further work is necessary to review the existing best practices in relation to each of the stages of the strategic planning framework and to address any gaps in knowledge and processes. This should be undertaken as a study which draws on learning and literature, including from related fields, to guide the detailed implementation of the strategy for improving coastal livelihoods.

1. INTRODUCTION

The enormous demand and high prices that live reef fish species attract has encouraged ecologically-unsustainable fishing practices, including the use of cyanide and explosives, with devastating consequences for some of the world's most productive and important reefs. Wild-harvest fisheries for live reef fish are largely over-exploited or unsustainable. Sustainable aquaculture – such as of groupers – is one option for meeting increasing demand for reef fish as well as maintaining livelihoods of coastal communities.

The APEC Fisheries Working Group is supporting several projects whose aim is to encourage sustainable grouper aquaculture research and development for a range of trade, environmental and socio-economic-related benefits. One major project is the Collaborative APEC Grouper Research and Development Network (FWG 01/2001), of which this sub-project is one element. The specific objectives of the FWG 01/2001 project are to:

1. Through the development of a regional research network, develop the capacity to establish a sustainable grouper aquaculture industry that will benefit all collaborating economies.
2. Provide an alternative source of income and employment to people currently engaging in dangerous and illegal fishing practices.
3. Protect endangered reefs and reef fish from the pressures of illegal and dangerous fishing practices.
4. Develop a new aquaculture industry with significant export potential and economic benefit to a diversity of stakeholders.
5. Reduce substantially the current reliance on wild-caught fingerlings for aquaculture purposes, because capture of wild juveniles is probably unsustainable, and is sometimes carried out using destructive fishing techniques which can have significant impact on the long-term status of reef fish stocks.

This report from the STREAM Initiative draws on secondary literature, media sources and four diverse case studies from at-risk reef fisheries. These include a review of the current situation regarding at-risk reefs in South Sulawesi from secondary sources and primary interviews; case studies of implementation of Marine Protected Areas (MPAs) from at-risk reef fisheries in Komodo in Indonesia and Hon Mun in Vietnam, where alternative livelihoods involving aquaculture are emerging; and an assessment of activities in Tubigon, Bohol Island in the Visayas Sea, Philippines, where land-based and caged-based aquaculture is being promoted with European Union support. Before the preparation of the final report, the Principal Investigator and case study partners brainstormed elements of a strategy for encouraging sustainable aquaculture, reviewed each other's case studies and shared views via a Netmeeting, linked through the internet.

2. IDENTIFICATION OF AT-RISK REEF FISHERIES IN APEC ECONOMIES

2.1 Marine Biodiversity

The Southeast Asian region occupies only 2.5% of the global ocean cover, yet it accounts for 27% of the world's coral reefs (Chou, 2000), which are world-renowned for their biological diversity (Table 1). They contain over 600 of 800 known reef-building coral species.

Southeast Asia is generally considered to contain the global epicenter of marine diversity. Indonesia and the Philippines together hold 77% of the region's coral reefs. It is not unusual to find a greater variety of species around a single island in this region than can be found on all the coral reefs in the Caribbean. Indonesia, Malaysia and the Philippines are all thought to possess a coral diversity of over 500 species, 30 species of mangrove and many seagrass species. Indonesia contains what is thought to be the most valuable cluster of reefs in the world in a remote archipelago close to the coast of Papua Province, in the Malacca Sea. Here it is estimated that more than 1,100 species of fish, 600 species of mollusk and 450 species of coral are to be found.

Table 1 Coral, Mangrove and Seagrass Species in Southeast Asia

Country	Reef Area (km^2)	Coral Diversity*	Mangrove Area (km^2)	No. of Mangrove Species	No. of Seagrass Species
Indonesia	51,000	581	42,550	45	13
Philippines	26,000	561	1,610	30	19
Spratly and Parcel Islands	57,000	362	N/A	N/A	N/A
Malaysia	4,000	550	6,420	36	12
Japan	2,600	420	4	11	8
Thailand	1,800	357	2,640	35	15
Myanmar	1,700	270	3,790	24	3
Vietnam	1,100	355	2,530	29	9
China	900	150	340	23	N/A

(Source: Burke et al., 2002)

* Predicted number of species, estimates rather than counts, based on predicted species distributions and may be exaggerated for some countries.

APEC economies that have reef areas, or are able to establish live reef fish aquaculture in their regions, include Australia, Brunei, Chile, China, Chinese Taipei, Hong Kong (China), Indonesia, Malaysia, Mexico, Papua New Guinea, Peru, Philippines, Singapore, Thailand, USA and Vietnam.

The majority of Southeast Asia's best-preserved reefs are located in a global priority conservation area called the Wallacea Bio-Region, identified by the major international conservation organizations (The World Wildlife Fund for Nature, The Nature Conservancy, World Resource Institute and Conservation International). However, the region also contains a huge concentration of reef fisheries at-risk from human activities, destructive fishing and over-fishing. Considering each of these provides an overview of the reef fish fisheries in APEC economies that are most at-risk from current unsustainable fishing practices.

2.2 At-risk Reef Systems of Southeast Asia

Reefs in Decline

Reef systems are a valuable resource, acting as a nursery for many oceanic and pelagic species and also as a source of adult fish. However, these systems are under increasing threats from a variety of anthropogenic factors (see Table 2 and Figure 1). Prime amongst these is the creeping and uncertain effect of global climate change (global warming), including coral bleaching and more frequent El Niño events, over-fishing and destructive fishing practices and habitat destruction, including sedimentation from coastal development (Whittingham et al., 2002).

Table 2 The Current State of the World's Coral Reefs

Region	% Reef Destroyed Pre-1998	% Reef Destroyed in 1998	% Reef in Critical Stage Loss 2-10 Years	% Reef Threatened with Loss in 10-30 Years
Arabian Region	2	33	6	7
Wider Indian Ocean	13	46	12	11
Australia, Papua New Guinea	1	3	3	6
Southeast Asia	16	18	24	30
Wider Pacific Ocean	4	5	9	14
Caribbean and Atlantic	21	1	11	22
Global Status 2000	11	16	14	18

(Source: GCRMN, 2002)

Table 3 Anthropogenic Threats to Coral Reef Biodiversity in Southeast Asia

Country	Over-exploitation	Destructive Fishing	Sedimentation	Pollution
Cambodia	X	X		
Malaysia	X	X	X	X
Indonesia	X	X	X	
Philippines	X	X	X	X
Thailand	X		X	X
Singapore	X		X	
Vietnam	X	X	X	X

(Source: Chou, 2000)

Consequently, coral reefs across the globe are in a state of decline. Assessments made in late 2000 already indicate that around 11% of what once existed has been lost due to human activities with the El Niño-induced bleaching of 1998 adding potentially another 16% to that figure (GCRMN, 2002), although some may recover slowly without further perturbation. There is regional variation in these figures (Table 2) for instance the situation in Australasia is better that in Southeast Asia where the world's largest area of coral reef is probably under the greatest threat from human activities (see Table 3 and Figure 1), including the impact of over-fishing (Figure 2), the growth of unsustainable and destructive fishery practices (Figure 3) and coastal development. Combined together Figures 1, 2 and 3 reveal the distribution and ranking of these threats, and clearly show that they are at their most serious in the Indonesian archipelago (especially Java, Bali and neighboring islands, and Sulawesi), throughout the whole of the Philippines and the coast of Vietnam and southeastern China.

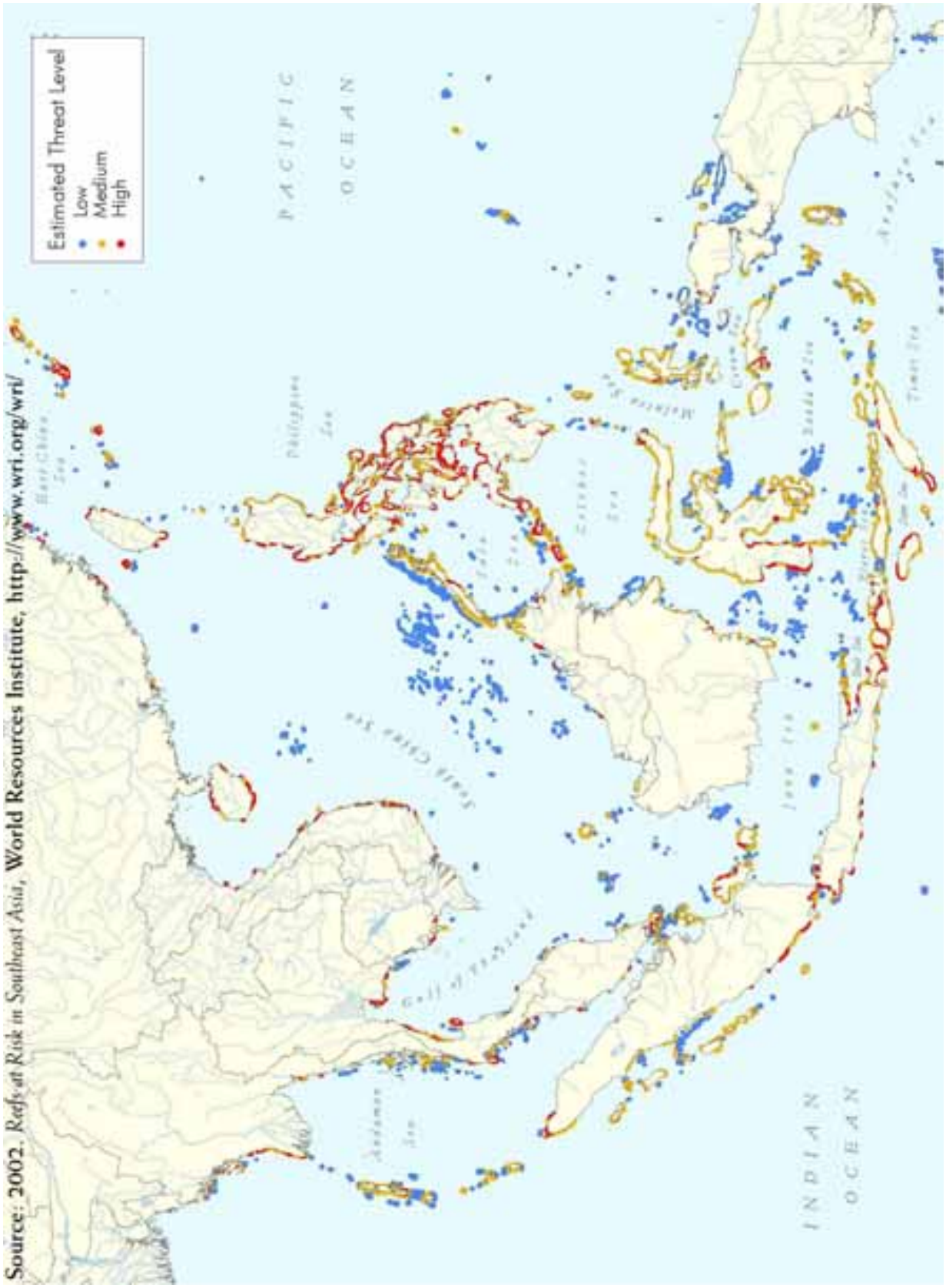

Figure 1 Estimated Threat to Southeast Asian Coral Reefs from Anthropogenic Factors

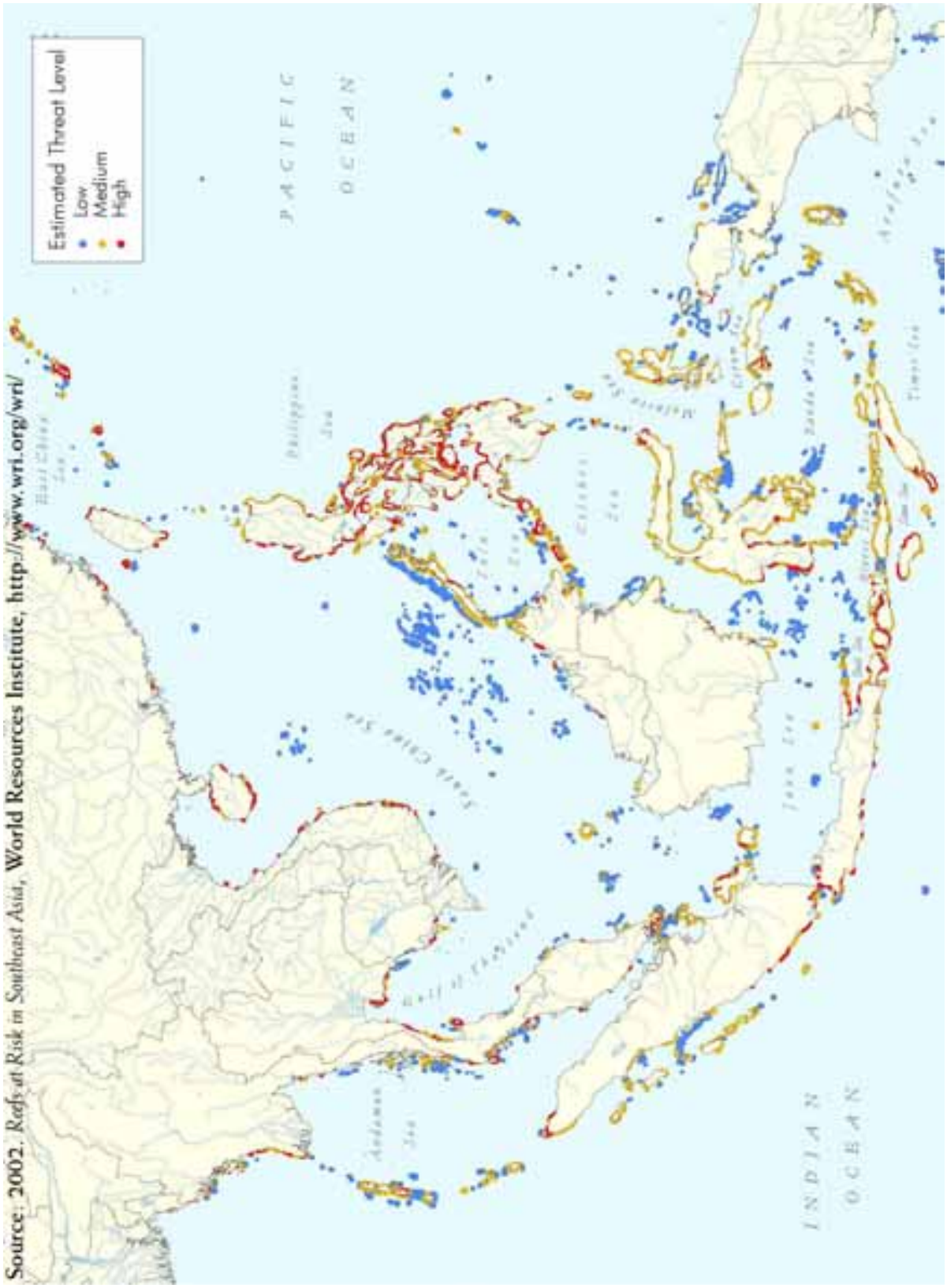

Figure 2 Estimated Threat to Southeast Asian Coral Reefs from Over-fishing

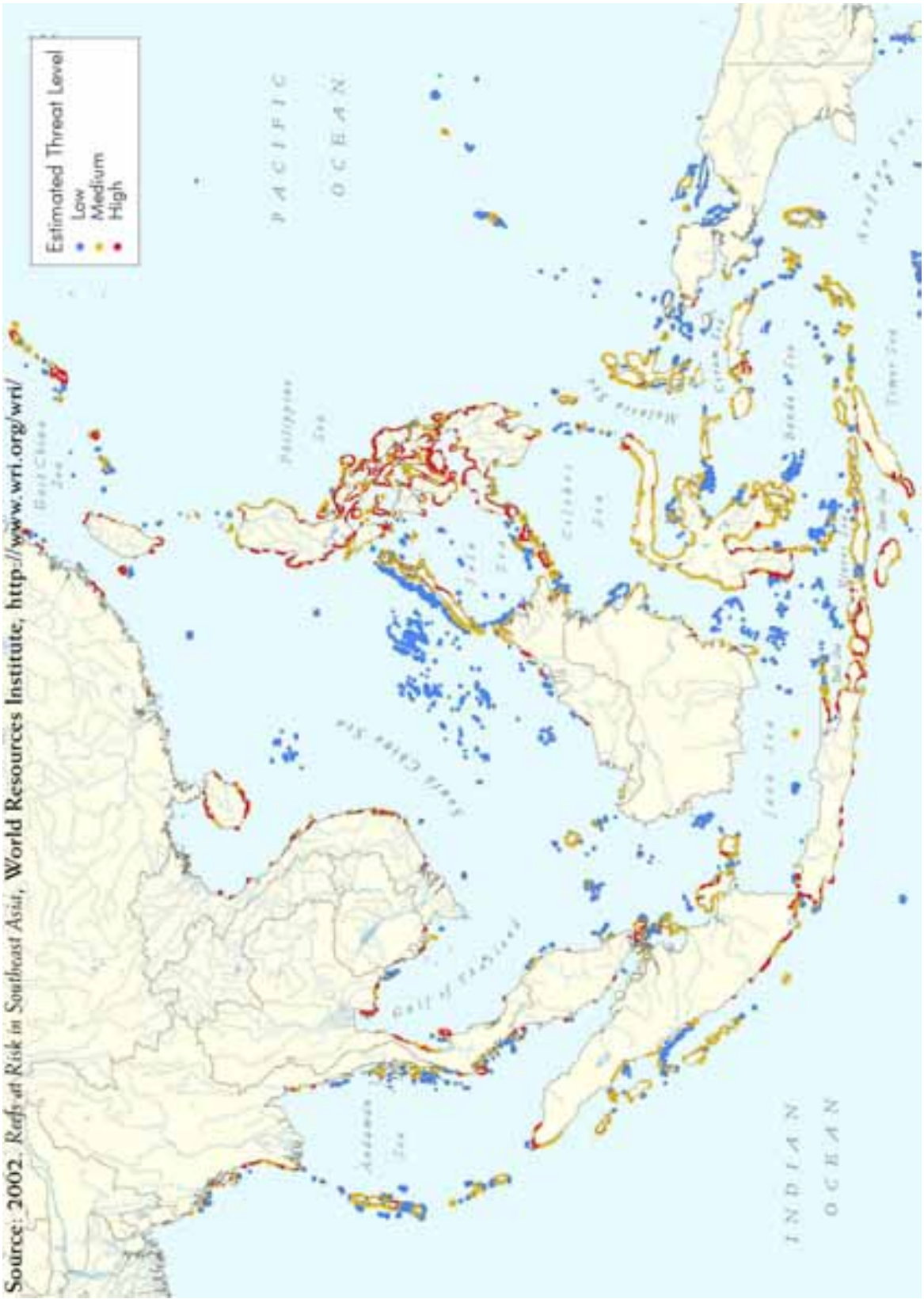

Figure 3 Estimated Threat to Southeast Asian Coral Reefs from Destructive Fishing Activities

A few coral reefs remain unaffected by human activities, such as those in Brunei and the Indian islands (see Table 4) (Burke et al., 2002). However, some 88% of Southeast Asia's reefs are severely threatened by human activity. The situation is especially severe in Indonesia (where 88% are at a medium or higher level of threat), the Philippines (98%), Malaysia (87%), Vietnam (96%), China (92%) and the Spratly and Paracel Islands, Taiwan, Singapore and Cambodia (all standing at 100%) (Table 4).

Table 4 Summary by Country of Level of Risk to Reefs in Southeast Asia

Country	**Reef Area (km^2)**	**Reef Area as % of Total in Region**	**Reefs At-risk Threat Index**								**Percentage AT Medium or Higher Threat**
			LOW		**MEDIUM**		**HIGH**		**VERY HIGH**		
			km^2	**%**	**km^2**	**%**	**km^2**	**%**	**km^2**	**%**	
Indonesia	50,875	51	6,930	14	19,809	39	23,403	46	733	1	**86**
Philippines	25,819	26	559	2	7,099	27	16,311	63	1,850	7	**98**
Spratly and Parcel Islands	5,752		0	0	5,752	100	0	0	0	0	**100**
Malaysia	4,006	6	533	13	1,771	44	1,541	38	161	4	**97**
India (Andaman and Nicobar Islands)	3,995	4	1,790	45	2,119	53	86	2	0	0	55
Japan	2,602	3	581	22	983	38	951	37	87	3	78
Thailand	1,787	1.8	419	23	427	24	917	51	24	1	77
Myanmar	1,686	1.7	742	44	604	36	336	20	4	0	56
Vietnam	1,122	1.1	43	4	252	22	551	49	276	25	**96**
China	932	0.9	71	8	130	14	706	76	25	3	**92**
Taiwan	654	0.7	0	0	189	29	367	56	98	15	**100**
Brunei Darussalam	187	0.2	147	79	30	16	10	5	0	0	21
Singapore	54	0.1	0	0	0	0	54	100	0	0	**100**
Cambodia	42	0.0	0	0	0	0	38	90	4	10	**100**
Regional Total	**99,513**	**100%**	**11,815**	**12**	**39,165**	**39**	**45,271**	**45**	**3,262**	**3**	**88**

(Source: Burke et al., 2002)

Destructive Fishing Techniques

Some fishers in Southeast Asia have adopted destructive fishing techniques, most notably blast and cyanide fishing (see Figure 3 and Boxes 1 and 2). Both of these activities are contributing to over-fishing and the destruction of non-target species and the reefs themselves, leading to potentially devastating changes to the marine environment, fisheries and coastal livelihoods (Burke et al., 2002).

Box 1 Blast Fishing

Although illegal in many countries, dynamite or "blast fishing" continues, as it is an efficient short-term method of fishing a reef (Hodgson and Liebeler, 2002). Such methods destroy not just non-target species in the vicinity, but leave craters in the coral, which take many years to recover, even after the cessation of such activities. Fish bombs are made mostly from artificial fertilizers such as ammonium and potassium nitrate (NH_4NO_3, KNO_3) mixed with kerosene in a bottle (Komodo, 2002). Blast fishers often hunt specifically for schooling fish to maximize impact, diving after the explosion to collect dead and stunned fish. The size of the crater that often results is dependent on the size of bomb, but a blast from a beer bottle-sized bomb will often destroy a 5 m diameter of stony coral; a bomb as big as a soda bottle can destroy 10 m^2 of reef (Komodo, 2002). Often smaller bombs will be thrown to kill small fish, which attracts bigger fish, which are then caught using bigger bombs. The explosives are relatively easy to obtain and are therefore freely used. Following the war in 1945, explosives left over in Southeast Asia by Japan and the allied powers were used to blast coral reefs to get lime for building materials. Today, other materials such as TNT and cheaper and easily obtained urea fertilizers are more commonly used.

Blast fishing is used for food fish (including those to be salted and eaten), rather than for the live fish trade or for live ornamentals, since it bursts the swim bladder, killing the fish that are then harvested before they sink and are lost. 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. Regularly bombed reefs frequently exhibit 50-80% coral mortality (WRI, 2002) requiring perhaps 40-50 years to restore the damaged coral reef ecosystem.

Blast fishing is considered one of the most destructive practices towards coral reefs and it has been estimated that the economic impact of this activity costs US$ 100,000 per km^2 with respect to the loss of coastal protection, fisheries and tourism. Direct loss of 85,000 km^2 of reef, creating a total loss of US$ 8.5 billion has been reported (Komodo, 2002). It is estimated that blast fishing will cost Indonesia and the Philippines US$ 2 billion and US$ 2.5 billion respectively over the next twenty years if it continues at current levels (WRI, 2002).

Box 2 Cyanide Fishing

The practice known as "cyanide fishing" – which uses cyanide liberated from metal salts to stun fish around and within coral reefs – is a method of choice around Southeast Asia to supply high-value fish to the lucrative live fish trade. Cyanide is an industrial chemical, which is generally used in gold mining, electroplating and steel refining. Free cyanide bonds with metals such as sodium or potassium to create salts which 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 in Hong Kong and other locations throughout the region, but also kills small fish and marine biota including coral polyps and symbiotic algae in the surrounding area.

The mortality rate during capture with cyanide is high – 50% for food fish and above 80% for ornamentals – and although the cyanide is eventually excreted, fish usually die 4-6 weeks after capture. The aquarium industry and aid agencies are working hard to educate collectors about this problem. According to reports from the WWF, over 6,000 divers squirt an estimated 150 tons of cyanide around 33 million coral heads annually worldwide. One spray (approximately 20 ml) can bleach an area of 5.5 m^2 of coral reef within 3-6 months and repeated sprayings can kill coral. Cyanide is also occasionally used for food fish in 45-gallon oil drum quantities spread across the whole reef.

Records suggest that during the first eight months of 1995, a total catch of 2.3 million kg of live grouper and Humphead Wrasse, worth over US$ 180 million, was exported to Hong Kong, Singapore and Taiwan. Another 1.9 million kg of ornamental fish worth US$ 800,000 was shipped to Europe and North America. Worldwide cyanide fishing is estimated to account for 85% of aquarium fish traded annually, worth US$ 200 million (Hodgson and Liebeler, 2002) and a proportion of the lucrative "live food fish trade". The Humphead, Maori or Napoleon Wrasse can command prices of up to US$ 100 per kg at retail (Sadovy, 2000), with the Humpback Wrasse *(Chelinus undulates)* commanding as much as US$ 10,000 for one large live specimen (Hodgson and Liebeler, 2002). The WRI (2002) values the world live fish trade at US$ 1 billion annually.

The use of cyanide for fishing is thought to be most prolific in Indonesia and the Philippines. The Indonesian government has limited the import quota for cyanide to 33 mt/yr. However, the actual import volume is believed to reach more than 7,000 mt/yr. Cyanide is traded freely on the market (no permit needed) with a current price of just Rp 40,000/kg (US$ 4.12). The industry originally began with foreign vessels and crew, but the use of local fishermen (trained in the use of cyanide) proved a more cost-effective strategy, first using live fish transport vessels and then air freight, which opened up further-afield markets such as China. In Sulawesi, divers were often boys from local tribes and sea gypsies at small collection centers scattered among remote islands, gathering several hundred tons of Napoleon Wrasse and grouper at the start of a chain that involves middlemen in Ujung Pandang and Manado, and live fish markets in big cities around the region.

The pressure on stocks around Sulawesi and in Southeast Asia in general has dramatically impacted on the size of the trade (Traffic, 1999). Live fish exports from Southeast Asia rose from 400 t in 1989 to over 5,000 t in 1995, but declined by 22% in 1996. Indonesia, accounting for more than 60% of this harvest from 1991-95, saw exports falling by over 450 t in 1996. The industry has spread throughout Southeast Asia, with national live fish exports rising for 3-4 years and then falling as local stocks are progressively depleted. The inevitable over-exploitation that has ensued has been a combination of open access to the resource, vessels and traders gaining high prices in an under-supplied market and the (short-term) livelihood opportunities they provide to many poor coastal communities in the region.

Impacts of Destructive Fishing Practices

The resulting degradation and disappearance of reefs is already leading to a dramatic decline in the productivity of coastal fisheries and to increasing levels of conflict among fishermen for the remaining resources. The economic effects of the loss of coral reefs can be calculated in a variety of ways. The loss of just one of the goods and services that the reef provides, the assimilation of carbon from the atmosphere, can be translated into a direct financial loss.

For this service 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. The value of Southeast Asian fisheries alone was estimated to be US$ 2.4 billion in 2001, and it is estimated that the reefs of Indonesia and the Philippines are worth US$ 1.6 billion and US$ 1.1 billion respectively each year. As a major threat to reefs in Indonesia, over-fishing (Figure 2) is expected to generate a loss of about US$ 1.9 billion over the next 20 years. In addition, losses from dynamite fishing are estimated at US$ 570 million over the same period (Chou, 2000).

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/km^2 within a certain period of time, but that the loss caused by the degradation of the resource was as much as US$ 476,000/km^2 (largely owed to tourism and fisheries), hence a loss of some US$ 440,000/km^2. For dynamite fishing, the balance was even worse, the activity generating just US$ 15,000/km^2, but resulting in up to US$ 761,000/km2 (largely due to tourism, fisheries and beach protection).

The live fish trade is expanding from its traditional base in Hong Kong throughout Southeast Asia and the demand for live fish is rising according. Presently, the main targets are groupers and wrasse but many others can be found in markets. These species end up displayed in expensive restaurants where they can command a price of up to hundreds of US dollars per serving (Komodo, 2002). This is illustrated by the price for one Humphead Wrasse, a species now proposed to go on Appendix II of the list of endangered species, which means its trade and exploitation is restricted (CITES, 2002). However, illegal exports continue in the absence of regional management plans and alternative sources, and as the species declines its luxury status and market value rise further still (IUCN, 2002).

Additionally, further destructive fishery practices include 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 which destroy coral as they descend (Komodo, 2002).

Due to the wide-ranging nature of reef fishers, any attempt to address these issues will require multiple case studies of key sites throughout Southeast Asia. Fishers can travel thousands of miles and populations can and indeed do migrate as a result of economic factors. Therefore, particular 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

by Indonesian fishers in protected areas of the Great Barrier Reef in Australia (Agence France Presse, 2002; BBC Worldwide Monitoring, 2002; Courier Mail, 2002).

Coastal Communities Depending on Fisheries and Reef Systems

About 1.9% of the world's population derive their livelihoods from fishing (FAO, 2002), many of them classified as poor (earning less than US$ 1 a day). Globally this figure accounts for over 23,000,000 with the vast majority found in Asia (Table 5).

Table 5 Estimates of the Number of Income-poor Small-scale Fishers in Asia and Related mployment

Category	Estimate
% of Population on < US$1 per day	25.6
Inland Fisheries	514,023
Marine Coastal	95,837
Marine Other	551,133
Unspecified	3,660,428
Total	4,821,421
No. of Related Income-Poor Jobs	14,464,262
Total Income-Poor	19,285,683

(Source: FAO, 2002)

It is therefore no surprise that fish accounts for the primary source of animal protein for one-sixth of the world's population, contributing 7% towards the world's food supply. However, fisheries are currently facing a global crisis: 47% are in a fully-exploited state and have therefore reached, or are close to, their maximum sustainable limits (FAO, 2002). Others are in a state of decline, or are exhausted as demand continues to outstrip supply (Agence France Presse, November 1, 2002; FAO, 2002; USA Today, November 4, 2002). It is likely that even if fish production rose, prices would still be expected to increase from between 4-16% by 2020, due to the expected drop in production. The reality may actually lead to price increases for fish sources of protein by as much as 70%.

Most of the world's coral reef systems are located in developing countries, typically regions within which populations have doubled over the last twenty years (Hodgson and Liebeler, 2002). Currently around 60% of these populations live within 100 km of the coast. In Indonesia, Malaysia, the Philippines, Singapore and Taiwan alone, this figure rises to 80% within 50 km of the coastline (Burke et al., 2002). Around half a billion people live within 100 km of a coral reef (Bryant et al., 1998). Many of these coastal peoples are dependent on fishery-based livelihoods, which are in turn dependent on coral reef systems. These populations are on the increase due to a combination of local population growth and as a result of migration of those who are attracted to the coast in search of new opportunities. The diversity and productivity of coral reef resources in these areas are acting as sinks for such people, providing a range of livelihoods strategies that are physically and economically accessible (Whittingham et al., 2002).

Therefore, coral reefs are vital to the livelihoods of millions worldwide and particularly within Southeast Asia. In some areas – for instance the coastal regions of major archipelagos, including Indonesia and the Philippines, and small Pacific island states – this dependence is extremely high (Burke et al., 2002; Whittingham et al., 2002). Reefs are known to act as a "key-stone resource", i.e., one ensuring that people just manage to escape poverty. Described

as “interstitial poor”, in that they are often overlooked in coastal development projects, many groups do not have the resources to undertake alternative development options (Whittingham et al., 2002) and are extremely vulnerable to any decline in reef condition.

Specific features of these groups are:

- As reefs are physically and biologically diverse, they do not lend themselves to mass exploitation; hence operators tend to be small-scale in nature, conducting subsistence-type livelihoods of fishing, processing, trading and the use of the reef to obtain building materials (Whittingham et al., 2002).
- Although many are involved in full-time livelihood strategies on the reef, some utilize the reef in times of “livelihood stress”, while others conduct land-based operations, again using the reef in times of increased need.
- The protected physical nature of the reef attracts the old, young and women who can also access the reef, “gleaning” at low tide without the need for resources such as boats.
- Access to reefs used to be influenced by social aspects of class, tribe and caste, but this is now disappearing and the majority of coastal peoples depend on the reefs for protection (Whittingham et al., 2002).

Whittingham et al. (2002) combined poverty and reef statistics for a range of Southeast Asian countries, as presented in Table 6.

Table 6 Southeast Asian Country Poverty and Reef Statistics

Country	Reef Area (km^2)	Total Popu-lation (millions)	Human Develop-ment Index Rank*	Popu-lation Living Below US$ 1 a day (%)	Population Living Below National Poverty Line (%)	GDP Per Capita (US$)	Number Employed in Fisheries and Aqua-culture
Indonesia	51,020	209.3	Medium	7.7	27.1	2,857	5,118,571
Philippines	25,060	74.2	Medium	n/a	36.8	3,805	990,872
Malaysia	3,600	21.8	Medium	n/a	15.5	8,209	100,666
Thailand	2,130	62	Medium	2	13.1	6,123	354,495
Myanmar	1,870	47.1	n/a	n/a	22.9	1,027	610,000
China	1,510	1,264.8	Medium	18.5	4.6	3,617	12,233,128
Vietnam	1,270	77.1	Medium	32	50.9	1,860	1,000,000
Taiwan, China	940	22.19	n/a	n/a	n/a	n/a	n/a
Brunei Darussalam	210	0.3	High	n/a	n/a	17,868	1,355
Singapore	100	3.9	High	n/a	n/a	20,767	364
Cambodia	<50	12.8	Medium	36	36.1	1,361	73,425

(Source: Whittingham et al., 2002)

* Data from UNDP Human Development Report 2002. High Human Development rank (1-48); Medium Human Development rank (49-126); Low Human Development rank (127-162) (UNDP, 2002).

Considering the data from Tables 4 and 6, one can begin to rank the role of reef fisheries in the livelihoods of poor people for different Southeast Asian countries (Table 7).

Table 7 Ranking of the Role of Reef Fisheries in Livelihoods of Poor People

Country	Human Development (Rank)	Employed in Fisheries and Aquaculture	Relation to Reefs	Livelihoods of Poor Related to Reef Fisheries
Indonesia	(102) lower-ranking Medium Human Development country	5 million	The majority of the population live on the coast, which stretches over 95,000 km. About 80% of Indonesia's fisheries production has been estimated to originate from small-scale production in near-shore waters.	Very strong
Philippines	(70) upper-ranking Medium Human Development country	1 million	The majority of the population lives on the coast. About 10% of total fish production is estimated to come from reef fisheries.	Very strong
Vietnam	(101) lower-ranking Medium Human Development country	1 million	Livelihoods of many poor coastal communities are associated reef fisheries.	Strong
China	(87) middle-ranking Medium Human Development country	12 million	These fisheries are less dependent on coral reefs as the lack of warm water currents has prevented extensive coral growth except in the south.	Less strong
Thailand	(66) medium-ranking Human Development country	0.35 million	Fisheries are less dependent on reef systems.	Less strong
Malaysia	(56) upper-ranking Medium Development country	0.1 million	Fisheries are less dependent on reef systems except in the areas around the coast of Sabah.	Less strong

NB The Paracel and Spratly Islands have no indigenous population.

2.3 Selection of At-risk Reef Fisheries

To derive a small number of useful case studies, several selection filters were employed at the outset of the project (Table 8).

Table 8 Selection of At-risk Reef Fisheries Case Studies

Selection Filters	
APEC economies that have reef areas or are able to establish live reef fish aquaculture	Regions include Australia, Brunei, Chile, China, Chinese Taipei, Hong Kong, Indonesia, Malaysia, Mexico, Papua New Guinea, Peru, Philippines, Singapore, Thailand, USA and Vietnam
Ranking of at-risk reefs	The total national areas (km^2) of reefs at medium or higher level of risk calculated from Burke et al. (2002) can be ranked as follows: Regional Total 87,571 (100%) Indonesia 43,753 (50%) Philippines 25,303 (29%) Spratly and Paracel Islands 5,752 (7%) Malaysia 3,886 (4%) India (Andaman and Nicobar Islands) 2,197 (3%) Japan 2,030 (2%) Thailand 1,376 (2%) Vietnam 1,077 (1.5%) Myanmar 944 (1%) China 857 (1%) Taiwan 654 (0.75%) Singapore 54 Cambodia 42 Brunei Darussalam 39
Where poor people's livelihoods depend on reefs	The dependence of poor people's livelihoods upon reef fisheries can be ranked as follows: Indonesia Philippines Vietnam China Thailand Malaysia
Where efforts are underway to identify and promote alternative livelihoods options	Lessons are being learnt in Indonesia (Komodo Marine Protected Area), in Vietnam (Hon Mun Marine Protected Area) and in the Philippines (Bahol EU development project)
Final selection of case studies	▪ A review of the current situation regarding at-risk reefs in South Sulawesi (the most at-risk region of Indonesia) ▪ Mariculture as a sustainable livelihood strategy in support of conservation and management: a case study from Komodo National Park, Indonesia ▪ Improving local livelihoods through sustainable aquaculture in Hon Mun Marine Protected Area Nha Trang Bay, Vietnam ▪ Improving coastal livelihoods through sustainable aquaculture practices the case of Tubigon, Bahol, Philippines

3. STRATEGY FOR ENCOURAGING SUSTAINABLE AQUACULTURE

3.1 Assessment and Analysis Undertaken for Each Region

Case Study from South Sulawesi, Indonesia

This case study looks more generally at the hugely important Indonesia reef fisheries situation focusing on the high-risk area of South Sulawesi. There are at least 14,000 units of coral reefs in 243 locations distributed around the Indonesian archipelago, with an estimated total area of between 51,000-86,000 km^2 (approximately 51% of Southeast Asia's and 14-18% of the world's coral reefs).

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/yr (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).

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 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, 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).

Developing Aquaculture

Grouper aquaculture in Southeast Asia is progressing and already accounts for up to 40% (as much as 25,000 mt, worth US$ 600 million) of the trade in market-sized fish in Southeast Asia (Sadovy, 2000, including Indonesian estimates for 2000; TNC, 2002).

Indonesian fishermen are identified as responding quickly to changing market forces and can rapidly adopt new fishing (or aquaculture) techniques as they become more profitable (Reefbase, 2002). Grouper culture in cages started in the late 1990s in Indonesia and now has grown to an industry worth perhaps more than US$ 20 million per year (although exact figures are unknown). The impetus was due primarily to the government/JICA/ACIAR-funded Gondol Research Institute for Mariculture (GRIM) in Bali established in 1994, which managed to achieve (from 1998) and extend (from 2001) mass seed production of groupers and other species in their Backyard Multi-species 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 institutes around Indonesia and Sulawesi have continued research and extension. 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.

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 2001 figures for mariculture production from the Fisheries Department.

The Indonesian Government's Coral Reef Rehabilitation and Management Program (COREMAP) is 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 15-year project on coral reef management in Indonesia, sponsored by the World Bank, ADB, AUSAID and the Indonesian Government.

A comprehensive approach includes developing alternative livelihood opportunities including aquaculture. The components include:

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
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

Factors that Influence the Ability to Adopt Sustainable Sea Farming Technology

The main factors that influence the ability of the community in this case study to adopt sustainable sea farming technology include:

Technical Issues

- Wild fry collection is unlikely to be sustainable and this precludes support for the industry by environmentally-responsible service providers. What little is known on natural fry mortality rates suggests that juveniles a few months old (>6cm) 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).
- Giant grouper *(Epinephelus lanceolatus)* has a big potential as an alternative livelihood since it will grow to 0.6-1 kg in only 4-6 months, a much more attractive pay-back period for small-scale farmers.
- The limited availability of feeds is affecting adoption. However, Humpback Grouper can be grown from 10 cm stocking size to 470 g in 15 months, feeding only pellets at a Food Conversion Ratio of 1.4:1. Researchers are now collaborating with the private sector (CP and Comfeed) to produce feed formulations (38-40% protein for bigger sizes and <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).
- Other potential aquaculture livelihoods are currently constrained by technical knowledge. Future species for production research in Gondol 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 low; they are now working on egg quality issues with this species.
- In Bali, the adoption of milkfish hatcheries by small farmers has created new livelihoods with more profit than from agriculture or catching wild seed, but their production is seasonal and they are now converting to grouper due to its higher potential profitability (Siar et al., 2002).

Environmental Planning and Management Issues

- There is limited 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, resulting 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).
- Existing acts and laws from previous government ministries are not directly focused on coastal issues and are centralised, product-oriented and unsystematic. Despite initiation of decentralization of the management of fisheries, there is still no act for community tenure and management of the sea (only for land area).

- No specific regulations are 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 and reporting on the size and scope of these trades.
- The shift from destructive fishing to aquaculture can be facilitated by well-managed Marine Protected Areas. However, the recent evaluation of the state of Southeast Asia's coral reefs conducted by the World Resources Institute suggested that <3% of Indonesia's 6.2 million ha of Marine Protected Areas were effectively managed (14% average for Southeast Asia) (WRI, 2002).
- The development of a market niche and/or price premium for cultured reef fish is constrained by the lack of cyanide detection labs in Indonesia or Hong Kong, although some recent progress in a more sensitive test has been made (Trakakis, personal communication).
- The limited certification and regulation of the trade in marine aquarium organisms constrains the provision of jobs and income to local fishermen (and hence incentives to protect coastal resources). The Marine Aquarium Council (MAC) 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 total world trade of marine aquarium species approached US$ 200 million by 2002 (Hodgson and Liebeler, 2002; MAC, personal communication). Aquaculture only accounted for <2% of this trade and slow growth due to economic and biological constraints to culture.
- With 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.
- In Bali, GRIM have reduced the dependence of the Indonesian industry on wild-caught juveniles, but there remains a seasonal undersupply of hatchery-reared fry and fingerlings.
- 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.
- Taking of juvenile lobsters from the reefs for on-growing before they have had the chance to spawn is probably unsustainable (without protected zones to allow recruitment); hence the industry is not promoted by responsible service providers.
- Seahorses have been included on the CITES list (at the 13 November 2002 meeting of the UN in Chile). This now requires that all catches and sales must be legal. Indonesia is the major supplier of seahorses for the 70 mt/year Asian traditional medicine market and the European and US aquarium industries. This increases the potential market for certified cultured fish.

Economic Issues

- Destructive fishing is lucrative. 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, and up to US$ 800/month for medium-large-scale workers, while 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, up to US$ 200 for fishers and US$ 1,100 for owners of large-scale operations (Erdmann and Pet-Soede, 1996; Pet-Soede and Erdmann, 1998; Pet and Pet-Soede, 1999; Pet-Soede et al., 1999).

- 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 at US$ 5/day and distributing 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 need to continue expanding to absorb the increasing hatchery production.
- Long pay-back periods are a constraint to poor potential entrants to aquaculture. However, some potential grouper species offer more attractive pay-back durations (see Technical Issues above).
- A factor which affects the ability of poor farmers to adopt grouper culture is its capital-intensive and relatively high-tech nature. Researchers[1] of grouper farming are trying to stimulate interest in seaweed *(Gracilaria)* farming to help the poorest coastal people. Extensive industries for both the capture and culture of seaweeds 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).
- The dried seaweed produced is largely destined for the growing export markets for agar-type products as well as some local consumption. Current prices for dried seaweeds of US$ 0.2-0.4/kg already result in reported incomes of US$ 40 per month for individual families (using only 300-400 m^2 each) and US$ 250 per month for groups of ex-cyanide fishermen (Sofianto et al., 2002).
- The complete hatchery-based rearing of coral reef organisms to satisfy the aquarium trade is capital-intensive, secretive and risky such that five companies worldwide have gone bankrupt.

Social Issues

- Wild seed collection already 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). Removing this source of livelihood has serious negative consequences for coastal communities and surrounding coral reef resources. Support for other livelihood options, which might include aquaculture, need careful consideration and support.
- Over the last 3-4 years 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 Islands and Taka Bonerate in the south. But some conflicts with cyanide

[1] 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

fishermen have surfaced since seaweed downstream of reefs where cyanide is being used is dying (Moka and Ibrahim, personal communication; Johannes and Riepen, 1995).

- 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).

Box 3 Lessons towards a Strategy for Encouraging Sustainable Aquaculture from Sulawesi

Community-based coastal resources management aimed at combating the lack of integration of development plans and regulatory systems between sectors and tiers of government and industry is vital. Well-managed Marine Protected Areas may facilitate the shift from destructive fishing to aquaculture. However, only a small percentage of MPAs appear to be effectively managed.

Successful technical research and outreach is an essential pre-requisite to the development of livelihood options based on aquaculture. Grouper culture is capital-intensive and relatively high-tech for poor people. Although species such as Giant Grouper may offer shorter pay-back periods that are essential to poorer producers, the hatchery component of the culture of reef organism is complex and risk-prone.

A clear understanding of the livelihoods of people fishing destructively is essential. The issue of indebtedness and its relation to adopting alternative livelihoods should not be under-estimated.

Investment in the production of sustainable aquaculture inputs, e.g., local supply of good quality fingerlings produced in a hatchery, and the availability of fish feed, is key to sustainable development and would benefit from collaborating with the private sector, perhaps mediated initially through service providers.

Certification and regulation of sustainable wild collection and of the aquaculture industry could provide jobs and income to local fishermen (and hence incentives to protect coastal resources), and could support a market niche and/or price premium for properly collected and cultured reef fish. Cyanide detection opportunities may help with regulation.

Alternative livelihood options must be sustainable and sufficiently lucrative to compete with destructive practices. Options might include components of the sustainable rearing of grouper, seahorses, lobsters and especially low-input seaweed culture.

Case Study from Komodo, Indonesia

Komodo National Park (KNP), Indonesia

This case study describes the partnership between The Nature Conservancy (TNC) and the Komodo National Park authorities, which since 1995 has integrated an alternative livelihood program into their conservation strategy. Komodo National Park represents one of few Marine Protected Areas in Southeast Asia where conservation at scale is being achieved, where serious action is taken to successfully abate destructive fishing practices and other serious threats for the reefs, and mariculture activities form an important component in providing alternative livelihoods for park inhabitants. In KNP, there are presently almost 3,300 people spread out over four settlements (Komodo, Rinca, Kerora and Papagaran). All villages existed prior to 1980, before the area was declared a National Park. In 1928, there were only 30 people living in Komodo village, and some 250 people in Rinca in 1930. The population increased rapidly, and by 1999 there were 1,169 people on Komodo, meaning an

exponential growth. Nearly 17,000 people live in fishing villages directly surrounding the Park. Technical expertise on aquaculture is combined with substantial biological, ecological and conservation expertise towards low-impact mariculture activities. A large amount and variety of information on technical and economic feasibility, and on perceptions from stakeholders, is available.

TNC is a USA-based environmental organization, whose mission is to preserve plants, and natural communities that represent life on Earth, by protecting the land and waters they need to survive. Together with the Indonesian Park Authority (PHKA), TNC has been working in KNP to establish a marine reserve that:

1. Ensures long-term protection of the natural community structure, habitat and species of the coastal and marine ecosystems within and around Komodo National Park, and
2. Protects a portion of the exploited reef fish stock to enhance fisheries in the traditional use zones inside the Park and in the waters surrounding the Park.

This aims to protect and safeguard the marine biodiversity in the Park as a source of recruits for surrounding fishing grounds. To obtain this goal, both parties identified some key issues to work on; full details of the workplan are contained in the "25-Year Master Plan for Management of Komodo National Park".

Developing Aquaculture

Widespread assessments around Indonesia of the status of species favored by the live reef fish trade, conducted in 2002, suggest that target species are disappearing and that most fishers and traders see aquaculture as a solution. Within the Komodo MPA context, the aquaculture activities are mostly intended to contribute to enhanced management success by facilitating a transition towards sustainable activities for some of the coastal communities who obtain part of their income from unsustainable fishing techniques. Additionally, the strategy aims to provide a source of high-valued cultured fish from Indonesia for the Hong Kong-based life reef fish trade, the Indonesian supply for which presently includes mainly wild captured fish.

To support this and to overcome initial lack of interest by business members in investing for development of aquaculture and to allow for learning about best practices, TNC has taken the leading role of investing in the initial phases of establishing multi-species reef fish mariculture. Technical expertise is brought to the project through partnerships with Gondol Research Institute (Bali, Indonesia), the Department of Primary Industries (Queensland, Australia) and the Network of Aquaculture Centres in Asia-Pacific (NACA, Bangkok, Thailand).

Factors that Influence the Ability to Adopt Sustainable Sea Farming Technology

The main factors that influence the ability of this case study community to adopt sustainable sea farming technology include:

Technical Issues

- The method to obtain fingerlings from the wild, known as "gango" (used extensively in the Philippines) was tested in the Komodo area but found to put an additional fishing

pressure on wild stocks, both those of grouper and non-target fish. However, the availability of a sustainable supply of fingerlings is necessary to empower agencies to support aquaculture.

- The successful technical research and outreach of the Gondol Research Institute in grouper seed production is a crucial technical component and prerequisite for sustaining grouper aquaculture. However, this technical development is not yet widely replicated in other APEC economies.
- Local supply of good quality fingerlings produced in a hatchery is of importance to the capacity to adopt aquaculture as:
  - It allows application of best practices for fish production.
  - It prevents capture of wild-stock juveniles and provides a steady stream of high-quality fingerlings which can strengthen supplier-community relations.
  - It limits the likely introduction of diseases, and genetic pollution through introduction of "foreign" DNA.
  - It provides a good opportunity for control of the entire production cycle with the potential benefit of certification of the production process.

Environmental Planning and Management Issues

- The design of national policy and law enforcement is a responsibility of the central government, which should have a strong commitment to ending destructive fishing practices. In Indonesia, policy against use of destructive fishing practices such as bombs and cyanide, made official in a 1991 Directorate General Decree, is an example of this.
- The suitability of the environment has a major impact on the ability to adopt aquaculture. The Komodo area, for example, has a number of strengths in terms of aquaculture development:
  - It offers considerable potential for a wide range of marine farming enterprises.
  - It has a low annual rainfall (100 cm) confined to two months a year.
  - It is not in a typhoon area.
  - It consists of a series of islands with virtually no land run-off and hence stable water quality.
  - It has a large number of both deep-water and shallow sheltered sites, suitable for aquaculture.
  - It has a number of sites suitable for establishment of a marine hatchery.
  - It has an existing live fish trade.
  - It has an extensive fishing community with associated knowledge and infrastructure.
  - It has a good local source of breeding stock.
  - It will implement exclusive use rights in multiple-use zones for local communities.
  - It has local expertise in holding and raising wild-caught fish in floating cages.
- The production of fingerlings from captive brood stock is sustainable but requires the establishment of a hatchery, for example, to produce fingerlings for grow-out by communities. The existence of, or support for, a hatchery is key to adoption.

- Skills and knowledge required for grow-out of grouper fingerlings need to be enhanced among fishers through well-directed training and capacity-building activities.

Economic Issues

- A multi-species hatchery (and multi-species approach to farming) reduces risks related to species-specific vulnerability to disease and to fluctuation in consumer preference and price.
- Under conditions of best practices, aquaculture may not provide similarly large financial incentives to the live reef fish trade[2].
- Investments to maintain the hatchery are too high to be carried by local fishermen, and there must be a facilitation role played by a service provider[3].

Box 4 Lessons from Komodo towards a Strategy for Encouraging Sustainable Aquaculture

The availability of a sustainable supply of fingerlings is necessary to empower responsible agencies to support aquaculture, to facilitate supplier-community relations, and to support effective, efficient, responsible and sustainable management. The successful technical research and outreach of the Gondol Research Institute in grouper seed production has been a crucial technical component and prerequisite for sustaining grouper aquaculture.

The central government should have a strong commitment to ending destructive fishing practices and to supporting coastal people's livelihoods.

Selecting suitable locations in terms of space, facilities and biological criteria is key to technical success of sustainable aquaculture. Opportunities to raise more than one species can reduce vulnerability.

Although MPAs are internationally recognized as a valuable approach which also supports the development of sustainable livelihoods, significant local selling of the approach and controls are required.

Social Issues

- Market acceptability for a cultured product for the lucrative Hong Kong trade is not yet assured and will influence the viability of aquaculture. Blind taste tests conducted by TNC some years ago in Hong Kong indicate that little difference was experienced between wild-caught and cultured grouper, yet the market for live grouper is largely based on the fact that target species are somewhat elusive and rare. Farmed grouper will then be less appealing to consumers who wish to experience a rare treat.
- Around Komodo, some 95% of middlemen claimed that they are ready to start grouper mariculture businesses, while 74% of fishers would be ready to join if they had the assurance that this would be as profitable as capture in the wild.

[2] As indicated by Halim (2002), the profitability for fishers and middlemen is thought to influence the extent to which mariculture of groupers can replace the wild-caught grouper trade.

[3] The business plan concluded that to start up a hatchery-based grow-out enterprise in two years, with a capacity of 27 tons/year, capital requirements amount to US$ 280,000. Operational costs in the first three years would amount to US$ 460,000, and the enterprise would break even after five years. After the facility is fully operational, annual profits would amount to US$ 435,000.

- Although MPAs are internationally recognized as a valuable approach which also supports the development of sustainable livelihoods, significant local selling of the approach and controls are required. Scientific evidence of the supportive role of MPAs for protection of fisheries livelihoods from total collapse are not easily translated or explained to local communities and the private sector, who most often think in a short time-span forced by relative poverty or disinterest in a sustained level of natural resources. Even when scientific evidence is presented graphically (see Komodo case study, Appendix F), local stakeholders are wary of the short-term impacts of zonation and management plans. To enhance understanding of the role of conservation in protecting livelihoods, park authorities and TNC engage in education and outreach activities.

Case Study from Nha Trang, Vietnam

Hon Mun Marine Protected Area, Nha Trang Bay

This case study describes the present status and trends, and provides recommendations for the improvement of aquatic resources management, within Hon Mun Marine Protected Area (MPA), Nha Trang Bay, Khanh Hoa Province, Vietnam. The case study also evaluates options for improving the livelihoods of local villagers through the development of ecologically sustainable aquaculture and fisheries, which include diversification, following careful selection and trial of appropriate culture species, and application of best-practice culture methods.

Hon Mun MPA, the first comprehensive MPA in Vietnam, encompasses some 160 km^2, including nine islands and their surrounding waters, and supports a resident population of some 5,138 people, the vast majority of whom rely on fishing and related activities as the primary basis of their livelihoods. The MPA has two key roles: improvement of local livelihoods and conservation of the outstanding biodiversity. By successfully combining these two goals, Hon Mun MPA would thereby provide a model or "pilot project" for the development of future MPAs in Vietnam.

Developing Aquaculture

With over-exploitation and depletion of traditional wild-caught fisheries, villager livelihoods are becoming increasingly focused on developing aquaculture. Since establishment of the MPA, access to some traditional fishing grounds has been restricted to replenish wild stocks, with the associated socio-economic impacts being borne mainly by MPA residents. Many residents consider aquaculture among the most suitable options for additional livelihoods and have raised concerns about access rights to areas suited to aquaculture development.

Aquaculture started in Nha Trang Bay in 1989 with the collection and fattening of high-value species by traders from Hong Kong. By the mid-1990s, the scope and range of aquaculture development was expanding rapidly. To date, village aquaculture has focused on cage culture for reef lobster and marine fish, resulting in an increased demand for wild-caught "seed" and "feed", which is well beyond the ecological sustainability of natural stocks within the MPA and in surrounding waters. Thus, although lobster and marine fish culture remain profitable, their sustainability appears to be short-lived. Similarly, areas suitable for the existing culture system are limited and in some locations cage culture is already at or near local carrying capacity.

Factors that Influence the Ability to Adopt Sustainable Sea Farming Technology

The main factors that influence the ability of this case study community to adopt sustainable sea farming technology include:

Technical Issues

- The aquaculture being practiced is solely dependent on the use of wild-caught seed, prices have surged upwards as demand exceeds supply, and stocks are being exploited without control, within and outside the MPA and from other provinces.
- No formulated diets are commercially available for lobster and marine finfish; "trash fish" and other "low-value" commodities are used for feeding with highly inefficient wet weight Food Conversion Ratios.
- There is a general upward trend in prices of fish for feeding culture species, reflecting limits in the supply chain and reducing profit margins. This in turn is encouraging unregulated (and possibly unsustainable) collection and feeding of wild shellfish and crustaceans.
- The simple culture technologies currently employed are suitable only for limited areas of inshore waters and protected bays, which are rapidly reaching their carrying capacity.

Environmental Planning and Management Issues

- In Vietnam, the creation of a Ministry of Natural Resources and Environment in mid-2002 is changing the institutional architecture for the management of marine fishery resources and the development and management of aquaculture. The Ministry of Fisheries maintains primary responsibility, but the role of the Ministry of Science and Technology (currently responsible for biodiversity, water quality and Environmental Impact Assessment), is under review.
- Vietnam's National Development Plan continues to seek to maximize production from the coastal zone through fisheries development and other industries. The strong aquaculture focus of the National Development Plan means that any aquaculture that is developed is seen as making a positive contribution to the national economy. However, the long-term costs of the impacts of aquaculture have not yet been incorporated into the economic analysis. There are concerns that national development planning, while seeking to address national aspirations for economic development in the short term, may in the long term, result in the further degradation of coastal resources.
- Small-scale aquaculture developments within Hon Mun MPA are approved at the village level. However, the cumulative impact of the many small developments needs to be clearly identified and carefully considered. There is currently inadequate planning and zoning; lack of supporting legislation (e.g., regulations, codes of practice) including consideration of sites for culturing of species that pollute by adding nutrients into the system and species that are capable of directly absorbing nutrient, such as seaweed, and species that remove nutrients by feeding on phytoplankton and zooplankton. There is also no formal consideration of potential conflicts or resource sharing with other users in the MPA.

Economic Issues

- The large scale of investment required, relative to annual income, constrains uptake of aquaculture by people whose average income is only just above US$ 1/day. Capital cost represents approximately 60% of average annual income. First-year running cost in

grouper and lobster aquaculture systems practiced in Hon Mun represents approximately 300% of average annual income[4].

- Financial and investment services provision is extremely limited for poor people in coastal communities, especially local, flexible micro-credit systems, the provision of financial and technical information and supporting legislative frameworks.
- Access to loans is limited to those people who have a good income stream, have collateral and typically have experience in larger scale businesses.
- Associated with the technical and environmental issues referred to above, are unstable, developing markets and wild fluctuations in input and product values.

Social Issues

- While traditional fishing grounds once existed for local people, Vietnamese waters are now designated as open access fisheries. Since the establishment of Hon Mun MPA, access to traditional fishing grounds has been restricted, resulting in inequitable opportunities for local resource users with the associated socio-economic impacts being borne mainly by MPA residents.
- There is a perceived historical trend in declining productivity of the fishery upon which nearly 80% of families primarily rely.
- Fishing with cyanide for the aquarium trade is prevalent and undertaken by both MPA villagers and outsiders.
- To promote a shift from unsustainable fishing to alternative income generation (AIG), AIG must be sufficiently lucrative, as some species caught by cyanide sell for over US$ 100/fish on the open market.

Box 5 Lessons from Vietnam towards a Strategy for Encouraging Sustainable Aquaculture

Policies and institutional arrangements should support practices that are environmentally and economically sustainable, equitable and coherent, and based on an understanding of the livelihoods of proposed recipients of service provision, to promote aquaculture systems that are at a scale which is technically and economically feasible, yet provide a return that is competitive with destructive fishing practices.

Aquaculture development should be promoted only after feed and seed availability is assured and where policies and enforcement mechanisms are in place to guide sustainable development and control unsustainable exploitation.

Service provision to poor people, especially financial and information services, are essential and should receive priority development support.

[4] The cost of an aquaculture cage ranges from 3-3.5 million VND (US$ 200-233), whilst the average per capita income of MPA residents during 2001 was 5.38 million VND/year or 478,000 VND/month (US$ 382/year or US$ 32/month). Grouper culture net incomes ranged from 31,500-1.11 million VND (US$ 21-74/cage/month). The lobster culture average net income/cage is 285,000-380,000 VND or US$ 19-25/cage/month.

Case Study from Bohol, Philippines

Tubigon Municipality, Bohol

This case study describes the coral reef fisheries in Tubigon, Bohol, Philippines, and service providers' attempts to eliminate unsustainable fishing practices and improve coastal livelihoods through better coastal resources management and through the introduction of aquaculture.

The location was chosen because of its reef fishery at-risk from unsustainable fishing practices, a degree of willingness of the local government unit to address the issue, the presence of supporting projects and civil society organizations, and the potential of linking possible sustainable aquaculture projects with the private sector. A European Union development-funded Local Government Development Foundation (LOGODEF) Mariculture Project, which has been supporting former illegal fishers with grouper cage culture, has just concluded in the municipality.

The municipality of Tubigon places the total number of marginal[5] fishers in the municipality at 1,463, although there is no systematic registry of marginal fishers in Tubigon. Most are poor, about one-quarter of fishers have motorized boats, one quarter non-motorized boats and the remainder has no boats. The area has a long history of destructive fishing and some recent success in regulating this.

Developing Aquaculture

The LOGODEF Mariculture Project had three elements: a) environmental management and protection, b) livelihood and employment generation, and c) local economic development and promotion. Grouper culture in Tubigon was introduced by LOGODEF in 1998 as an alternative to unsustainable fishing methods such as the use of cyanide and dynamite in fishing. Green Grouper *(Ephinephelus sp.)* fingerlings are caught within Tubigon municipal waters, but the number available was insufficient to supply the needs of the present grouper culturists. Most of the grouper fingerlings grown by culturists were caught in nearby municipalities, in other areas on the island of Bohol and as far as Bais City on the island of Negros. Red snapper *(Lutjanus sp.)* has been grown in the same cage together with groupers. Apart from grouper and snapper, mudcrab and lobster are also being grown, although there are no sources of seeds for these species in the area. There are 141 grouper culturists in Tubigon, organized into nine groups in seven villages. Seven groups are financially and technically assisted by LOGODEF, while two groups are assisted by the NGO Feed the Children (FTC). Many of the grouper culturists interviewed were involved in some form of illegal fishing in the past (use of dynamite, cyanide, and use of banned active gears). The groupers are fed with trash fish (usually Slipmouths, *parutpot* in the local language, *Leiognathus sp.*) from illegal fishing operators. The grouper culturists do not deal with the buyers directly. It is the LOGODEF fishery technicians who contact the buyers, negotiate the price and arrange delivery.

[5] The Philippine government classifies fishery activities into three sectors: municipal, commercial and aquaculture. The term "marginal" here refers to municipal fishers. These are fishers who use boats with a displacement of not more than three gross tons. Fishers using boats beyond three gross tons are classified as commercial fishers.

Factors that Influence the Ability to Adopt Sustainable Sea Farming Technology

The main factors that influence the ability of the community in this case study to adopt sustainable sea farming technology include:

Technical Issues

- Two key technical issues impacting on the ability of fishers to adopt aquaculture are the limited supply of wild seed and so-called "trash fish", and the lack of production technology for grouper fingerlings and feeds within the technical support agencies and private sector in the Philippines.
- Trash fish comes from illegal fishing operators (so-called "liba-liba gear" operators) and therefore aquaculture based on trash fish feeding would not be considered a responsible sustainable livelihood option and is unlikely to receive institutional support.

Environmental Planning and Management Issues

- Policy reform is key to the ability of community members to adopt aquaculture, especially the formulation of a local policy on coastal resource management, devolution of resource governance to local government units, and the declaration of municipal waters (15 km from the shoreline) as an exclusive zone for small fishers. There are clear local agreements on access rights and responsibilities of various stakeholders and zones for different resource uses established.
- Institutional strengthening, especially capacity-building for local government units, has resulted in more responsive local government delivering resource management services – such as regulation, protection and extension – which have supported resource users to adopt aquaculture.
- A key thing that happened in Tubigon is that the fishers' needs, perspectives and interests are represented in discussions on how the coastal resources on which they depend for their livelihood is managed. The creation of the municipal Fisheries and Aquaculture Resource Management Councils (FARMC) – as spelled out in RA 8550 of 1998 and Article 8 of the Tubigon CRM Code of 2000 – made this possible. The FARMC is a body composed of fishers, government officials, NGOs and commercial fishers, which advises and assists the municipal government in the implementation of its coastal resources management program.
- A strong local government commitment to eradicate illegal fishing, and support from many agencies – including Haribon Foundation, LOGODEF, IMA, Marine Aquarium Council, Coastal Resource Management Programme (CRMP) and Feed the Children[6] – over ten years, has built an important "fear of getting caught" which has encouraged the uptake of alternative livelihoods including aquaculture. Experiences elsewhere in the Philippines have shown that incumbent administrations usually disregard and do not build on the gains of the programs implemented by past administrations, especially when there is no legislated policy in relation to these programs.
- A strong focus on building human capital has delivered diversified sources of income that now include sustainable aquaculture activities.

[6] What seems to have made it work in Tubigon is the fact that the area has been a "learning site" for many CRM groups for almost a decade, which seems to have enhanced the overall human capital (knowledge and skills in CRM) and social capital (trust in their government officials, trust between NGOs and government, networking with outside groups) of the area, making it more equipped to deal with CRM issues in a more constructive sense.

- A strong focus on building social capital by encouraging group-building and networking has resulted in fishers and farmers who are confident to articulate needs and represent interests in resource management bodies such as the FARMCs and Municipal Development Councils (MDCs).
- The conduct of the participatory processes was made possible through the support of development agencies and NGOs such as CRMP, LOGODEF and FTC.

Economic Issues

- The national poverty incidence (proportion of families with income below the poverty line) in 2002 was 34.2%. The local annual per capita poverty threshold in 2000 was 13,916 pesos or US$ 247. The municipal profile of Tubigon estimates the monthly income of anchovy fishers at 4,500 pesos (US$ 84) or US$ 1,008 annually. The LOGODEF Mariculture Project requires investments that poor fishers in Tubigon cannot afford. The investment cost for one module (two 3x3 m cages), including operating costs for one cycle operated by two fishers, is about 90,000 pesos (US$ 1,682), or about 45,000 pesos (US$ 841) per fisher[7]. A gill net costs only 5,000-6,000 pesos (US$ 93-112)[8] which could earn money for a fisher on a daily basis.
- Fishers in the coastal town of Macaas have not stopped or decreased their other fishing activities, so a 30% contribution to their livelihoods from mudcrab and grouper culture is additional income for these communities.
- As is done in many "fairly traded" products, the price structure of the fish can include a small percentage to establish a development fund. This has been done in the production of raw sugar (called *muscovado*) from the island of Panay and its export to several countries in Europe and Japan[9]. The development fund can be used to fund projects that will improve aquaculture production.

Social Issues

- According to the municipal mayor, "enhancing the character of a community's natural leaders by training them and exposing them to other projects so that they can expand their horizons and broaden their thinking and later they can serve as champions for a program" can strongly influence adoption.
- Resource governance programs are most successful when they are the joint responsibility of government and its constituency, and external development programs strengthen both.
- One of the factors for the success of the dramatic reduction in the practice of illegal forms of fishing in Tubigon is local market denial, i.e., a supported program to stop the purchase of fish captured by illegal means.

[7] Based on LOGODEF calculations in 2001
[8] Based on estimates of fishers interviewed
[9] Ronet Santos, one of the authors of this report, was involved in a project to revive the dying *muscovado* industry in the island of Panay from 1986-92. The women farmers from the small village of Pisang, in the town of Janiuay, until now are exporting *muscovado* to at least eight countries in Europe.

Box 6 Lessons from the Philippines towards a Strategy for Encouraging Sustainable Aquaculture

The introduction of sustainable aquaculture practices should be part of a coherent wider program of intervention in coastal resources management, involving the participation of resource users in the design of the intervention along with partnerships with relevant organizations. Adequate social preparation and technical support are necessary to ensure success, and programs should link aquaculture to responsible resource governance.

A strategy to improve coastal livelihoods would be likely to deal with:

- *Asset building*, i.e., building new skills, for example, aquaculture (increasing human capital), encouraging group-building and networking (increasing social capital), providing alternative credit (increasing financial capital), and securing entitlement to reef area (increasing natural capital).
- *Strengthening policies, institutions and processes*, i.e., formulating a clear policy with the participation of resource users, communicating this policy clearly, enforcement of the policy, and building the capacity of local governments for resource governance.

3.2 Strategy for Encouraging Sustainable Aquaculture in Communities that Depend on Reef Fisheries

From "Destructive Fishing Practices" to "Sustainable Livelihoods"

When APEC proposed this study and called for expressions of interest to carry it out, their rationale was that wild-harvest fisheries for live reef fish are largely over-exploited or unsustainable and that sustainable aquaculture is one option for meeting increasing demand for reef fish such as groupers as well as maintaining livelihoods of coastal communities. APEC referred to significant technological advancements in sustainable grouper and reef fish aquaculture in recent years.

However, the "road" from "destructive fishing practices" to "alternative sustainable livelihoods, involving aquaculture" is a complex one with many twists and turns. It must be mapped, built and traveled by a wide range of stakeholders. These will necessarily include, but are not limited to, poor people in coastal communities who depend on reefs and reef fisheries, people fishing destructively, regulators, enforcers, entrepreneurs, financial institutions, private, government and NGO service providers, technologists, managers, traders, developers and conservationists.

The era when technologists were the principle actors, spurred on by technical possibilities and hoping for uptake by (poor) people and involvement by other stakeholders, is now fading. Contemporary development efforts are the subject of much scrutiny and are increasingly based on guiding principles which promote development that is people-focused, participatory, practical, flexible, supportive, transparent and reflective (Haylor and Savage, 2002).

The phrase and practice of "participatory development" was already common among NGOs in different parts of the world by the 1970s. By the 1990s, many governments, including those in Asia-Pacific and bilateral donors – including USAID, GTZ, DFID and SIDA – were emphasizing decentralized governance and primary stakeholder participation. By the beginning of this millennium, large complex and powerful development actors such as the World Bank reported that they too "… now recognize the need for laying much more emphasis on the

institutions and social foundations for the development process and on managing vulnerability and encouraging participation" (Wolfensohn, 2000).

The objective of this section of the final report is to set out such a strategy, drawing on the four selected case studies (identified in Table 8, summarized in the previous section and appended) as well as other materials. In view of the principle of flexibility, and the diversity of the livelihoods of coastal communities and of APEC economies, such a strategy would provide guidance rather than a "blueprint".

Developing a Strategic Planning Framework

During the course of this sub-project, a strategic framework was brainstormed within the STREAM Initiative and reviewed with each of the case study partners. At the outset four core stages of strategic planning were identified. Then, the elements comprising each stage were deconstructed, drawing on case study partners' individual experiences with coastal communities and attempts to discourage destructive fishing practices and to encourage sustainable livelihoods. The four stages are outlined below.

Stage 1 Analysis

A successful strategy for encouraging sustainable aquaculture in communities that depend on reef fisheries would be guided by the principles referred to above. In addition, it would:

- Be based on a comprehensive understanding of the local institutional and policy context
- Be based on a sound understanding of the livelihoods of poor people
- Learn from successful processes and ways of working, and
- Include a communications strategy linking all legitimate stakeholders.

Stage 2 Knowledge

Leading from the analyses in stage 1, information, facts and data would be required, detailing:

- Institutional roles and responsibilities, how policy is implemented, how legislation is enforced
- People's objectives, assets and vulnerability, and the impacts of policies on their livelihoods
- The ways in which institutions work, inter-institutional relationships, experiences of co-management (power-sharing), and funding mechanisms, and
- The mechanisms that exist for communication and information-sharing, and people's preferred ways to receive information.

Stage 3 Constituency-building

In order to develop the institutions and social foundations for the development process, and to manage vulnerability and encourage participation, actions would be required to unify communities and stakeholders around sustainable options to improve coastal livelihoods. This would include:

- Partnership negotiation
- Developing co-management agreements
- Group-building
- Awareness-raising
- Capacity-building
- Negotiating (self-sustaining) funding, and
- Building a stakeholder network.

Stage 4 Action

Actions will be context-specific but would include the following areas:

- Participatory planning
- Developing a communications strategy
- Identifying alternative livelihoods strategies
- Prioritizing strategies based on institutional, socio-cultural, environmental and technical sustainability
- Building and enforcing policy and legislative sanctions for unsustainable practices, and
- Instituting appropriate supporting roles and responsibilities.

This resulted in a draft framework (Figure 4) to map generic elements along the "road" from "destructive fishing practices" to "sustainable livelihoods, involving aquaculture".

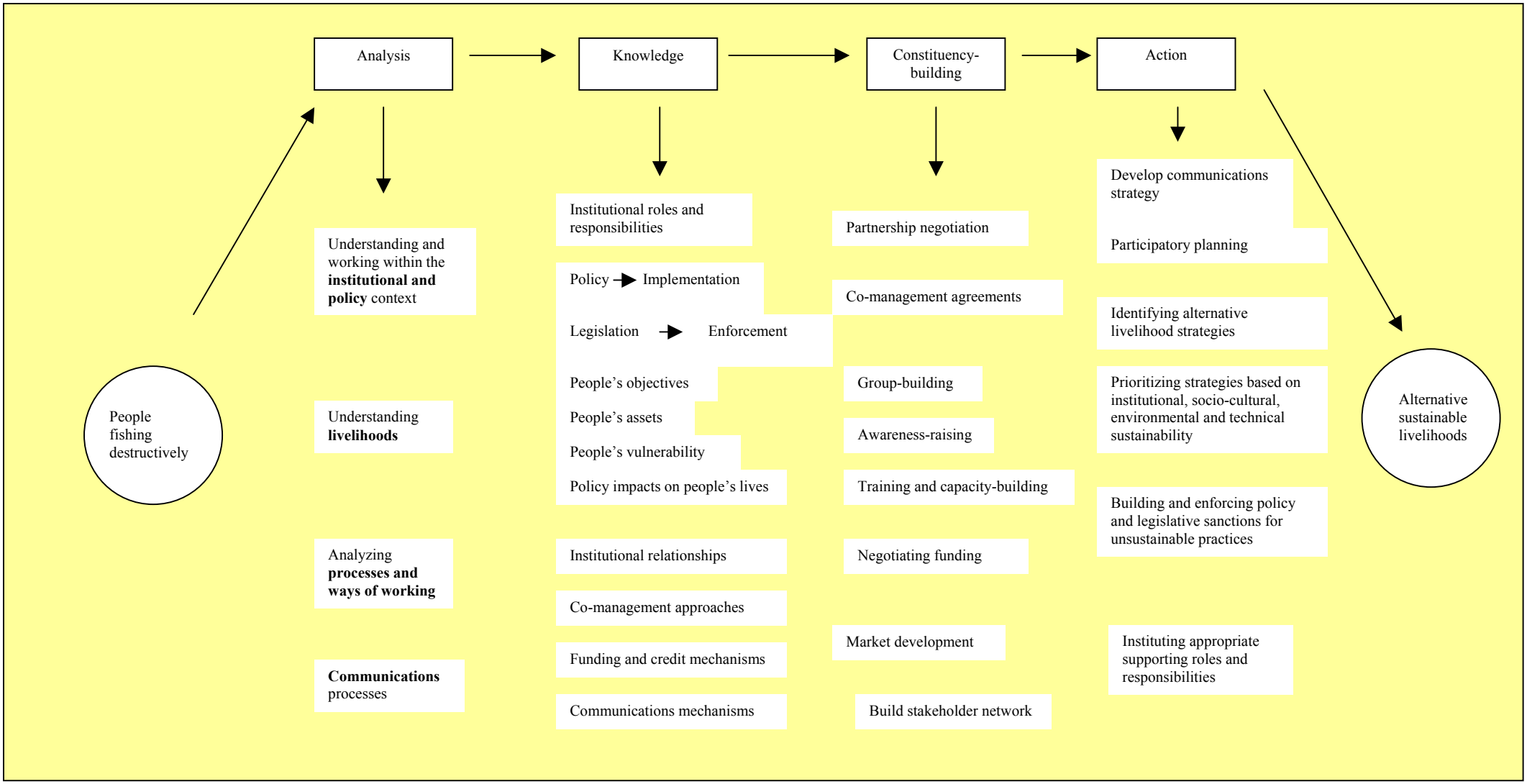

Figure 4 Generic Elements along the Road *from "Destructive Fishing Practices" to "Sustainable Livelihoods"*

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The STREAM Initiative
Network of Aquaculture Centers in Asia-Pacific (NACA)
Suraswadi Bldg, DOF Complex
Kasetsart University Campus
Ladyao, Jatujak
Bangkok 10900 Thailand

Tel +66 +66-2-940-5457
Fax +66-2-561-1727
Switchboard +66-2-561-1728-9 ext 108
E-mail ghaylor@loxinfo.co.th
Website http://www.streaminitiative.org

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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

A Report to the Collaborative APEC Grouper Research and Development Network (FWG/01/2001)

Matthew R P Briggs

2003

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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 km^2 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 m^2 per 100 m^2 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 km^2 (approximately 51% of Southeast Asia's and 14-18% of the world's coral reefs) (Dutton et al., 2001; Hodgeson and Liebeler, 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).


Source: 2002. Reefs at Risk in Southeast Asia, World Resources Institute, http://www.wri.org/wri/
Estimated Threat Level
Low
Medium
High
PACIFIC
OCEAN
INDIAN
OCEAN

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/km^2 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/km^2 (largely owed to tourism and fisheries). For dynamite fishing, the balance was even worse, the activity generating just US$ 15,000/km^2, but resulting in losses of up to US$ 761,000/km^2 (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 cm^2 of live coral, often up to 1 m^3 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).

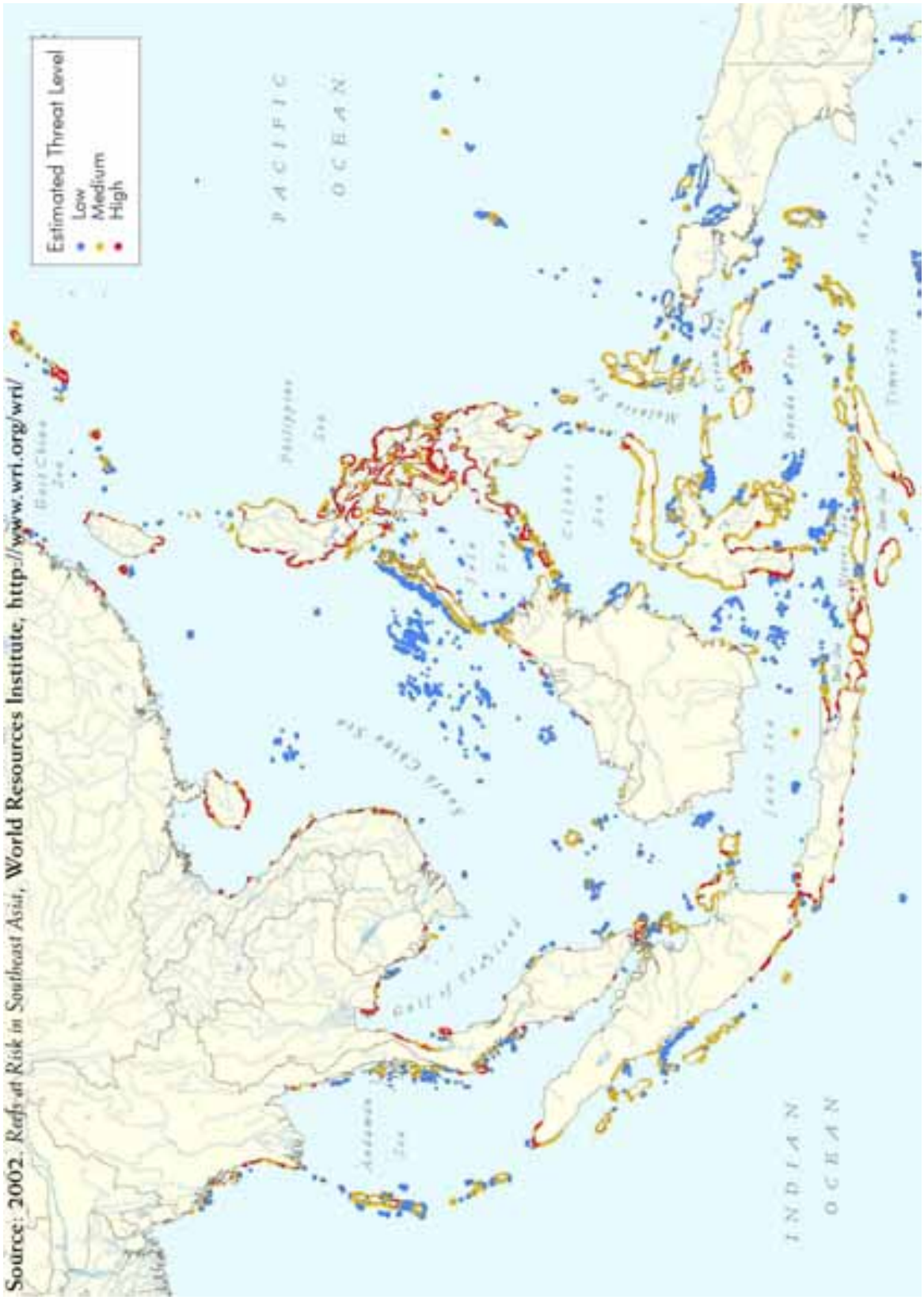

Figure 2 Estimated Threat to Southeast Asian Coral Reefs from Destructive Fishing Activities

In Indonesia, fishing sustainably can generate as much as US$ 63,000/km^2 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 km^2 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 km^2 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 lead to lost limbs and lives; bombs as big as a soda bottle can destroy 10-20 m^2 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 m^2 per 100 m^2 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.

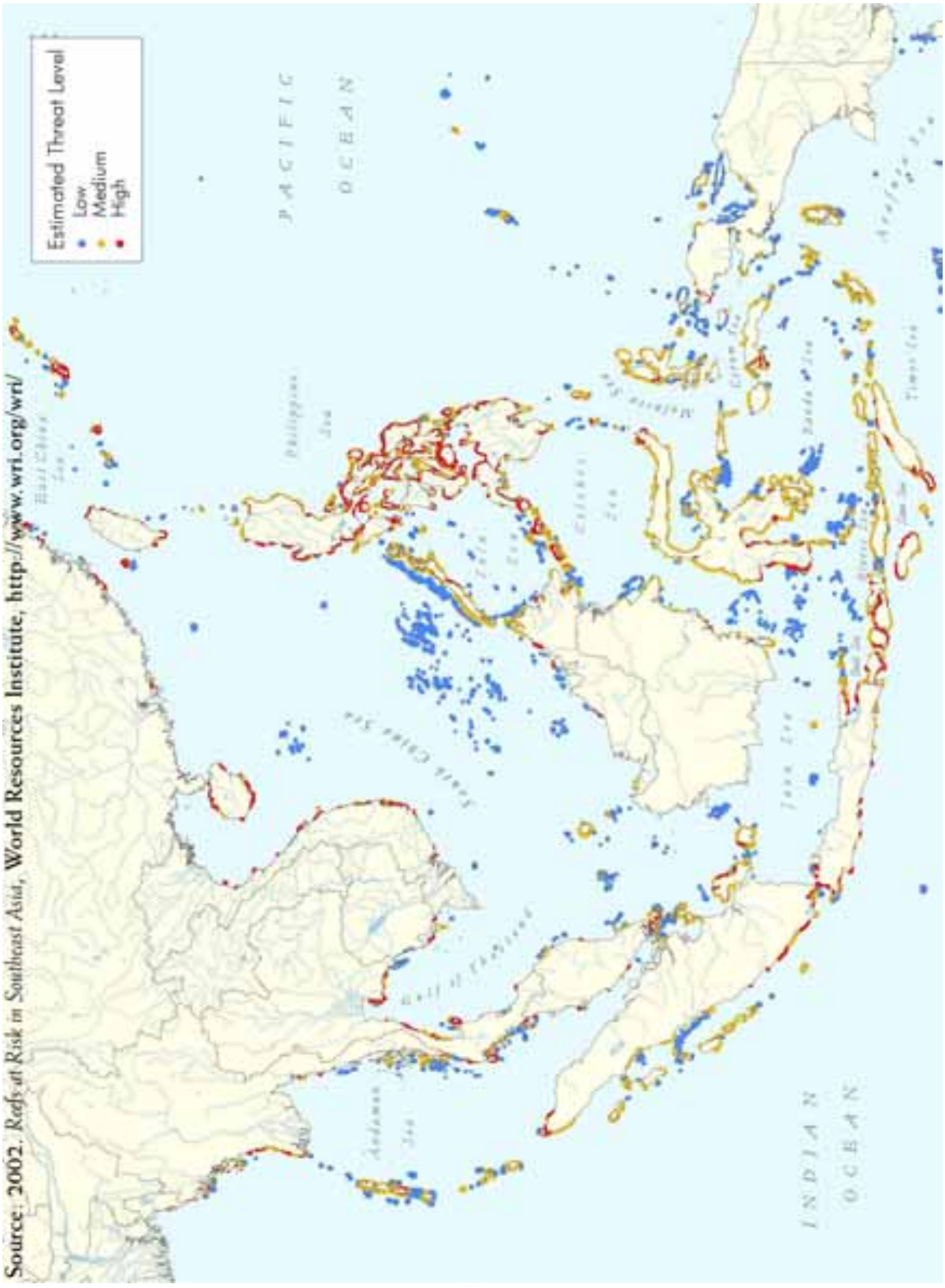

Figure 3 Estimated Threat to Southeast Asian Coral Reefs from Over-fishing

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 m^2 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 m^2 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 m^2 per 100 m^2 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).

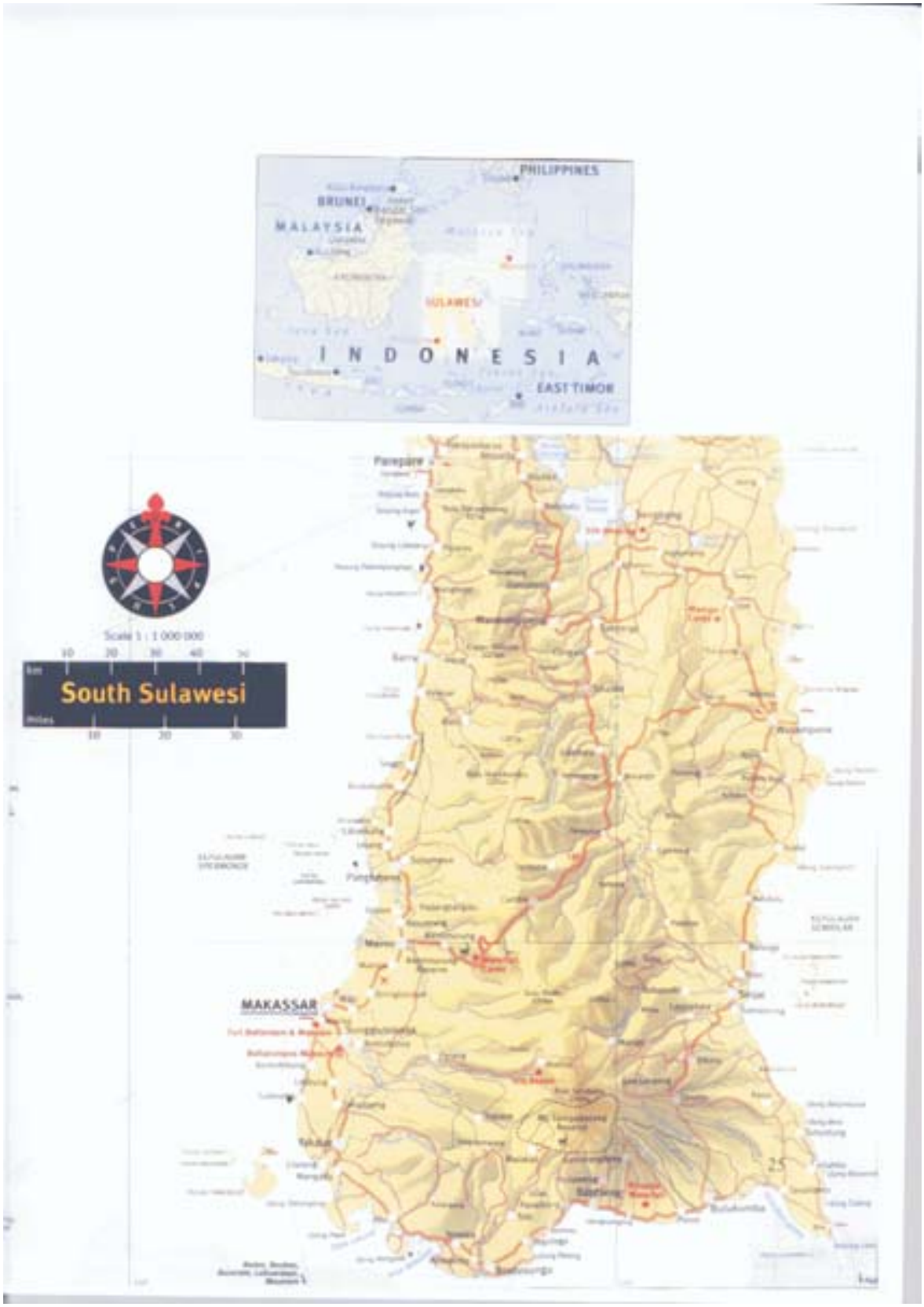

Figure 4 South Sulawesi Case Study Area within Indonesia

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 Kepelauan 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 evolutional 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
Penaeus merguiensis	3,928	5.7	1.45
Grouper Spp.	3,510	2.6	0.74
Seabass	2,270	1.5	0.66
Penaeus monodon	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
Metapenaeus Spp.	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
Gracilaria Spp.	19,158	1.6	0.08
Penaeus monodon	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
Tilapia Spp.	1,846	0.7	0.40
Metapenaeus Spp.	1,424	1.2	0.83
Penaeus merguiensis	1,289	1.7	1.34
Mullet Spp.	1,255	0.5	0.39
Swimming Crab	743	0.2	0.31
Mysis Spp.	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$)	0.89	1.12	0.11-0.17
Harvest density (no/cage)	200-300	200-300	500
Survival rate (%)	60-70	60-70	95
Feed	Trash fish	Pellets	Pellets
FCR	8-10:1	3.5:1	1.7-2.2:1
Diseases	VNN, Vibrio	Cryptocarion	?
Farmer class	Mid-rich	Mid-rich	Low-mid
Market value cage (US$/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. merguiensis* 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/m^2 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/m^2 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/m^2 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 alverezi*), *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 Balanglompo 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 peal 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 1974[1]. 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 km^2 of shallow reefs and 1,226 km^2 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 km^2 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 km^2 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.

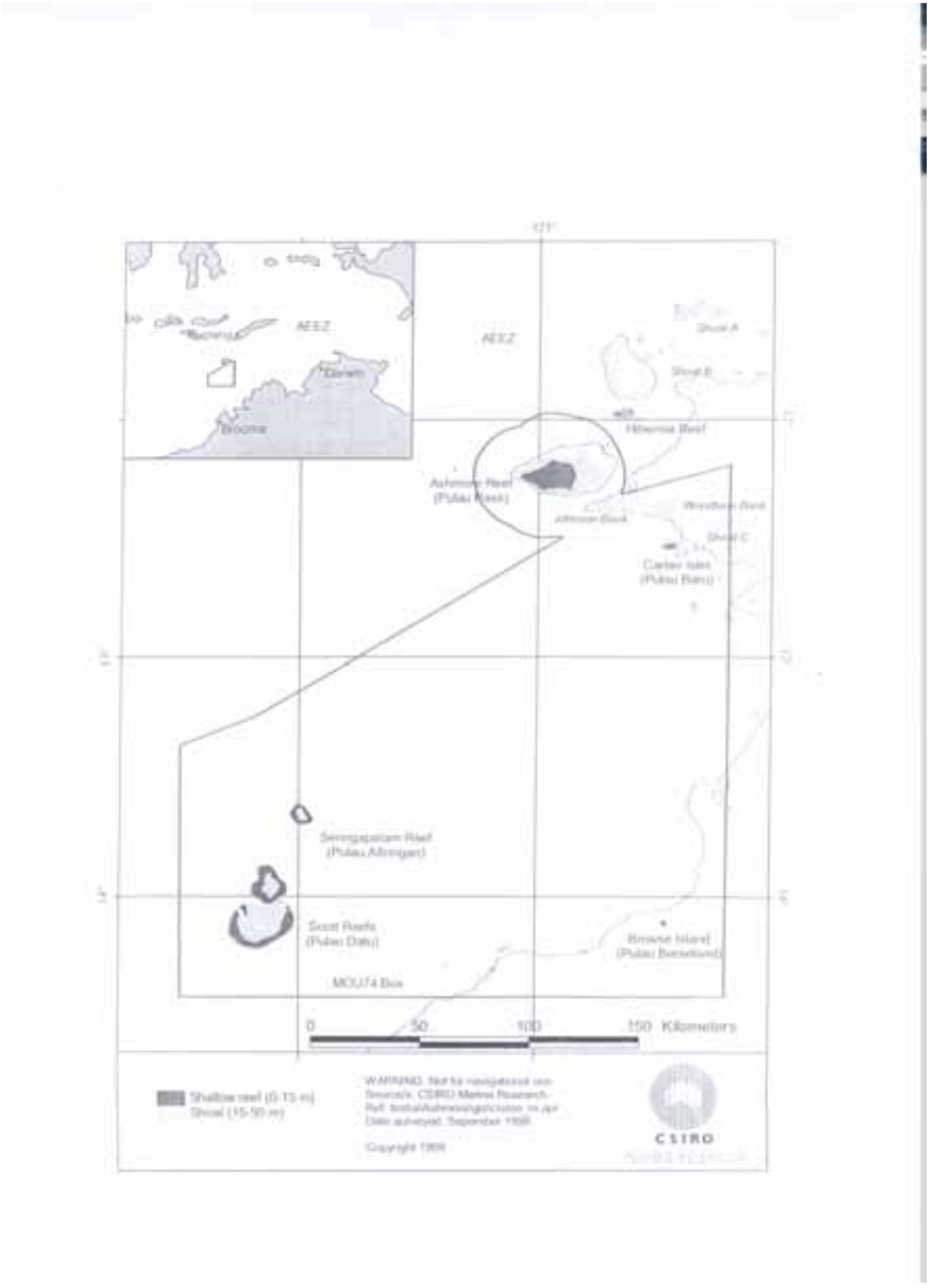

Figure 5 The MOU Box and Relative Positions of Indonesia, Australia and the Australian Fishing Zone (AEEZ)

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 dissincentive.

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 lead 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 el., 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/km^2 and for blast fishing up to US$ 746,000/km^2. 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/km^2 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 km^2 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 ciguatoxin-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)
C. undulates (Humphead Wrasse)	55	108
C. altivelius (Humpback)	66	103
P. leopardus (Leopard Coral)	38	64
E. lanceolatus (Giant)	26	63
E. fuscoguttatus (Tiger)	24	49
E. polyphekadion (Flowery)	22	45
E. coioides (Estuarine, Orange-spotted)	13	28
L. argentimaculatus (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/m^2, 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 superceded 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 alvarezi (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 m^2 plots in front of their villages in 2001 (Sofianto et al., 2002).

By early 2002, 100 families were each cultivating 300-400 m^2 plots, producing 0.75 kg of dry seaweed/m^2 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.

8. ACKNOWLEDGEMENTS AND CONTACTS

Rokhmin Dahuri, Minister of the Ministry of Marine Affairs and Fisheries, Republic of Indonesia, Jakarta. Tel: 62-021-3500041

Dr Ketut Sugama, Director, Research Center for Aquaculture, Agency for Marine Affairs and Fisheries Research, Jakarta. Tel: 62-02105709160,2, e-mail: sugama@indosat.net.id

Dr Anugerah Nontji, APU, Director, Coral Reef Rehabilitation and Management Program (COREMAP), Jakarta. Tel: 62-021-3143080, e-mail: coremap@indosat.net.id

Dr Kasim Moosa, Coral Reef Rehabilitation and Management Program (COREMAP), Jakarta. Tel: 62-021-3143080, e-mail: coremap@indosat.net.id

Arief Wicaksono, Director, International Marinelife Alliance (IMA), Jakarta. Tel: 62-0816-1441799

Mr Muharijadi Atmomarsono, Director, Research Institute for Coastal Fisheries and Aquaculture (Balit Kantor), Maros, South Sulawesi. Tel: 62-0411-371544, e-mail: litkanta@upandang.wasantara.net.id, hariatm@indosat.net.id

Asda Laining, Researcher, Research Institute for Coastal Fisheries and Aquaculture (Balit Kantor), Maros, South Sulawesi. Tel: 62-0411-373618, e-mail: rsyah@indosat.net.id

Jamaluddin Jompa, Vice Director, Center for Coral Reef Studies (CCRS) of Marine Science Department, Hasanuddin University, Makassar, South Sulawesi. Tel: 62-04110584356, 62-8124230107, e-mail: jjompa@indosat.net.id

Magdalena Littay, Marine Biologist, Marine Science Department, Hasanuddin University, Makassar, South Sulawesi

Willem Moka, Coral Reefs Information and Training Centre (CRITC), Hasanuddin University, Makassar, South Sulawesi. Tel: 62-0411-584356, e-mail: pstkuh@indosat.net.id

Ir Rahmat Ibrahim, Head, Fisheries Department of South Sulawesi (Dinas Perikanan), Makassar, South Sulawesi. Tel: 62-0411-873680, e-mail: rahmatibrahim@telkom.net

Ridman Simangjah, Head, private grouper cage farm, Lampung Province, South Sumatera. Tel: 62-0811-948488, 62-0816-802976, e-mail: simr@mweb.co.id

Ir Haruna Hamal, Head, Brackishwater Aquaculture Development Institute (BBAP), Galesong, Takalar Province, South Sulawesi. Tel: 62-0411-320730

Leidman, Shrimp Specialist, Brackishwater Aquaculture Development Institute (BBAP), Galesong, Takalar Province, South Sulawesi. Tel: 62-08124261256

Dr Djusdil Akrim, Quality Control Manager, Bantimurung Indah, Seaweed Processing Plant, Maros, South Sulawesi. Tel: 62-0411-371152, 444444

Marine Aquarium Council (MAC), Elizabeth Woods

Bill and Elshinta Marsden, Technical Adviser and Head, Yayasan Laut Lestari, Manado, North Sulawesi. Tel: 62-0811196521, e-mail: fish@ikann.org, http://www.ikann.org

Ian Dutton, Indonesian Director, The Nature Conservancy (TNC), Jakarta. Tel: 62-02107817040, e-mail: crmp@cbn.net.id

Silvianita, Indonesian Coral Reef Foundation (TERANGI), Jakarta. Tel: 62-021-71792886, http://www.terangi.or.id

Dino Trakakis, Commercial live reef fish exporter, Jakarta. Tel: 62-021-4531628, 62-8111-00095, e-mail: indofisheries@aol.com

Yenny Christiang, Pusat Pendidikan Lingkungan Hidup (PPLH-Puntondo), South Sulawesi. Tel: 62-0411-858202, e-mail: pplhsuls@indosat.net.id

Adhi Goenarso, General Manager, PT. Sulawesi Agro Utama, Makassar, South Sulawesi. Tel: 62-0411-319598, 321598

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The STREAM Initiative
Network of Aquaculture Centres in Asia-Pacific (NACA)
Suraswadi Bldg, DOF Complex
Kasetsart University Campus
Ladyao, Jatujak
Bangkok 10900 Thailand

Tel +66-2-940-5457
Fax +66-2-561-1727
Switchboard +66-2-561-1728-9 ext 108
E-mail ghaylor@loxinfo.co.th
Website http://www.streaminitiative.org

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Annex 2

MARICULTURE AS A SUSTAINABLE LIVELIHOOD STRATEGY IN SUPPORT OF CONSERVATION AND MANAGEMENT – A CASE STUDY OF KOMODO NATIONAL PARK, INDONESIA

IMPROVING COASTAL LIVELIHOODS THROUGH SUSTAINABLE AQUACULTURE PRACTICES

A Report to the Collaborative APEC Grouper Research and Development Network (FWG/01/2001)

Lida Pet-Soede, Ecosafe Consultants, Bali, Indonesia

2003

CONTENTS

FOREWORD

This report was prepared for STREAM, a NACA initiative, and aims to present a case study illustrating the benefits of establishing alternative livelihood programs, particularly related to mariculture, for conservation purposes. In their approach, The Nature Conservancy, partnering with Komodo National Park authorities, has integrated alternative livelihoods into the conservation strategy from the early start of their Komodo program in 1995. Komodo National Park represents one of few Marine Protected Areas (MPAs) in Southeast Asia where conservation at-scale is being achieved, where serious action is taken successfully to abate destructive fishing practices and other serious threats to the reefs, and mariculture activities form an important component in providing alternative livelihoods for park inhabitants. Technical expertise on aquaculture is combined with substantial biological, ecological and conservation expertise towards low-impact mariculture activities. A large amount and variety of information on technical and economic feasibility, and on perceptions from stakeholders, is available.

The author acted as an editor in utilizing and summarizing the vast amount of information that is available from the PHKA/TNC Komodo program. Credits and authorship must thus be granted to the entire collaborative team of PHKA and TNC. Dr P J Mous of The Nature Conservancy provided valuable comments in his review of the report. Sources used in this report can all be downloaded from www.komodonationalpark.org

Finally, as pointed out by Frank Vorhies of IUCN during long talks about the business of biodiversity, we should consider to stop using the phrase Alternative Sustainable Livelihoods or Alternative Income Generating Schemes. Destructive methods and over-fishing practices are by definition not sustainable, even while they may appear to provide benefits to many people over a relatively long period of time; this is merely the result of expanding collection areas into previously un-fished grounds. Thus, the word “alternative” could be left out and discussing Sustainable Livelihoods and Sustainable Income Generating schemes may help conservationists and fishers reach common understanding of what it is that management and regulation aims to achieve: sustainable exploitation and livelihoods under protection of biodiversity and ecologically-functional sites.

Lida Pet-Soede
March 2003

EXECUTIVE SUMMARY

Together with the Indonesian Park Authority (PHKA), The Nature Conservancy has been working in Komodo National Park since 1995 to establish a marine reserve that 1) ensures long-term protection of the natural community structure, habitat and species of the coastal and marine ecosystems within and around Komodo National Park, and 2) protects a portion of the exploited reef fish stock to enhance fisheries in the traditional use zones inside the Park and in the waters surrounding the Park. This would protect and safeguard the marine biodiversity in the Park as a source of recruits for surrounding fishing grounds. One of the facilitating approaches to minimize pressure on the reef and demersal resources of KNP is the alternative livelihood program. Since 1997, TNC and PHKA conducted studies and developed facilities in support of production of grouper fingerlings. The aim is to provide these fingerlings to local communities for grow-out to marketable size. This project was created for two important reasons: to provide sustainable fish culture as an alternative to non-sustainable fishing practices in and around KNP, and to transform part of the Indo-Pacific capture-based (unsustainable) grouper fishery into a culture-based (sustainable) grouper trade. The other mariculture project component comprises seaweed culture. Furthermore, TNC/PHKA implements alternative livelihood projects in eco-tourism and offshore fisheries. These other projects are not discussed here.

Key characteristics of the fish mariculture project in KNP are the context of Marine Protected Area management and the full-cycle operation, which includes a local hatchery for fingerling production. Technical difficulties that have occurred along the way include collecting a healthy brood stock and providing sufficient food of good quality to maintain health. Furthermore, other difficulties were experienced in guiding the perception that these activities were initiated in support of KNP management, rather than for enrichment of some selected business entrepreneurs. Continued education and enhanced awareness of these issues have increased local understanding of the mariculture project, which is now instrumental in building an increasing constituency for management of KNP.

This case study aims to illustrate that mariculture activities could contribute greatly to conservation purposes and more sustainable use of natural resources. Thus mariculture can play an important role responding to dwindling natural fish stocks, through generating alternative incomes rather than through generating alternative sources of protein. When embedded in a comprehensive and integrated Marine Protected Area strategy, such as is the case in Komodo National Park, mariculture can greatly enhance local understanding and support for the need to protect certain parts of the marine and coastal environment to prevent further and imminent collapse of fisheries and related coastal communities' livelihoods. This point should be carried forward and put in the right policy and institutional context as a highly beneficiary impact of mariculture.

More attention should be directed to share the lessons learned within this context to educate policy-makers. The perception needs to shift from viewing mariculture as an opportunity to produce more fish, towards viewing it as an opportunity to support livelihoods, integrated with comprehensive Marine Protected Area management. Thus, mariculture, when designed to allow for low ecological impact and maximum community involvement and benefits, can contribute to turning the tide of dwindling stocks and collapsing community livelihoods.

1. INTRODUCTION

Throughout the world, it has been shown that fisheries management approaches such as restricting fishing effort through licensing; setting quotas and influencing catching efficiency through alternative fishing gear are extremely difficult to enforce and thus result in little reduction of pressure on fish stocks. Failure of these traditional fisheries management strategies is often used to make a case for producing fish protein through mariculture. However, rather then abandoning the need to better managed capture fisheries and direct all resources to start producing fish from culture, mariculture should be integrated with the fisheries management tool of choice: Marine Protected Area (MPA) management.

Confirmed by recent publications, for example, by the American Fisheries Society (Coleman et al., 2001), the most successful strategy is true enforcement of no-take zones in a network of MPAs. The location of these must be carefully selected to allow for maximum fish reproduction capacity and optimum functional larval dispersal. Also, site selection considerations need to include criteria of resilience against natural phenomena and climate change. Redirecting resources and technical assistance to establish selection and true implementation of a network of Marine Protected Areas with no-take zones would be a first requirement to safeguard part of the world's fish and marine biodiversity and some part of the fish reproductive biomass. It has been proven that through these processes marine reserves aid fisheries (Roberts et al., 2001).

Critics continue to debate the ecological function of MPAs but forget that for Indonesia, none of the officially recognized MPAs is fully implemented as of yet, and failure in producing hard evidence of stabilized reef conditions and fish populations is merely the result of limited capacity, either technical or financial, to run an integrated management program for the existing MPAs. Furthermore, there are few that encompass absolute no-take zones of scale. In Indonesia, MPAs are still regarded as an opportunity to raise tourism revenue rather than a way to "put money in the bank" for safeguarding ecosystems from collapse. Zonation plans more often reflect compromises between economic stakes than sound ecologically-based site selection to serve source and sink functions. Also, many conservation groups shy away from direct support for law enforcement or working with communities that create the problems. Rather, less confrontational approaches are taken. Often, participation in alternative income generating (AIG) schemes does not even require firm commitments from the actual "wrong-doers" to quit destructive fishing or leave alone particular areas or species. Evidence of conservation successes is hard to produce unless a fully integrated approach is taken that combines serious no-take-zone management with alternative capture methods, AIG schemes, education, awareness and implementation of collaborative responsibility schemes.

For Komodo, such an integrated approach has been designed and implemented since 1996 by the Komodo Park Authority aided by The Nature Conservancy (TNC). TNC is a USA-based environmental organization, whose mission is to preserve plants and natural communities that represent life on Earth by protecting the land and waters they need to survive. Together with the Indonesian Park Authority (PHKA), TNC has been working in KNP to establish a marine reserve that 1) ensures long-term protection of the natural community structure, habitat and species of the coastal and marine ecosystems within and around Komodo National Park, and 2) protects a portion of the exploited reef fish stock to enhance fisheries in the traditional use zones inside the Park and in the waters surrounding the Park (Meyer and Mous, 2002). This would protect and safeguard the marine biodiversity in the Park as a source of recruits for

surrounding fishing grounds. To obtain this goal, both parties identified some key issues to work on and the full details of the work plan are contained in "25 Year Master Plan for Management Komodo National Park Book 1: Management Plan" (PKA and TNC, 2000). This management plan describes strategies to achieve the main targets of protection, conservation, resource use, education, and an improved management system in a context appropriate for local socio-economic and cultural conditions. In the management plan, TNC and PHKA point out key components for consideration: management of natural resources, borders and zonation, legal issues and law enforcement, tourism, constituency-building and participatory planning, community development and alternative livelihoods, capacity-strengthening and training, management of park administration and infrastructure, and park finance (See also Appendix A).

The Komodo National Park (KNP) provides a case example where mariculture activities are integrated with Marine Protected Area (MPA) management. With this conservation purpose, it differs from generic coastal community economic development activities and it also puts the activities in a different institutional and policy framework: that of the Indonesian Protected Areas, administratively captured under the Indonesian Ministry of Forestry and Conservation. Another key characteristic is the full production cycle approach, including establishment of a local hatchery that produces fingerlings from local brood stock. Primary reasons for this are to prevent placing further full-cycle pressure on wild stocks and local brood stock prevention of diseases and genetic pollution.

Within the Komodo MPA context, the mariculture activities are mostly intended to contribute to enhanced management success by facilitating a transition towards sustainable activities for some of the coastal communities who obtain part of their income from unsustainable fishing techniques. Additionally, the strategy aims to provide a cultured source of high-valued fish from Indonesia for the Hong Kong-based life reef fish trade, the Indonesian supply for which presently includes mainly wild captured fish.

The Komodo case analysis will particularly focus on issues related to the above-mentioned special characteristics, while also providing general project descriptions:

Institutional and Policy Context: Background on the institutional and policy framework is provided, including descriptions of the roles and responsibilities taken so far by the different groups engaged in the collaborative management for Komodo National Park.

Local Inhabitant Livelihood Context: Background to the economic and social importance of sustaining livelihoods for park inhabitants who depend on natural resources is provided, including descriptions of current resource use and impacts of park management strategies.

Technical, Operational, Marketing and Financial Context: Background to the specifics of the mariculture activities is provided, including descriptions of the hatchery set-up, lessons learned and the status of the project in achieving objectives.

Communication and Outreach Context: Background to the position of the mariculture project within the overall protected area management strategy is provided, including descriptions of community-involvement in management, yet also providing recommendations for targeting a wider audience to enhance understanding of meaningful mariculture development in achieving conservation and sustainable livelihood objectives.

2. INSTITUTIONAL AND POLICY CONTEXT

It must be understood that while the Park was established to protect the unique Komodo Dragon, its marine richness and geographic and oceanographic position now mean that marine and coastal conservation in KNP serves a larger than local purpose only. While there is evidence of high levels of endemism, the large water masses flowing through the narrow straits separating KNP from Flores and Sumbawa, indicate that larval dispersal may serve reefs and fish populations in a wider area than Komodo alone. Further, the frequent occurrence of large migratory marine life also indicates the area's regional importance (Kahn, 2002). Thus, aside from local management objectives, management of Komodo National Park will also have a positive impact on regional conservation objectives. As such, the alternative livelihood projects that have been initiated do not just serve the purpose of facilitating adjustment of local communities to management regulations; it is focused to enhance success of KNP management. A lot of effort has been invested in the selection of livelihoods and in establishing a solid basis, both ecologically and economically, to make them work. Once the technical shortfalls are solved and the economic foundation is solid, the intention is also to manage the fish mariculture project[1] in collaboration with various partners from the private sector and communities.

Collaborative management is chosen to achieve conservation in KNP; yet where capacity of partners is still limited, the park authority continues to carry the mandate. This approach must be seen in the recent, incomplete, Indonesian trend of transition of shared responsibilities for management of resources. Where capabilities of other groups are sufficient, they may take on partial roles and responsibilities (see Appendix B), yet it is clear that there will always remain particular roles that need to stay with park authorities. National parks within Indonesia are national assets serving functions to the entire Indonesian society and even for Southeast Asia. Responsibilities that likely must stay with the central government are, for example, the design of national policy and law enforcement. Policy against use of such destructive fishing practices as bombs and cyanide, now made official in a 1991 Directorate General Decree, is an example of this (See also Appendix C).

In Komodo National Park (KNP), both blast fishing and cyanide fishing were common before the management of the park was intensified (Pet, 1999). Based on information from rapid rural appraisals, ecological assessments and fisheries studies conducted in the area, it was clear that the threat of illegal destructive fishing methods was the first major problem that needed to be addressed to protect the marine habitats of KNP. It was therefore decided to form a cross-sectoral enforcement team in which park authority, police, army and local governments work together to carry out a routine patrolling program, monitoring all fisheries activities in the park.

The routine patrolling program started on 28 May 1996. Patrols took place almost on a weekly basis but the frequency dropped to an average of only 1.5 patrols per month in 1997. The incidence of dynamite and cyanide fishing dropped significantly during the first period of intensive patrolling in 1996 (Pet, 1999). The routine patrolling program has led to several arrests of fishermen using destructive fishing methods in and around the park. A reduction of

[1] It must be noted that aside from developing mariculture of fish, seaweed culture also falls under the mariculture program (See Appendix E).

more than 75% was recorded for dynamite incidents. Developments in 1997, however, showed that the routine patrolling program should be kept up to prevent a return of destructive fishing, especially cyanide fishing for aquarium fish and for lobster, live groupers and Napoleon Wrasse. Recent monitoring data on the status of the reef habitat in Komodo National Park indicate a significant increase of live coral cover from 1996 to now (Pet and Mous, 1998, with 2000 update). For every 16-m^2 live coral cover in 1996 there was 21 m^2 of live coral cover in 2000. There are few sites in the world that can boast such improvement, especially considering the devastating impacts of the 1998 coral bleaching event that caused serious deterioration of reefs throughout the world (Cesar et al., 2003).

Komodo Field Office and PHPA staff were trained to record data on resource utilization patterns during routine patrols to determine who is doing what, where and when in the Park[2]. Continued over time, these data will also show any changes in the behavior of fishermen due to management measures and indicate which groups of fishermen or areas in the Park need extra attention. Management responses already included:

- Designing of zonation and regulations in such a way that objectives can be achieved with a minimum of conflict with local resource users
- Determining which fishing groups pose threats to the Park and should therefore be targeted by enforcement programs and alternative livelihood projects, and
- Determining which type of fishing activities are particularly threatening and should be prohibited in the Park.

[2] This is in a situation preceding any implementation of marine zonation or regulations other than a ban on dynamite and cyanide fishing.

3. LOCAL INHABITANT LIVELIHOOD CONTEXT

Generally, establishing MPAs with no-take zones and regulation of activities in use zones implies regulating the level and type of resource extraction. This will affect some people that now live in an MPA, and in the short term, may affect the amount and type of products that come from an MPA. However – and this is important to note and supported by emerging strong scientific evidence – rather than MPAs being blamed for reducing fish productivity, they are the tools of choice for protecting fisheries against total collapse. Currently, some misperception exists, claiming that MPAs impact negatively on Government of Indonesia (GOI) intentions to produce vast amounts of fish and other marine products for the national economy and its society's benefits. Fortunately, senior staff members of the newly-formed Ministry of Fisheries and Marine Affairs in Indonesia understand well that it is actually the other way around: that without safeguarding parts of Indonesia's fishery stocks, the entire coastal fishery is doomed to collapse, leaving coastal communities in poverty. Regardless of the above facts, there is an employment issue related to MPA management implementation and to facilitating behavior change for sustained livelihoods for communities depending on resources in an MPA. Alternative livelihood generation is often initiated, thus enhancing the success of management schemes that include no-take zones and gear regulation.

In KNP, there are presently almost 3,300 inhabitants spread out over four settlements (Komodo, Rinca, Kerora and Papagaran). All villages existed prior to 1980 before the area was declared a national park. In 1928, there were only 30 people living in Komodo Village, and some 250 people on Rinca in 1930. The population increased rapidly, and by 1999, there were 1,169 people on Komodo, meaning an exponential growth. Nearly 17,000 people live in fishing villages directly surrounding the Park. Regular monitoring of resource utilization patterns within the park, combined with village interviews, indicate that Park inhabitants mainly derive their income from a pelagic lift-net fishery targeting squid and small pelagic fish, which does not threaten the coral reef resources of the Park. This fact provided a good scope for protection of the coral reefs in the area in cooperation with local communities (Bakar, 1996). The *bagan* fishery of local communities did need protection against over-fishing so that this advantage would not be lost through collapse of stocks of small pelagics. Non-*bagan* yields represent only some 5% in terms of weight of the total yield (*bagan* + non-*bagan*) landed by park inhabitants (Komodo and Rinca). Fishermen commented that non-*bagan* activities are still important to them, since middlemen exploit the *bagan* fishery, which leaves little of the profits for local fishermen (Bakar, 1996). Freeing the fishermen from these middlemen may be an important strategy in keeping them from destroying the reefs.

Several surrounding communities were involved in fishing with cyanide and other destructive methods and were over-fishing the fish and invertebrate stocks in the Park. The most important conclusion from the monitoring of utilization patterns was perhaps that the resources in KNP were most seriously threatened by outside communities from Sape, South Flores and Sulawesi. The most important threat to the coral reef ecosystem was, in the early years, still the use of hookah compressors and it was therefore addressed immediately. Shellfish such as abalone and pearl oysters were caught with compressors and by reef gleaning, both destructive methods. The same holds true for sea cucumber, whereas lobster were almost entirely caught by compressor fishing. KNP could not allow the compressor fishing to continue and park authorities and TNC have managed to implement a local ban on hookah compressor use through establishment of local legislation. Park inhabitants and

surrounding communities were little affected by this compressor ban since this was a minor activity for these communities, except perhaps for inhabitants of Pulau Mesa located just outside the Park. Although compressor activity was anyway already reducing for Pulau Mesa, the compressor fishers from this community had to be helped to change their practice and this community was engaged firstly in the alternative livelihood programs.

Further, resource utilization monitoring showed that the main yield category from non-lift-net activities in KNP was fish (almost 95%), mostly caught by gillnets and by trolling and bottom hook and lines. Demersal trolling lines or *kedo kedo* were wiping out the coral trout stocks, bottom hook and lines took all predators and bottom long lines were decimating the sharks and large groupers. These gear types formed considerable threats to the demersal and sedentary fish stocks in the Park, and gillnetting had to be banned from the National Park as soon as possible. Heavy hook and line fishing by outside fishers from Sape focused around the grouper spawning aggregation sites, which aggravated the situation. Large amounts of spilled nylon fishing line were encountered at fish spawning aggregation sites and certain species like *Plectropomus areolatus* were decimated before actual spawning took place. In a concentrated effort, park authorities and TNC managed to establish fishing bans at sites where groupers and Napoleon Wrasse were known to aggregate for spawning. Population characteristics are being continuously monitored in a routine fish spawning aggregation site (SPAGS) monitoring program[3]. Also, total demersal fishing effort in the Park was greatly reduced through establishing no-fishing zones at all reefs. Communities affected by both measures were then also engaged in alternative livelihood programs.

While no specific household economics are available for local fishers who have been impacted mostly by the improved management of KNP – the blast and cyanide fishers – estimates of these incomes from other areas indicate that especially blast fishing is not of extreme high individual profitability (Pet-Soede et al., 1999). The large-scale live grouper wild-capture fishery provides a different picture with high individual profitability (Pet-Soede, unpublished). Thus, even when farming of grouper was going to be successful at the level of local communities, wild-capture still provided an attractive financial incentive for fishers, and strict enforcement against use of illegal substances such as cyanide remained necessary. When successfully implemented, enforcement could shift the financial balance (now including costs related to increased risk of arrests and penalty in court) more positively towards the farming of grouper rather than wild-capture (Appendix D).

[3] Monitoring methods first designed with help of Lyle Squire, and improved by TNC in their routine monitoring program, are being used for training of partner groups at other sites including Bunaken National Park in north Sulawesi (reports at www.komodonationalpark.org), at Karimunjawa National Park in Java, and at Pohnpei (Pet et al., 2001)

4. TECHNICAL, OPERATIONAL, MARKETING AND FINANCIAL CONTEXT

The region-wide preference to develop live food fish businesses is fuelled by the high demand for live fish (mostly grouper and Napoleon Wrasse) from the Southeast Asian regional business centers of Hong Kong, Singapore, Japan and mainland China. Growth and reproductive biology characteristics of the most wanted species, combined with high levels of fishing pressure on these fish stocks (Mous et al., 2000), means that this high demand cannot be continuously fulfilled from operations that depend on fishing in the wild. Yet, mariculture development requires investments in appropriate technology and infrastructure, and live food fish industry members are not really lining up to provide such investments.

Perceptions of live food fish industry members (82 middlemen and 92 fishermen) on mariculture of the disappearing target fish were assessed in five provinces around Indonesia: Southeast Sulawesi, South Sulawesi, East Nusa Tenggara, West Nusa Tenggara and Lampung (Halim, 2002). Some 41% of the middlemen and 50% of fishermen had noticed that the abundance of wild grouper is decreasing and most of the people interviewed see mariculture as a solution. Some 95% of the middlemen claimed that they are ready to start grouper mariculture business, while 74% of the fishers would be ready to join if they had the assurance that this would be as profitable as capture in the wild. One important issue identified by Halim as key to adoption of mariculture activities relates to the time delay that exists because fish needs considerable time to grow to marketable size. Further, it was mentioned that skills and knowledge required for grow-out of grouper fingerlings need to be enhanced through well-directed training and capacity-building activities.

To support this and to overcome initial lack of interest by business members in investing in development of mariculture, and to allow for learning about best practices, TNC has taken the leading role of investing in the initial phases of establishing multi-species reef fish mariculture. Technical expertise is brought to the project through partnerships with Gondol Research Institute (Bali, Indonesia), the Department of Primary Industries (Queensland, Australia) and the Network of Aquaculture Centers in Asia-Pacific (NACA, Bangkok, Thailand) (Meyer and Mous, 2002).

Starting in 1997, a method to obtain fingerlings from the wild was tested in the Komodo area with the assistance of consultants from the Philippines (Mous et al., 1999). This method, *gango*, has already been used extensively in the Philippines. After one year of field trials, it was concluded that *gango* puts an additional fishing pressure on the wild stocks, both those of grouper and non-target fish. Therefore it was decided not to implement *gango*, but to produce fingerlings from captive brood stock (Meyer and Mous, 2002). This required establishment of a hatchery to produce fingerlings for grow-out by communities.

The next phase of the mariculture project included technical surveys, consultation with experts, development of partnerships, and development of a business plan for a hatchery and grow-out industry in the Komodo area. Identified by fish culture consultants in 1997, important strengths of the Komodo area included:

- It offers considerable potential for a wide range of marine farming enterprises.
- It is relatively unique in a number of mariculture attributes.

- It has a low annual rainfall (100 cm) that is confined to two months of the year.
- It is not in a typhoon area.
- It consists of a series of islands with virtually no land run-off and hence stable water quality.
- It has a large number of both deep water and shallow sheltered sites, suitable for mariculture.
- It has a number of sites suitable for establishment of a marine hatchery.
- It has an existing live fish trade.
- It has an extensive fishing community with associated knowledge and infrastructure.
- It has a good local source of breeding stock.
- It will implement exclusive use rights in multiple-use zones for local communities, and
- It has local expertise in holding and raising wild-caught fish in floating cages.

Based upon these recommendations, TNC established 2.4 tons of brood stock in fish cages near the proposed hatchery site. A one-year development project was implemented, aiming to establish the hatchery, develop a steady production of larvae, achieve good survival and growth rates of larvae, and train local staff in hatchery practices. Basic environmental impact assessments (EIA) have been carried out (UKL/UPL), as required under Indonesian law, and were approved by the District Planning Agency (BAPPEDALDA). The approval was followed by a letter of recommendation of the *Bupati* (District Head) of Manggarai District (Meyer and Mous, 2002). This phase was concluded successfully in late 2000, when fishes in the broodstock were shown to spawn spontaneously in the holding cage facility.

Throughout this period, preparations for construction of the land-based hatchery were conducted. Land was donated for this purpose by the Tahija Foundation and, based on the Strategy and Action Plan of 2001 (TNC, 2001), blueprints for construction were prepared. Construction started in April 2002 and the hatchery is now almost completed. Once the hatchery is producing fingerlings, local communities can become involved in grow-out. Four grow-out units have been planned, each consisting of a complex of 16 floating cages, varying in size between 9 and 25 m^2 surface area. These facilities would aim to produce 25 tons/year per grow-out unit over 3-4 harvests for their first try-out year. Grow-out is prepared for Estuary Grouper *(Epinephelus coioides)*, Mouse Grouper *(Cromileptes altivelis)*, Tiger Grouper *(Epinephelus fuscoguttatus)*, Seabass *(Lates calcarifer)* and Mangrove Jack *(Lutjanus argentimaculatus)* (Meyer and Mous, 2002). This multi-species approach reduces risks related to species-specific vulnerability to disease and to fluctuation in consumer preference and price. The species composition of the first batch of fingerlings depends on hatchery practicalities, as this batch will be used for training in grow-out in village-based fish farms rather than for the generation of revenue. The grow-out process takes 11-22 months depending on species, until the fish reaches 0.5 kg of weight.

In anticipation of the grow-out phase, where local villagers will be employed at the mariculture project to learn necessary skills, villagers have visited the broodstock facilities and posters have been distributed that explain the concept behind the project. Eventually, the enterprise plans to collect larger quantities of grown-out fish to sell to fish trading companies

(already visiting the area with live fish transport vessels). As soon as production of fingerlings and grow-out are feasible and economically viable, final steps will include identification of business partners to take over the enterprise. Local communities will be supported to take over the grow-out enterprises and establish business relationships with the mariculture enterprise. Systems of controls, checks and balances will be put in place to ensure responsible and sustainable development. A franchising system is presently under consideration. A carrying capacity analysis will be conducted to determine the optimal production capacity, and the project will be handed over to another group under the condition that "best practices" will be adhered to. This group may be a fishery cooperative or a local business partner.

Under conditions of best practices, the project may still not provide similarly large financial incentives to the live reef fish trade. As indicated by Halim (2002), the profitability for fishers and middlemen is thought to influence the extent to which mariculture of groupers can replace the wild-caught grouper trade. Investments to maintain the hatchery are too high to be carried by local fishermen, yet as explained earlier, local supply of good quality fingerlings produced in a hatchery is of key importance:

- It allows application of best practices for fish production.
- It prevents capture of wild-stock juveniles through providing a steady stream of high-quality fingerlings in firmly set supplier-community relations.
- It prevents introduction of diseases and genetic pollution through introduction of "foreign" DNA .
- It provides a good opportunity for control of the entire production cycle with even potential positive benefits of certification of the production process.

An expert team provided a first assessment of the economic viability. The recommended business plan envisages that Seabass and Estuary Grouper would be used to get experience with hatchery techniques during the start-up phase of the project, after which the focus will be changed to Mouse Grouper, which is more profitable, but its culture also poses more technical challenges. The business plan concluded that to start up a hatchery-based grow-out enterprise in two years, with a capacity of 27 tons/year, capital requirements amount to US$ 280,000. Operational costs in the first three years would amount to US$ 460,000, and the enterprise would break even after five years. After the facility is fully operational, annual profits would amount to US$ 435,000.

To measure the profit for fishermen is not easy. Their need for instant cash cannot be filled with future higher incomes (Halim, 2002). While issues related to the delay in receiving first revenue for grow-out must be dealt with in some way, the total profitability of this alternative will depend on whether or not there is a market for cultured groupers. Blind taste tests conducted by TNC years ago in Hong Kong indicate that little difference was experienced between wild-caught and cultured grouper, yet the market for live grouper is largely based upon the fact that target species are somewhat elusive and rare. Farmed grouper will then be less appealing to consumers who wish to experience a rare treat.

5. COMMUNICATION AND OUTREACH CONTEXT

As indicated above, one of the facilitating approaches to minimize pressure on the reef and demersal resources of KNP is the alternative livelihood program (Widodo, 2002). Aside from the mariculture project, two other major projects have been initiated so far in coordination with local communities. One is to enhance opportunities for fishers to engage in sustainable pelagic fisheries (Halim and Mous, 2000). Before the alternative livelihood program started, most pelagic fisheries focused on squid and a large variety of highly abundant pelagics – such as Spanish mackerel, yellow-fin tuna, skipjack, anchovies, sardines, sprats, Indian mackerels, and scads – provided a high-price potential that was hardly exploited. One important step to enhance the productivity was to place several Fish Aggregating Devices (FADs) around KNP. This pulls fishers away from the reefs, reducing the pressure there, and results in fairly-efficient pelagic fish catches as these aggregate near the FADs. Further, TNC and PHKA, together with fishermen groups and local fish traders, are also working on post-harvesting practices, fish processing techniques and marketing of large pelagic fish. Training aims to produce a variety of high-quality products such as dried-salted, salt-boiled, *katsuobushi* and spiced-dried. A new demand for frozen fish such as tunas is also coming up and the building of an ice plant or freezing facility is being considered.

Another component of the livelihood program focuses on eco-tourism activities. Studies in 2002 resulted in an inventory of other alternative livelihood opportunities proposed by local communities. The list of options identified by the communities includes carving, weaving, making cake and pastry, sewing and embroidery, with names of people that are interested in each activity. These activities would support eco-tourism activities in KNP, as visitors will seek specific handicrafts from KNP. Together with local NGOs, TNC and PHKA are empowering local communities, especially women, to enhance skills required to conduct these new activities. The training also aims to enhance general understanding on conservation issues, so that the output of the alternative livelihood program will be thorough.

All alternative livelihood projects create opportunities to engage in education and awareness-building with local communities and private sector industry on best practices and ecological and economic sustainability in relation to a well-managed KNP. As at most other MPA locations in Indonesia, a major misunderstanding hampers successful implementation of protected areas and this is with the role of MPAs for fisheries management. Scientific evidence of the supportive role of MPAs for protection of fisheries livelihoods from total collapse are not easily translated or explained to local communities and the private sector, who most often think in a short time-span forced by relative poverty or disinterest in a sustained level of natural resources. Even when scientific evidence is presented graphically (for example in Appendix F), local stakeholders are wary of the short-term impacts of zonation plans and management plans. To enhance understanding of the role of conservation in protecting livelihoods, park authorities and TNC engage in education and outreach activities. For this purpose, a series of films, booklets and school kits have been designed. Further, stakeholder meetings are frequently held to explain to concerned villagers and to invite constructive input to share responsibility over sustained resources in and around KNP. The alternative livelihood engagement of local communities and the private sector further enhances a local constituency for park management.

Additionally, while the experience in the KNP mariculture project shows that full-cycle farming of some high-valued reef fish is possible, there is urgent need for guidance on best practices in mariculture throughout Indonesia. For many species, technology and knowledge is still lacking for full-cycle farming and any license or other support to set up other high-value grouper fish farms in Indonesia must be regarded with utmost care as the business may actually engage in grow-out of wild-caught animals, rather than in full-cycle farming, and thus continue to exert pressure on the reef fish populations (Sadovy and Pet, 1998). Understanding of the ecology and biology of fishing and fish farming or fish rearing is limited at the Indonesian management level. While this must be urgently enhanced through well-directed training and awareness campaigns at national policy and regional administrative levels, a limited policy should be considered in the case of issuing of mariculture licenses.

Finally, and following trends in consumer preferences towards sustainable produced fish, mariculture development would benefit from certification schemes that provide additional marketing value to fish produced under best practice conditions. Awareness and outreach campaign activities could thus enhance support for mariculture and transformation of unsustainable wild-capture of target species.

6. CLOSING REMARKS

It is proven around the world that the production of fish through mariculture is technically viable. Under conditions of ample funding and expertise – such as in this case study – mariculture activities could contribute greatly to conservation purposes and more sustainable use of natural resources. Thus mariculture can play an important role in responding to dwindling natural fish stocks by enhancing MPA management results.

When embedded in a comprehensive and integrated Marine Protected Area strategy such as in Komodo National Park, mariculture can greatly enhance local understanding and support for the need to protect certain parts of the marine and coastal environment to prevent further and imminent collapse of fisheries and related coastal communities' livelihoods. This point should be carried forward and put in the right policy and institutional context as a highly beneficial impact of mariculture.

More attention should be directed to share lessons learned within this context to educate policy-makers. There should be a shift from the perception of a need for producing more fish, towards the understanding that mariculture, when well-designed to allow for low ecological impact and create maximum community involvement and benefits, can contribute to turning the tide of dwindling stocks and collapsing community livelihoods.

Additionally, and preferably in the form of certification and eco-labeling schemes, marketing strategies should be initiated to increase awareness of the need for management and transformation of fisheries and to increase the demand for sustainable cultured fish. This would provide local communities with a real incentive to change behavior.

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APPENDIX A SUMMARY OF 25-YEAR MANAGEMENT PLAN COMPONENTS FROM BOOK 1

(downloadable from www.komodonationalpark.org)

Management: The master plan identifies two components for resource management: 1) Co-management with the Provincial Government and Local Communities, and 2) Adaptive Management. For co-management, a new structure that includes a Collaborative Management Board, Collaborative Tourism Council, and Community Stakeholder Board is recommended. This type of management emphasizes a bigger role for the district governments in Manggarai and Bima, as these districts are the gate entries to the Park. For Adaptive Management, a process that is based on new information from the field is described, including recommendations on data collection methodology and a schedule.

Borders and Zonation: The KNP was declared as a national park in 1980 with total area of 1,817 km^2. In the 25-year management plan, an additional 504 km^2 is proposed based on a rapid ecological assessment, which noted that there are still places that contain high diversity of fish and coral outside the existing borders and also that there is need for a buffer zone. As for zonation, a new design was proposed based on ecological data, current understanding of ecological and conservation principles, socio-economic and cultural needs of the local communities, and feasibility. It contains zones called Core, Wilderness, Tourism Use, Traditional Use, Pelagic Use, Special Research and Training, and Traditional Settlement. The detailed descriptions and permitted and prohibited activities are listed.

Legal Issues and Law Enforcement: TNC and PHKA collated legal regulations dating from 1915 to the present that relate to KNP establishment. Overlapping jurisdictions, such as the right to give fishing permission and loopholes, were identified and both parties allowed five years to evaluate the issues. Meanwhile, for implementing the day-to-day legal obligations and law enforcement, the capacity of park rangers is strengthened and facilitation of patrol is provided.

Tourism: TNC and PHKA have designed an eco-tourism concept with all stakeholders, especially the private sector, local dive operators and tourist guides. Eco-tourism activities vary from watching the famous Komodo Dragon and savanna, to marine activities like diving or fishing with special permits. The strategies for eco-tourism also define how to minimize negative impact on natural resources and local communities, while generating income for park financing.

Constituency-building and Participatory Planning: Aware of the complexity of ecological processes and competing natural resource uses, a management strategy that emphasizes constituency-building and participatory planning was designed. A coordination forum that includes local stakeholders is actively discussing and reviewing the sustainable establishment of KNP, including park enforcement, zonation and alternative livelihood opportunities. An environmental education and awareness program that will involve local communities, government, local NGOs, universities and mass media is included.

Community Development and Alternative Livelihoods: There are three target sectors identified with local communities: pelagic fisheries, mariculture and eco-tourism. In the

pelagic fisheries project, techniques are upgraded with Fish Attracting Devices (FADs), infrastructure is enhanced to maintain product quality, and training is given to enlarge variety of products. In the mariculture project, two types are developed: for food fish such as groupers, and for culture of seaweed. For the food fish project, a hatchery is developed and for seaweed culture, training was conducted and set-up facilitated. For the eco-tourism project, training of guides and operators is provided to raise awareness on conservation values of best tourism practices.

Capacity-strengthening and Training: A variety of targeted training courses are provided to enhance skills of KNP personnel. A work plan to improve management through education and training has been designed.

Management of Park Administration and Infrastructure: Recommendations for managing park administration and infrastructure are provided, including organizational structure, responsibilities for each staff position, personnel requirement, needs for restructuring of management and coordination, and development of facilities and infrastructure.

Park Finance: A tourism concession is recommended, aside from government subsidies.

APPENDIX B SUMMARY OF PROPOSED COLLABORATIVE MANAGEMENT STRUCTURE FOR KNP

(from fact-sheet "Collaborative Management Initiative in Komodo National Park", downloadable from www.komodonationalpark.org)

The goal is a well-managed self-sustaining park, i.e., effectively protecting the biodiversity in the park, enhancing fisheries around the park, maximizing benefits to local communities, and ensuring use of the park's resources for tourism and education in a sustainable way.

The Komodo National Park 25-year management plan was developed in association with extensive coral and fish monitoring programs, comprehensive community outreach and conservation awareness campaigns and sustainable livelihood activities, and a strong cross-sectoral patrolling and enforcement program. The implementation of the plan and the on-going conservation efforts will only be sustainable when these two critical constraints are addressed: 1) limited park management capacity, and 2) decline in the government budget to support Marine Protected Areas in Indonesia. It is difficult under present circumstances for one single agency to manage a large number of protected areas. Collaborative management strengthens effective management of protected areas and has become the accepted practice worldwide. A collaborative management initiative and a long-term financing plan have been developed to address the key constraints for professional and effective management of the Park.

Collaborative Management: Institutional-strengthening and Capacity-building

Komodo National Park is embarking on a collaborative management approach, involving all key stakeholder groups in the management of the protected area. These include the park authority (PHKA), local government, a joint venture between an international NGO (TNC) and a local tourism company (Jaytasha Putrindo Utama), as well as local communities, government agencies, and private sector organizations. A tri-partite collaborative management agreement between the joint venture, called *Putri Naga Komodo*, PHKA and the local government is being developed to strengthen the park's capacity in conservation management, monitoring and enforcement and sustainable livelihood activities, awareness programs and eco-tourism activities.

In the Proposed Collaborative Management Structure for KNP there is ample room for local communities and the private sector to engage in advising and decision-making processes.

Tourism Concession: Long-term Financing

The 25-year management plan establishes an Eco-tourism Concession with the goal of protecting the park's bio-diversity and generating revenue required for the park in a way that is environmentally sound, socially responsible and economically viable. While the collaborative management agreement provides the governance structure for the management of the park, the Tourism Concession will be responsible for financial management, investments in park infrastructure and marketing. A joint venture (JV) company *Putri Naga*

Komodo has been established to run the concession. The charter of the JV directs that any profits and revenues earned will be invested back into conservation. The rationale behind the agreement was based on a proven track record of each partner in investing in KNP, as well as complementarity between the conservation NGO and the tourism-oriented private sector company. This concept has been presented at various national and local meetings for government audiences, NGOs, the tourism sector and local communities. In addition, it has been presented at several international and national conferences and workshops to solicit feedback and comments.

A controlling shareholding in the concession ensures TNC's ability to fulfill its obligation to ensure the compatibility of all activities in the park. To ensure compliance with the collaborative management and concession agreements, bio-diversity conservation benchmarks will be evaluated regularly by the Government of Indonesia, public financial auditors and international organizations (such as IUCN and UNESCO).

Indonesian law requires that the concession include an Indonesian shareholder. To enhance the standard and the quality of visitation facilities, and the experience visitors have in the park, a joint venture company was formed between TNC and an Indonesian company with extensive tourism expertise and experience, which has been selected as a minority shareholder in the concession. It is expected that an enhanced visitor experience will justify increased user fees by foreign visitors to support protection of the park. At appropriate fee levels, the park is expected to achieve financial self-sustainability in 7-15 years. Incentive mechanisms are being developed to ensure the sustainable use and protection of the park's resources. Regulatory compliance systems will also be put in place and/or strengthened. As the concession terms are still under negotiation with the Ministry of Forestry, they are not yet publicly available. We can state unequivocally, however, that the terms and conditions explicitly state that, "the objective of the concession is to sustain the preservation of bio-diversity in the park by generating revenues based on eco-tourism activities and building on-site capacity". Shareholders will not, under any circumstances, make any financial gain from the company established for this purpose as stated in the JV articles of association. All revenue generated in and from the use of the park will be used specifically and only for management and conservation of the park, and to continue to fund existing local communities and government interests.

The Indonesian National Park Authorities under the Ministry of Forestry will have the full mandate over park management and enforcement activity. A micro-enterprise fund for local family-based businesses and a community development grant system will be developed to finance urgent welfare needs. No exclusive or preferential rights to any aspect of park entry or use will exist in any form, to anyone. Equal access to the park by all users is assured, subject only to total visitation numbers from all sources not exceeding a rigorous science-based assessment of the sustainable carrying capacity of the park. There will be no hotel or resort development in the national park and concession area.

This is a fundamental transformation in park management towards a more professional management system. The involvement of the public and tourism sectors and local communities will be assured through their on-going representation in the advisory council to the collaborative park management, consisting of three divisions: public sector, local communities living in and around the park, and the private tourism sector. This represents a groundbreaking policy experiment for the government of Indonesia and for management of protected areas in general.

APPENDIX C SUMMARY OF INDONESIAN LAWS ON THE SEA AND ITS RESOURCE EXPLOITATION

Legislation Relating to Commercial Marine and Coastal Fisheries

Legislation	Year	Description
Ministerial Decree (Agriculture) No. 607	1976	Areas for Catching Fish
Presidential Decree No. 39	1980	Abolishment of Trawl Nets
Ministerial Decree (Agriculture) No. 607	1978	First stage in Implementing the Abolishment of Trawl Nets
Ministerial Decree (Agriculture) No. 633	1980	Implementing Directive on the Abolishment of Trawl Nets
Act No. 4	1982	Basic Provisions for the Management of the Living Environment
Act No. 5	1983	Indonesian Exclusive Economic Zone
Act No. 9	1985	Fisheries
Ministerial Decree (Agriculture) No. 473a	1985	Determination of Total Allowable Fish Catch
Act No. 17	1985	Ratification of Principles of the Archipelagic Concept and United Nations Convention on the Law of the Sea (UNCLOS)
Presidential Decree No. 26	1986	Ratification of ASEAN Agreement on the Conservation of Nature and Natural Resources
Ministerial Decree (Agriculture) No. 417	1988	Utilization of the Fishery Resources in the Indonesian Exclusive Economic Zone
Act No. 5	1990	Conservation of Living Natural Resources and Their Ecosystems
Government Regulation No. 15	1990	Business in Fisheries
Presidential Decree No. 32	1990	Management of Protected Areas
Directorate General Decree No. 1k/220/d4.744/91k	1991	Catching Fish with Prohibited Substances/Instruments
Presidential Decree No. 23	1991	List of Business Fields Closed to Investment (Includes Utilization and Exploitation of Sponges)
Act No. 5	1994	Ban on Catching the Napoleon Wrasse Fish (*Cheilinus undulatus*)

Source: Llewellyn (2000, unpublished)

Legislation Relating to Marine Migratory Species

Legislation	Year	Description
Ministerial Decree (Agriculture) No. 35	1975	Protection for Several Types of Wild Animal (Dolphins)
Presidential Decree No. 43	1978	Ratification of Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)
Ministerial Decree (Agriculture) No. 327	1978	Protection of Several Types of Wild Animals (Whales, Dolphins, Crocodiles, Leatherback Turtle)
Ministerial Decree (Agriculture) No. 716	1980	Protection of Several Types of Wild Animals (Whales, and Grey, Olive and Loggerhead Turtle)
Presidential Decree No. 26	1986	Ratification of ASEAN Agreement on the Conservation of Nature and Natural Resources
Ministerial Decree (Forestry) No. 12	1987	Protection of Several Types of Wild Animals (Black Coral, Giant Clams and Other Marine Invertebrates)
Act No. 5	1990	Conservation of Living Natural Resources and Their Ecosystems
Government Regulation No. 7 and 8	1999	Protection for Several Types of Wild Animals (Coelacanth and Green Turtle)

Source: Llewellyn (2000, unpublished)

APPENDIX D SUMMARY OF HOUSEHOLD BENEFITS OF DESTRUCTIVE FISHING PRACTICES

Midpoint Estimates of Monthly Average Income in US$ for Crew and Owners of Destructive Fishing Operations in Indonesia

Destructive Activity	Small-scale	Medium-scale	Large-scale
Blast fishing ('97)			
- Crew	55	146	179
- Owner	55	393	1,100
Cyanide fishing			
** Food fish ('97)*			
- Crew	100	252	400
- Owner	100	413	35,000
** Aquarium fish ('02)*			
- Crew	120	253	114

APPENDIX E SUMMARY OF ECONOMICS IN THE LIVE REEF FOOD FISH TRADE

Fishing with poisons can be considered a traditional fishing method in the sense that it has occurred for hundreds of years, all over the world (Eldredge, 1988). Chemical poisons like sodium cyanide (NaCN) and potassium cyanide (KCN) appeared recently in fisheries and were mainly used in the aquarium trade. Here, concentrations are not meant to kill but only tranquilize the fish, which facilitates their capture. This feature was gratefully used when a market for high-quality live food fish emerged from Hong Kong, Taiwan and mainland China (Johannes and Riepen, 1995). This live food fish trade concentrates on groupers (especially the genus *Epinephelus* and *Plectropomus* and the species *Cromileptes altivelis*) and Napoleon Wrasse (*Cheilinus undulatus*).

The high prices paid for these fish make it feasible for owners and middlemen to employ skilled divers and use relatively advanced methods to capture the fish and keep it alive. A diver with a squirt bottle filled with cyanide solution uses hookah dive gear to roam reefs for target species. Once spotted, he chases the fish into a crevice and squirts the solution to stun the fish. If successful, he breaks away the coral and grabs the fish to put it in a net or on a hook after which he brings it slowly to the surface. An epidermic needle, or sometimes a simple straw, is used to "vent" the expanding swim bladder.

Groupers and Napoleon Wrasse migrate many miles each season to come to spawning sites to reproduce (Samoilys and Squire, 1994). Experienced cyanide divers are skilled in locating them; thus wiping out fish at an aggregation site equals the elimination of top predators from several square miles of reef. Sizes of cyanide operations vary from single outboard engine canoe operations to large-scale mother ships with several dinghies and some 20 crew. Catches vary accordingly and so do costs. Unpublished data show average net profits per boat-owner and per month in the cyanide fishery in 1997 of US$ 100 for small-scale operations with the owner as a single crew member, US$ 413 for medium-scale operations with the owner not forming part of the crew but owning several boats, and no less than US$ 35,000 for large-scale operations. Crew members on average earned incomes per month of US$ 100 in small-scale operations, US$ 252 in medium-scale operations and US$ 400 in large-scale operations including average bonuses for good catches. These profits and incomes are higher than profits and incomes in any type of conventional fishery.

APPENDIX F SUMMARY OF THE SEAWEED MARICULTURE PROJECT

A total of 34 participants from 12 villages took part in the seaweed farming training in 2000 (Pedju et al., 2002). Additional support was also provided for each participant, such as rope, bamboo, anchor, plastic, seed, buoys and dried materials. Each participant started cultivating 100 square meters of plantation area, in front of the villages surrounding KNP. Growing of seaweed started in April 2001 in the targeted villages of Pulau Seraya Besar, Pasir Panjang, Pulau Kukusan, Manjaga, Pulau Papagaran, Pulau Mesa and Bajo Pulau.

At present, there are 100 families, divided in ten groups, involved in the project. Each family successfully developed their planting areas to 300-400 square meters. The main buyers in Sape purchased dry seaweed products at an average price of Rp 3,500/kg (US$ 0.30-0.40/kg). The harvest time (45 days) is relatively short. Within this period one family can produce (on average) dry seaweed products of about 75 kg per 100 sq m, which is worth (on average) Rp 250,000. Capital costs for each harvest of 75 kg amount to some Rp 75,000. Each family currently cultivates 300-400 sq m and produces about 250 kg of dry seaweed per planting cycle with a value if Rp 875,000, at a cost of about Rp 275,000. This is currently resulting in a net income of about Rp 600,000 (US$ 60) per cycle per family. Each family is expected to complete about eight cycles per year and will produce around two tons per year. Total production of dry cultured seaweed by the 100 families in the development project is expected to be around 200 tons per year.

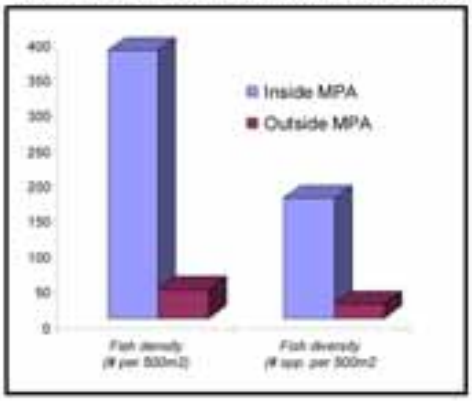
APPENDIX G EXAMPLE OF POPULAR TRANSLATION OF MPA AS A FISHERIES TOOL CONCEPT

Why Marine Protected Areas?

Examples of Success

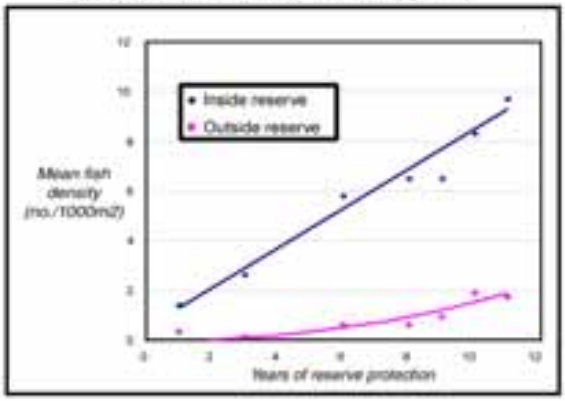
Kenya

(McClanahan 1994. Data from Malindi, Watamu, Kisite and Mombassa National Parks, Kenya)



Philippines

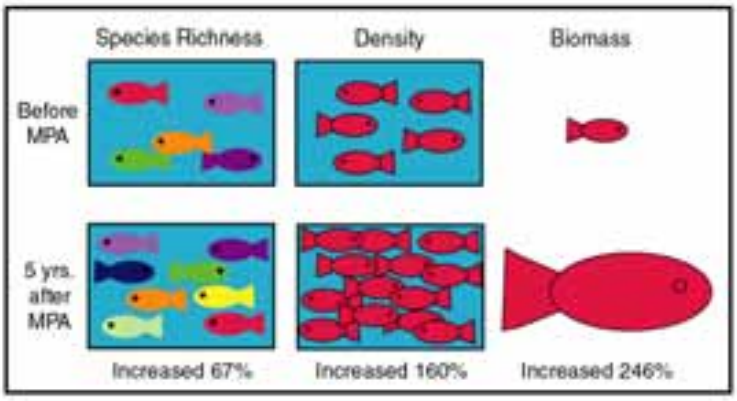
(Russ and Alcala 1996. Data from Apo Island Marine Reserve, Philippines)



Biodiversity Benefits: Well-managed, scientifically designed Marine Protected Areas reduce the impact of current and future threats. They maintain species and genetic diversity, conserve endemic or rare species, protect sites of critical or vulnerable life history stages, and allow damaged ecosystems to recover.

New Caledonia

(Wantiez et al. 1997. Data from Noumea Marine Reserve, New Caledonia)



Fisheries Benefits: Well-managed, scientifically-designed Marine Protected Areas reduce the impact of over-fishing, allowing fish density, biomass and species richness to recover. Eventually, increases in fecundity and longevity are seen, allowing damaged habitat and depleted stocks to recover. This in turn creates spillover to adjacent areas, increasing larval export and the abundance of focal species.

MPAs are an important fisheries management tool, especially when they include no-take reserves that are permanently closed to all forms of extractive harvesting targeting fisheries.

Studies cited from: Ward et al. 2001. *The Role of Marine Reserves as Fisheries Management Tools* and Roberts, C.M. and J.P. Hawkins. 2000. *Fully-protected marine reserves: a guide.*

The STREAM Initiative
Network of Aquaculture Centres in Asia-Pacific (NACA)
Suraswadi Bldg, DOF Complex
Kasetsart University Campus
Ladyao, Jatujak
Bangkok 10900 Thailand

Tel +66-2-940-5457
Fax +66-2-561-1727
Switchboard +66-2-561-1728-9 ext 108
E-mail ghaylor@loxinfo.co.th
Website http://www.streaminitiative.org

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Annex 3

IMPROVING LOCAL LIVELIHOODS THROUGH SUSTAINABLE AQUACULTURE IN HON MUN MARINE PROTECTED AREA, NHA TRANG BAY, VIETNAM

IMPROVING COASTAL LIVELIHOODS THROUGH SUSTAINABLE AQUACULTURE PRACTICES

A Report to the Collaborative APEC Grouper Research and Development Network (FWG/01/2001)

IUCN Vietnam Program

2003

Contents

Tables and Figures

Note: Throughout the report, monetary figures are presented in Vietnamese Dong (VND) and converted to US Dollars using a nominal conversion rate of US$ 1 = 15,000 VND and rounded to the nearest dollar.

Executive Summary

This case study describes the present status and trends, and provides recommendations for the improvement of aquatic resources management within Hon Mun Marine Protected Area (MPA), Nha Trang Bay, Khanh Hoa Province, Vietnam. The case study also evaluates options for improving the livelihoods of local villagers through the development of ecologically sustainable aquaculture and fisheries, which include diversification following careful selection and trial of appropriate culture species, and application of "best practice" culture methods.

Hon Mun MPA, the first comprehensive MPA in Vietnam, encompasses some 160 km^2, including nine islands and their surrounding waters, and supports a resident population of some 5,138 people, the vast majority of whom rely on fishing and related activities as the primary basis of their livelihoods. The MPA has two key roles: improvement of local livelihoods and conservation of the outstanding biodiversity. By successfully combining these two goals, Hon Mun MPA thereby provides a model or "pilot project" for the development of future MPAs in Vietnam.

With over-exploitation and depletion of traditional wild-caught fisheries, villager livelihoods are becoming increasingly focused on developing aquaculture. Since establishment of the MPA, access to some traditional fishing grounds has been restricted to replenish wild stocks, with the associated socio-economic impacts being borne mainly by MPA residents. Many residents consider aquaculture among the most suitable options for additional livelihoods and have raised concerns about access rights to areas suited to aquaculture development.

To date, village aquaculture has focused on cage culture for reef lobster and marine fish, resulting in an increased demand for wild-caught "seed" and "feed", which is well beyond the ecological sustainability of natural stocks within the MPA and in surrounding waters. Thus, although lobster and marine fish culture remain profitable, their sustainability appears to be short-lived. Similarly, areas suitable for the existing culture system are limited and in some locations cage culture is already at or near local carrying capacity.

The main issues concerning the promotion of local livelihoods through sustainable aquaculture practices can be categorized as:

1. *Technical issues*: use of wild-caught seed, trash fish and other low-value commodities for feeding; monoculture; disease; application of simple culture technologies that limit suitable areas for aquaculture
2. *Environmental planning and management issues*: inadequate planning and zoning; lack of supporting legislation (regulations, codes of practice)
3. *Economic issues*: lack of capital; unstable, developing markets, and
4. *Social issues*: poverty, inequitable opportunities for local resource users.

These issues are being addressed to develop sustainable aquaculture in Hon Mun MPA. Various criteria were developed to assess the suitability of different species. The criteria emphasize the need for sustainability, integrated planning and minimizing adverse environmental impacts, and have been discussed widely with local communities.

The Hon Mun MPA Project (the Project) has planned and implemented a series of aquaculture trials to demonstrate the feasibilities of species diversifications, the use of hatchery-produced seeds, and species that feed successfully from natural food sources or formulated pellets.

Among the 15 candidates, trials have been implemented for species such as seaweed *(Kappaphycus alverezii)*, green mussel *(Perna viridis)*, sandfish *(Holothuria scabra)*, rabbit fish *(Siganus guttatus)* and groupers *(Epinephelus malabaricus* and *E. tauvina)*. To date, most trials have shown success, indicating that there is a wide variety of species other than lobster and marine fish that have the potential of being cultured successfully to help improve livelihoods of local villagers.

To further assist planning and management of sustainable aquaculture in MPA waters, the "Hon Mun MPA Aquaculture Masterplan" (the Masterplan) will be developed as an integral part of the Hon Mun MPA Regulation and Zoning Scheme, minimizing conflicts with other resource users in the MPA, and providing guidance to local villagers. The Masterplan will establish zones for the culture of different species within the MPA and identify the carrying capacity of each proposed aquaculture site. The Masterplan will also seek to balance the different types of species cultured and to develop an integrated system where environmental impacts are minimized. As part of this approach, an integrated culture system – with sandfish (detritus feeders) cultured underneath lobster or marine fish (carnivores) cages – is being developed. Although the trial system is yet to be completed and evaluated, the concept is sound and good results are expected. While further research and development of various sustainable aquaculture systems is beyond the scope of the present Project, efforts will be made to enhance the active involvement of national aquaculture research institutions through recommendations and coordination of expertise and resources.

Given the limited spatial extent of areas suitable for existing culture systems within MPA waters, it is proposed that priority allocation of sites be provided to local people seeking to undertake aquaculture activities. Local people will then have the opportunity to lease their rights to investors from outside the MPA. Extension services will also be crucial in assisting local aquaculture farmers and fishers in sustainable aquaculture development and fisheries management in general.

Even with all the above measures in place, the limited spatial extent of areas suitable for existing culture systems, combined with technological, financial and social constraints, mean that aquaculture alone will not provide sufficient additional or alternative income for all local villagers. To this purpose, the Project is also promoting sustainable fisheries coincidentally with aquaculture development. These MPA management initiatives include implementation of core "no-take" zones for fisheries replenishment at key locations to restore depleted wild fish, crustacean and shell-fish stocks, with likely fishery benefits of larval replenishment and adult "spill-over" into adjacent fishing zones. If successful, these initiatives, with the other additional income streams being developed, should help to ensure improved livelihoods for local villagers and conservation of the MPA's outstanding biodiversity attributes.

1. Introduction

1.1 Study Area

Hon Mun Marine Protected Area (MPA) is situated in Nha Trang Bay, offshore from Nha Trang City in Khanh Hoa Province, on the coast of central-south Vietnam. The MPA encompasses an area of 160 km^2 and includes nine islands and their surrounding waters (Figure 1). The MPA has a resident population of 5,138 people, the vast majority of whom rely on fishing as the primary basis of their livelihoods.

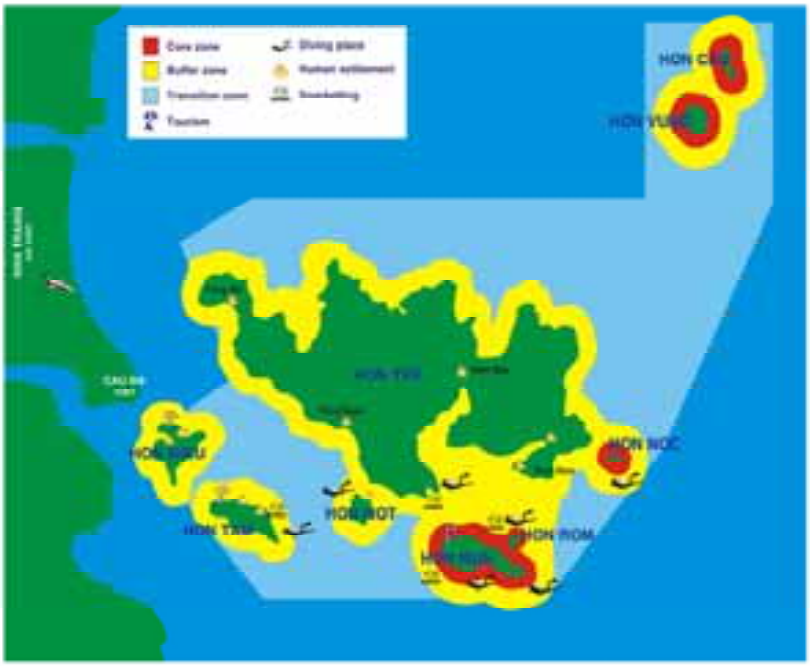

Figure 1 Map of Hon Mun MPA Showing Core, Buffer and Transition Zones

The islands, which are located between 1 and 15 km from the mainland, provide the basis for a diverse array of coastal and marine habitats, including coral reefs, soft bottom communities, seagrass beds, mangroves, sandy beaches and rocky shores, and associated high levels of biodiversity. Recent surveys have revealed that biodiversity is higher than previously thought, with some 350 species of reef building corals, 220 species of demersal fish, 106 species of mollusk, 18 species of echinoderms, 62 species of algae and seagrass (Vo et al., 2002a-e). This represents the highest marine biodiversity yet known from Vietnamese coastal waters, and indicates that Hon Mun MPA shares strong biogeographic affinities with neighboring nations and the Indo-West Pacific center of diversity.

Hon Mun MPA waters are a major supplier of fish and other seafood products, through harvest of wild stocks and through increasing development of village-based aquaculture (mostly reef lobsters *Panulirus spp.* and groupers *Serranidae*). Wild harvest methods include traditional techniques, modern intensive techniques, as well as the illegal use of bright light (>2000 W), blast and poison fishing, the latter causing major damage to marine habitats (see later). The MPA is also developing as a major destination for dive tourism and other

recreational boating activities, while larger commercial vessels use the nearby Cau Da Port. With rapid expansion of these activities, both legal and illegal, levels of environmental threat and impact are increasing and related declines in habitat quality and biodiversity attributes are impacting on the livelihoods of island communities.

1.2 Coral Reef Fisheries and Aquaculture

The highly productive waters of Hon Mun MPA have a long history of being fished by island communities. However, traditional subsistence fishing has been rapidly replaced by modern intensive and extensive fishing practices, including illegal blast and poison fishing. Fishers from others areas in Khanh Hoa Province also fish the waters of Hon Mun MPA, representing an additional, and as yet unquantified, source of fishing pressure.

Although MPA waters remain a major source of fish and other seafood products, fisheries resources are believed to be in decline. While gross output figures show that extraction continues to increase, albeit only marginally, important indicators of the state of commercial fisheries, such as catch per unit effort (CPUE) and capital investment, are unavailable for most fisheries. Nonetheless, islanders' perceptions, catches from traditional Dam Dang fixed nets and biodiversity surveys all indicate that the fisheries are in decline within the MPA.

From the mid-1990s onwards, aquaculture developed rapidly in MPA waters and now represents a significant source of income for the island communities. This shift may be an indication of declining fisheries resources, increasing effort and capital investment required to be able to profit from these fisheries, and of uncertainty in relation to catch levels.

1.3 Reefs at Risk

Throughout the world, and notably in Southeast Asia, coral reefs and associated biodiversity are under threat from a range of human activities (see e.g., Bryant et al., 1998; Spalding et al., 2001; Talaue-McManus, 2000; Veron, 2000). This is particularly true of Vietnam, which has experienced a doubling in population since the end of the "American War" and is now in a period of rapid economic development and industrialization (Talaue-McManus, 2000).

The coral reefs of Nha Trang Bay are under threat from a range of local, regional and global impacts. At the local level, direct human impacts include over-fishing, use of destructive fishing practices such as poison and blast fishing, anchor damage, tourist and diver damage, oil spills and the release of ballast water (Vo et al., 2002a). Regional threats include over-fishing by people from other areas and pollution from adjacent coastal river catchments, while the major threat at the global level is coral bleaching.

1.4 Hon Mun Marine Protected Area

Recognizing regionally important biodiversity values and the intense and increasing pressure placed upon them by human use, the Government of Vietnam established the first comprehensive MPA in Vietnam, with assistance from The World Conservation Union (IUCN), through the GEF/World Bank and DANIDA-funded Hon Mun MPA Pilot Project.

The objective of Hon Mun MPA is:

> To enable local island communities to improve their livelihoods and, in partnership with other stakeholders, effectively protect and sustainably manage the marine biodiversity at Hon Mun as a model for collaborative MPA management in Vietnam.

Hon Mun MPA therefore has two key roles: first, that of addressing socio-economic issues within local island communities, and second, the sustainable management of marine biodiversity. These roles are of course closely interlinked, with the first being an essential component of the second. By working in partnership to improve the livelihoods of local island communities, the Project aims to reduce or eliminate the socio-economic factors driving the gradual degradation of marine habitats and loss of biodiversity within the MPA.

In relation to these purposes, the project has developed additional income generation policies for locals (including aquaculture) and the MPA Authority has issued a Temporary Regulation and Zoning Scheme which provides the management framework for the MPA.

1.4.1 Temporary Regulation and Zoning Scheme

On 11 March 2002, the People's Committee of Khanh Hoa Province issued a Temporary Regulation and Zoning Scheme for the establishment of Hon Mun MPA. The Scheme seeks to promote a management regime for the protection of marine biodiversity, while providing for the regeneration of fisheries stocks and balancing the various uses of the areas.

1.4.1.1 Restating National Legislation

At present, national legislation prohibits unsustainable and destructive fishing practices such as the use of strong light (>2000 W), dynamite and cyanide. However, these laws are not strongly enforced. These practices are known to be used to varying degrees within the MPA. The Temporary Regulation and Zoning Scheme restates national legislation at the provincial level and, with the MPA Authority now actively patrolling and enforcing this regulation, it is hoped unsustainable and destructive fishing practices can be eliminated from the MPA.

1.4.1.2 Provision of Protection Zones Restricting Fishing Activities

The Temporary Regulation and Zoning Scheme sets out a series of management zones to regulate use and resource extraction within the MPA. This multiple-use zoning system is the key management tool used to balance marine biodiversity conservation and resource use. The scheme applies three zones with different levels of use and protection:

Core Zone

Core zones surround four islands within the MPA with high biodiversity values. Fishing activities, except a traditional *dam dang* fixed net, are banned within these zones.

Buffer Zone

Buffer zones surround the four islands' core zones. Buffer zones are open to traditional fishing gears; however, management activities are focused on "no anchoring" and "no trawling" zones as well as planned aquaculture.

Transition Zone

The transition zone is open to traditional fishing gears, with management focused on limiting trawling activities.

1.5 Sustainable Aquaculture

An integral component of the Hon Mun MPA Project is the development of alternate income generation (AIG) activities. These are being developed to provide sustainable alternatives to current economic activities that pose a threat to the marine environment and/or have been restricted under the Temporary Regulation and Zoning Scheme.

With a history of fishing the waters of Nha Trang Bay, and close ties to the marine environment, it is not surprising that the majority of people from island communities look to aquaculture as a preferred alternate source of income. But the question needs to be asked: Is aquaculture sustainable in the context of Hon Mun MPA or is it another unsustainable form of resource extraction?

The guiding principle behind the term "sustainable aquaculture" is that of sustainable development. While there are many different definitions of sustainable development, the most widely accepted is that from the Brundtland Report:

> Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987).

More specifically, FAO defines sustainable development, in relation to forestry and fisheries, as:

> Sustainable development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable (FAO Fisheries Department, 1997).

In the context of Hon Mun MPA, careful consideration must been given to the future needs and aspirations of local island communities. This is achieved in the present case study through extensive consultation and discussion, and demographic and socio-economic projections (see later).

As an alternative source of income, aquaculture has potential to relieve fishing pressure on wild stocks, and to therefore aid the conservation of marine biodiversity. However, as well as possessing great potential as an AIG activity, aquaculture carries with it a number of threats to the marine environment and, if not planned, developed and managed sustainably, will have negative impacts on marine biodiversity of the MPA.

Scope of Report

This case study investigates existing conditions with regards to biodiversity and resource use, including fisheries, aquaculture and tourism, within Hon Mun Marine Protected Area, Nha Trang Bay, Vietnam. It identifies the main threats facing the MPA, with particular reference to issues concerning aquaculture development, and highlights the barriers to sustainable aquaculture. Finally, it provides a series of proposed actions and recommendations for the development of sustainable aquaculture within the MPA.

The case study draws upon existing information from a number of technical reports prepared by the Hon Mun MPA Project during its establishment phase (see References). These include investigations relating to:

- Aquaculture
- Traditional fishing practices
- Marine and coastal habitats
- Coral reef biodiversity
- Socio-economics
- Credit

2. Current Situation

2.1 Status and Recent Declines in Biodiversity and Coral Reef Fisheries

The Hon Mun MPA contains a diverse array of coastal and marine habitats, most notably coral reefs, seagrass beds, mangroves, sandy beaches, soft bottom communities and rocky shores. These habitats support exceptional biodiversity, particularly among the coral reef species – corals, fish, mollusks, echinoderms, crustaceans and others – which was one of the main reasons for establishing the MPA (Cheung and Vo, 1993; Vo et al., 2002a-e).

Recent surveys have revealed that biodiversity is even higher than previously thought, with 350 species of reef building corals, 220 species of demersal fish, 106 species of mollusk, 18 species of echinoderms, 62 species of algae and seagrass (Vo et al., 2002e). Hon Mun MPA thus supports the highest known tropical biodiversity of Vietnamese coastal waters, sharing strong biogeographic links with the Indo-West Pacific center of biodiversity and neighboring nations. Remarkably, this exceptional biodiversity is housed within the small habitat areas that remain in good condition, as large areas of the MPA have been degraded by destructive fishing practices and other impacts (Table 1).

Table 1 Approximate Area and Percentage of Sub-littoral and Coastal Zones Occupied by Different Habitats, Hon Mun MPA

Habitat Type	Approximate Area (ha)
Coral reef community in good condition	73 ha, 24 %
Coral reef community in degraded condition	101 ha, 33 %
Rocky - sandy areas with sparse corals	98 ha, 32 %
Sandy areas (mostly seagrass beds)	34 ha, 11 %
Mangroves	~ 1 ha

Source: Vo et al., 2002b

Although coral reefs remain in good condition in a few areas of the MPA, with corals covering almost 100% of the seafloor, and with associated high levels of biodiversity, in many other areas the once-flourishing coral reefs and associated biota have been badly damaged by over-exploitation, destructive fishing practices (blast and poison fishing) and other impacts (Vo et al., 2002a-e; Table 1). Notably, degraded reef habitats currently occupy more of the MPA than those in good condition (Table 1). Similarly, while demersal fish diversity is among the highest reported from Vietnamese reefs, stocks of most target species are low and fish are generally small in size, or they have become locally extinct (see later).

Thus, the exceptional biodiversity attributes of Hon Mun MPA remain under serious threat (Vo et al., 2000a-e), notably from over-exploitation and destructive fishing practices employed by the resident fishing community as well as by fishers from further afield. These fishers collectively exploit the MPA's fisheries resources for their subsistence, and increasingly, to supply the demand for seafood, both locally for the expanding tourism industry, and for burgeoning regional markets in East Asia.

Fishing methods cover almost the entire gamut of tropical fisheries, including purse seining, lift netting, push netting, hook and line and dive fishing, traditional *dam dang* fixed nets, and also include illegal activities such as light fishing (>2000 W), poison (cyanide) and blast (dynamite) fishing (Figure 2).

Figure 2 Blast Fishing Damage (from Vo et al., 2002b)
(The blast crater is approximately 6 m wide and 1 m deep.)

Blast and poison fishing has degraded a large part of the MPA, including most of the northern coast of the largest island, Hon Tre (Figure 1, Table 1). A direct consequence of habitat degradation and over-exploitation is the reduction of local biodiversity (Vo et al., 2002a-e). Many species of reef fish, sharks, mollusks, crustaceans and echinoderms, particularly those targeted by fishers, are now rare or locally extinct in MPA waters, indicating that they are being unsustainably exploited. Notable examples include the commercially important ornamental angel fishes *(Pomacanthidae)*, targeted for the aquarium industry, and the highly prized food fishes, groupers *(Serranidae)*, snappers *(Lutjanidae)* and emperor breams *(Lethrinidae)*. These all exhibit low diversity in species composition, are locally scarce in abundance, and when present are generally small in size. Indeed, larger fishes are generally scarce in MPA waters (Figure 3).

Commercially targeted groups have been in poor condition for more than a decade (Cheung and Vo, 1993) and species diversity continues to decline, indicating both long-term and continuing depletion. Notable absentees include the Humphead Maori Wrasse *(Chelinus undulatus)* and Barramundi Cod *(Cromileptes altivelis)*. Once common components of many Indo-West Pacific reef fish assemblages, these species are among the most favored of all target fishes for the Asian live fish trade, and are now locally extinct in many reef areas of East Asia, almost certainly including Hon Mun MPA (Table 2, Annex Table).

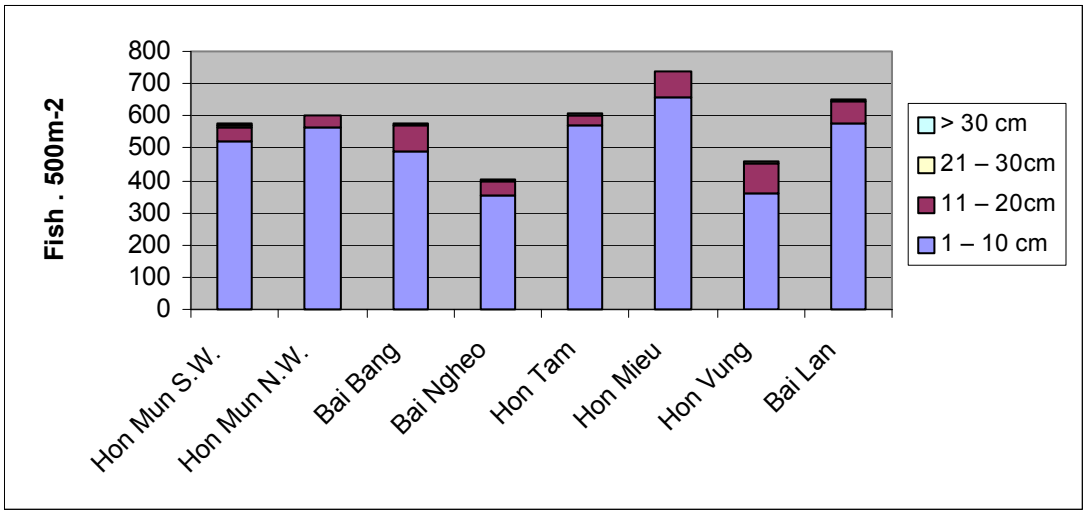

Figure 3 Size Distribution of Fish at Permanent Monitoring Locations, Hon Mun MPA (2002) (from Vo et al., 2002c)

Table 2 Average Density (and Standard Deviation) of Reefcheck Indicator Species at Eight Permanent Monitoring Locations, Hon Mun MPA (August 2002) (after Vo et al., 2002c)

Indicator Species					
Groupers > 30 cm *Serranidae*	Barramundi Cod *Cromileptes altivelis*	Sweetlips *Haemulidae*	Humphead Wrasse *Chelinus undulatus*	Bumphead Parrotfish *Bolbometapon muricatum*	Lobsters *Panulirus spp.*
0.1 (0.4)	0	1.3 (2.0)	0	0	0

For echinoderms, diversity has also declined, and for several edible species (e.g., the sandfish *Holothuria scabra*), their absence also clearly reflects intense harvesting pressure (Annex Table). For mollusks, the commercially important reef abalone *(Haliotis assanina)* and large ornamental giant triton *(Charonia tritonis)* are now exceedingly rare or locally extinct (Annex Table). For crustaceans, large reef lobsters *(Panulirus spp.)* are no longer present within the MPA (Table 2), although harvest of wild juveniles still occurs, to supply the lucrative local market for aquaculture "grow-out" activities.

In addition to local extinctions, another large suite of species has locally restricted distributions within MPA waters, many of which are also rare at their few sites of occurrence (Vo et al., 2002c-e). Many of these are unlikely to form viable populations at present levels of abundance. Of these, some are highly desired commercially, and their local rarity is clearly attributable to over-collecting (e.g., coral trout and other reef groupers). It will require some years before local populations can recover, provided present management initiatives for the reef fisheries are successful.

A similar picture of extensive over-exploitation emerges for the pelagic fishes targeted in the traditional *dam dang* fixed-net fishery. Overall abundances have been declining over the past five years, as documented in commercial fishery statistics (see Haiphong Institute of Oceanography, 2002).

Socio-economic surveys reveal that members of island communities are aware of the impacts of increased fishing pressures on fisheries resources. Figure 4 clearly illustrates that the perceived decline in fisheries resources is considered by villagers to be closely linked with population growth and the expansion of the MPA fishing fleet.

Thus it is clear from biodiversity data, from *dam dang* fixed-net catches, and from socio-economic surveys with villagers (see below), that the various forms of over-exploitation are placing increasing pressures on renewable fishery resources and outstanding biodiversity values, while declining catches are placing economic pressures on the fishing communities themselves.

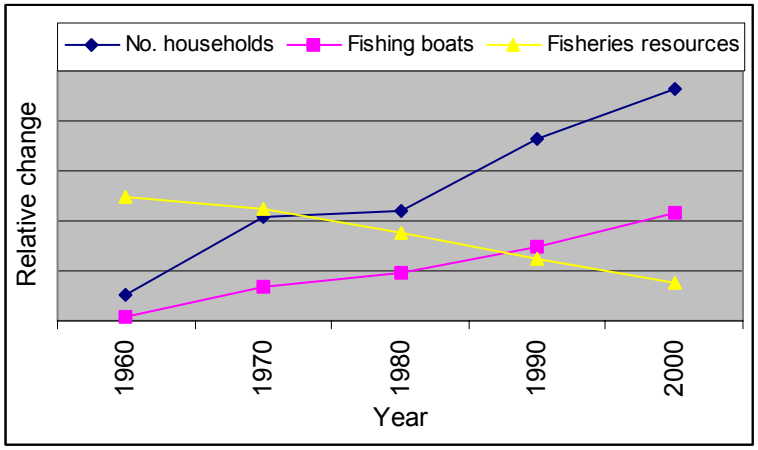

Figure 4 Perceived Changes in Population (Households), Fishing Fleet and Fisheries Resources (after Nguyen and Adrien, 2002)

2.2 Socio-economic Status of Island Communities

To better inform decisions on mechanisms for co-management, the Project has developed a detailed understanding of the socio-economic status of local village communities and their dependence on natural resources.

In 2002, Hon Mun MPA had a resident population of some 5,138 people, with an almost equal distribution of males and females (50.8:49.2). The population is relatively young, with 36% being under the age of 15. The population is housed in six villages, ranging in size from 32 to 522 households. In total, there are 988 households with an average of 5.2 persons in each, with only slight differences between villages. The large majority of these households, 78.4%, are headed by men.

The education level of most adults is low, with 64% of household heads having the equivalent of a Grade I education (basic literacy skills 7-11 years), 22% Grade II (12-15 years) and only 5% Grade III (16-18 years). For partners, usually women, the level of literacy is lower, with only 7% having a Grade II level of education and 5% Grade III.

The average per capita income of MPA residents during 2001 was 5.38 million VND/year or 478,000 VND/month (US$ 382/year or US$ 32/month). The majority of MPA villagers consider themselves as being of "medium" level of wealth (earning 300,000-750,000 VND or

US$ 20-50/month), indicating that the level of poverty in the area is not considered overwhelming. The relative level of poverty, however, varies quite strongly between villages, with the "poor" category ranging from less than 10% to more than 50% of village populations. In general, the level of nutrition is adequate except for the poorest 11% of households, which are considered to be beneath the poverty line according to national definition of poverty.

The major economic activity in the villages within the MPA is fishing (Figures 5a, b), with 79% of household heads being fishers. For 71% of these household heads, fishing is the only source of income, making them susceptible to both fish catch and price fluctuations.

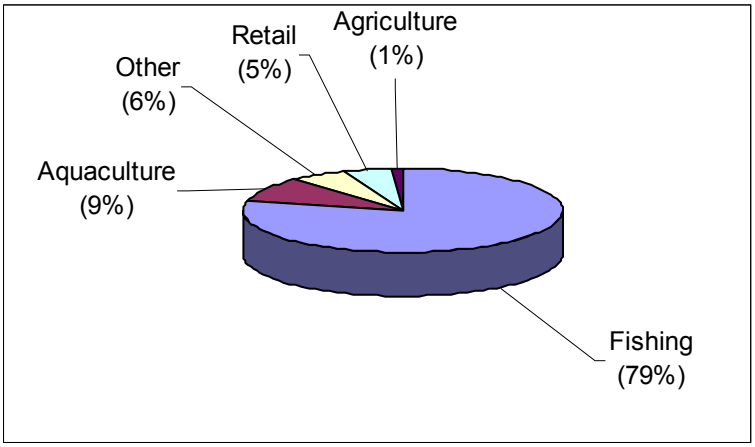

Figure 5a Distribution of Main Activities of MPA Household Heads

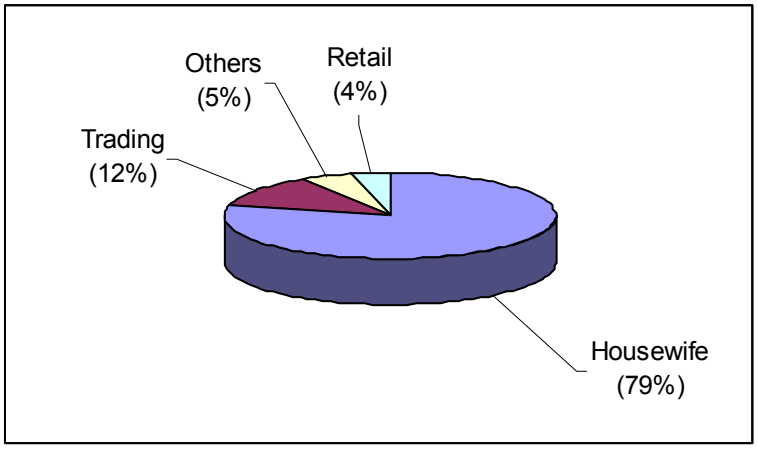

Figure 5b Distribution of Main Activities of Partners of MPA Household Heads

Aquaculture has developed rapidly since 1999 and now represents the main economic activity for 9% of household heads, and is a secondary activity for a further 27% of household heads. The continuing shift to aquaculture reflects both its economic value and recognition among fishing communities of declining wild stocks.

Approximately 80% of households involved in aquaculture were also involved in other income-generating activities such as agriculture, animal husbandry, small businesses and hired work. Income diversification make these households less vulnerable in relation to market fluctuations. However, it should be noted that people living within the boundaries of Hon Mun MPA do not own agricultural land; rather, cooperative activities such as plantations and forestry may be undertaken by a group of people.

2.3 Coral Reef Fisheries

There are 380 motorized fishing boats in the MPA with an average length of 9.3 m, a 20-CV engine, and a present value of 55 million VND (US$ 367). Forty-six percent of the MPA community of fishers owns a boat while the remaining 54% work as hired crew members. In addition to the local fisher community, there is a substantial in-migration of fishers during the main season to meet labor demands, mainly of boats operating large nets at night.

The range of fishing gear used within the MPA is wide (Figure 6); however, each village has its own gear-specificity, and 74% of boat owners operate a single gear type. As a consequence each village community tends to have its own specific use of MPA waters.

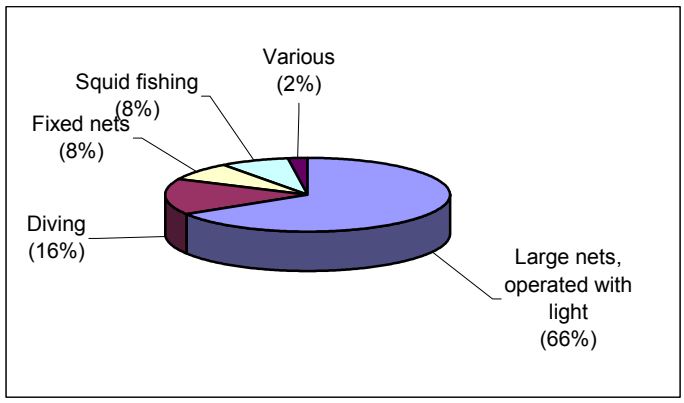

Figure 6 Distribution of Main Fishing Gears within Hon Mun MPA Fishing Fleet

Large nets operated at night using light attraction account for 66% of the types of gear used within the MPA. This category is comprised of push nets (61%), purse seine nets (23%), lift nets (11%) and lobster nets (5%). Lobster nets are generally used in addition to purse seine nets to catch lobster seedlings for use in local aquaculture. This practice has increased dramatically over the last two years to meet growing demand.

Of the remaining fishing categories, diving accounts for 16%, being largely restricted to one village. Poison fishing, mostly using cyanide, is conducted by some divers. However, the extent of its use and exact nature of the financial arrangements are not known at present. Similarly, blast fishing using dynamite is also conducted by some poorer fishers within MPA waters, notably in more remote areas. These two forms of destructive fishing have degraded coral reefs along much of the north coast of Hon Tre over the past decade. However, recent arrests and extensive education and awareness campaigns should limit these activities in future.

Squid fishing accounts for 8% and is performed using hook and line at night, or to a lesser extent, using nets during the day. Fixed nets account for a further 8% of gear types and include single-layered gillnets through to three-layered tremmel nets, and a single traditional *dam dang* fixed net. The various gear categories (2%) includes swimming crab traps and nets, beach seines and other gears of limited use.

While traditional fishing grounds once existed for local people, Vietnamese waters are now designated as open access fisheries. This presents challenges in establishing fishing areas for local people, where the direct benefits of protection go to all users via the open access policy.

2.3.1 Cost/Benefit Analysis per Type of Gear

On average, each fishing gear is used for 200 days per year, with the main season lasting for approximately five months. An estimated 70% of the gross income of local villagers is gained during this important fishing season.

The average net income is dependent on the type of boat and fishing undertaken (Figure 7). An owner of a small boat who undertakes squid hook and line fishing earns an average of 43,000 VND/day (US$ 3), while push net fishers receive 340,000 VND/day (US$ 23). For hired crew members, average net income varies from 14,000 VND (US$ 1) for lift net fishing to 66,000 VND (US$ 4) for push net fishing per day.

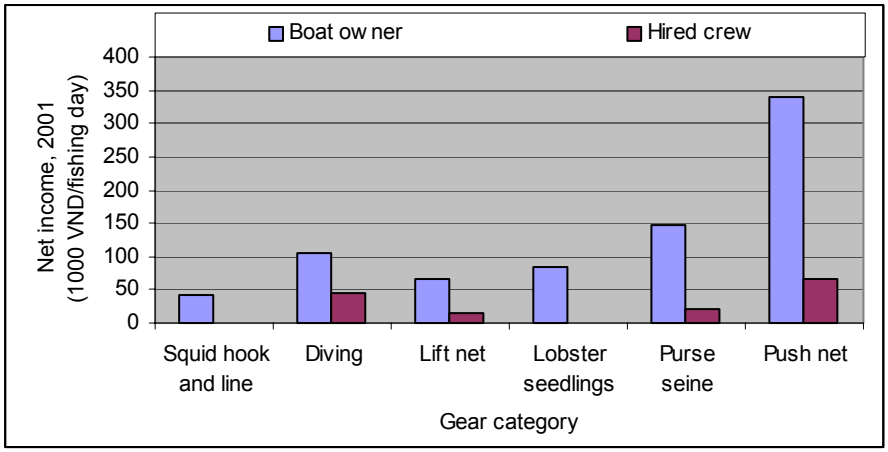

Figure 7 Estimated Income from the Different Fishing Gears Used within Hon Mun MPA

2.3.2 Recent Fisheries Investment Trends

Of the 380 motorized boats owned by residents of the MPA, 75 have been purchased since 1999. Many of these boats are considered medium-large in size and are powered by 30-60-CV engines suitable for large push nets and purse nets. The government levies an annual tax on each of the larger fishing vessels. Smaller boats are used for the diving and tremmel net fisheries.

It is assumed that wealthier and more successful boat owners receive incomes that allow for capitalization. In the case of the illegal poison and blast fishing, there must be financial links between fishers and the middlemen who buy the product. However, it is unknown at present if pressure is put on fishers to fish illegally.

In addition to the MPA fishing fleet, there is also significant pressure being placed on fisheries resources from boats based outside the MPA. These are typically larger boats used for push nets and purse seine nets, and number approximately 650 vessels. This represents a greater source of fishing pressure than that from the MPA fishing fleet.

2.4 Aquaculture

2.4.1 Development History of Aquaculture in Nha Trang Bay

Aquaculture started in Nha Trang Bay in 1989 with the collection and fattening of high-value fish by traders from Hong Kong. By 1996, the industry had entered a period of rapid development and culture species included grouper *(Epinephelus spp.)*, snapper *(Lutjanus spp.)*, shrimp, and to a lesser extent, ornamental fish and cuttlefish. Most fish were exported live to markets in Hong Kong, China, Taiwan and Japan; however, some were marketed in local restaurants and hotels. The rapid growth experienced by the aquaculture industry was later hampered by outbreaks of diseases (Figure 8) and a shortage of wild-caught seed.

Figure 8 Decline in Aquaculture Finfish Production in 1999, Nha Trang City (due largely to disease outbreaks in grouper culture)

In recent years, there has been a clear shift towards lobster culture, which is highly profitable and less susceptible to disease outbreaks. The number of lobster cages increased rapidly and lobster culture has become an important sector of economic development throughout Khanh Hoa Province. In 2001, total production from lobster culture reached 790 tons, with an export value of VND 450 billion (US$ 30 million).

Within the MPA, marine fish and lobster culture is being practiced at Vung Me, Tri Nguyen, and, to a lesser extent at Hon Mot, Dam Bay, Bich Dam and Vung Ngan (Figures 1 and 9).

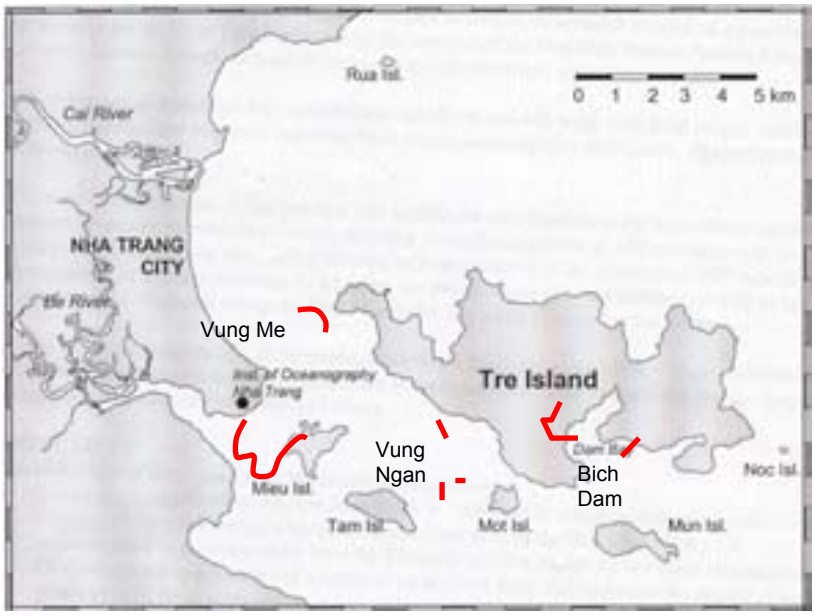

Figure 9 Existing Aquaculture Development (red lines) in Hon Mun MPA, Nha Trang Bay

2.4.2 Current Aquaculture Practices

2.4.2.1 Extent and Spatial Distribution

As mentioned above, aquaculture has become a significant economic activity and the subject of much investment. The relative importance of aquaculture as an economic activity varies between villages, with 87% of households in Vung Me engaged in aquaculture and only 11% in Vung Ngan.

By mid-2001, there were more than 1,675 cages, with a total culture area of 2.52 ha, being used for lobster and marine fish culture within the MPA. A survey in January 2003 showed that the number of cages had increased by over 31% to 2,438. This aquaculture development is not evenly distributed throughout the MPA (see Table 4), but is instead restricted to sheltered bays and/or areas close to Nha Trang City.

Table 3 Number of Cages, Culture Areas, Ownership and Level of Involvement of Islanders in Aquaculture in Villages in Hon Mun MPA up to Mid-2001

Villages	Number of Cages	Culture Area (m^2)	Owned or Partly Owned by Islanders (%)*	Involvement Level (%)
Bich Dam	90	1,984	84.9	11.8
Dam Bay	80	365	72.6	15.6
Hon Mot	111	3,074	54.2	61.7
Tri Nguyen	336	8,510	100.0	26.4
Vung Me	987	9,095	36.5	86.8
Vung Ngan	50	2,100	95.2	12.6
Total/Average	1,654	25,128	69.4	29.6

2.4.2.2 Lobster Culture

On average each household engaged in lobster culture had 2.5 cages in production, and produced 160 kg of lobsters (valued at 335,000 VND or US$ 22/kg) for a gross income of 53.6 million VND or US$ 3,573/production cycle. Operating costs were 26 million VND (US$ 1,733) and 10.5 million VND (US$ 700) for seed and feed respectively, which accounted for 68% of gross income. The average net income was 17.1 million VND (US$ 1,140) during the last production cycle. Based on a production cycle of 14-18 months, the average net income from lobster culture is estimated to be in the range 0.95-1.22 million VND/month (US$ 63-81), placing the operator in the "wealthy" income category. The MPA net average income is 478,000 VND or US$ 32/month. The average net income/cage is 285,000-380,000 VND or US$ 19-25/cage/month. It should be noted that cages varied in size and ranged in cost from 3-3.5 million VND (US$ 200-233).

Notably, some 40% of all lobster cages in the MPA are situated in Vung Me, while the village represents only 10% of the overall population in the MPA, highlighting the importance of aquaculture there.

2.4.2.3 Grouper Culture

Each household engaged in grouper culture had on average 1.2 cages in production and produced 73.3 kg of fish. Due to sample size and inconsistencies in the data, the following figures are given as ranges. Seed costs ranged from 2-12 million VND (US$ 133-800) and feed costs ranged from 0.54-15 million VND (US$ 36-1,000). Gross incomes ranged from 5.8-28.8 million VND (US$ 387-1,920) and net incomes ranged from 3.7-13.3 million VND (US$ 247-887).

The production cycle for grouper culture is shorter than that of lobster culture, taking just 10 to 12 months. Based on this, the net income from grouper culture is estimated to be in the range 308,000-1.33 million VND or US$ 21-89/month. These figures span from the lower end of the "medium" through to the higher end of the "rich" wealth categories; however, further socio-economic investigation is required to produce more reliable figures.

2.4.2.4 Recent Aquaculture Investment Trends

While the average number of lobster cages in production was 2.5 cages/household, this figure does not include new cages that had not been in use for a full production cycle. On average, each household had 3.7 lobster cages, indicating significant new investment in lobster culture and additional capacity that is yet to be included in production figures.

Figure 10 shows a dramatic increase in the number of aquaculture farms in Hon Mun MPA during 2002. Surveys reveal that, of 22 new aquaculture farms established in Vung Me and Vung Ngan, fifteen are exclusively owned by outsiders. These 15 farms comprise 178 cages, representing 82.4% of the total number of new cages in these two areas. Ownership data is not available for other areas but is expected to show similar investment patterns.

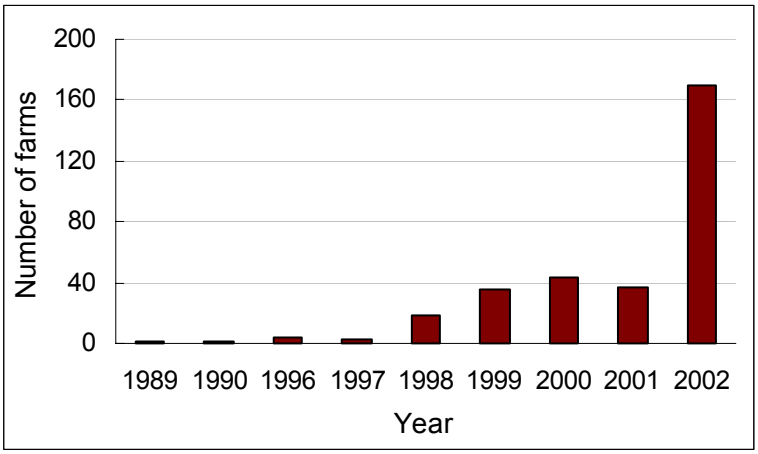

Figure 10 Recent Development of Aquaculture Farms within Hon Mun MPA

2.4.3 Current Issues and Constraints on Sustainable Aquaculture

2.4.3.1 Use of Wild-caught Seed

Current aquaculture practices in Hon Mun MPA rely solely on wild-caught seed-stocks. Rapid development of lobster and marine fish culture has dramatically increased demand for seed. In 2002, prices for 2-3 cm juvenile lobsters surged from 70,000-80,000 VND to 120,000-130,000 VND (from US$ 5 to US$ 9), and lobster farmers were forced to seek seed-stock from other provinces to meet their demand. Unconfirmed reports suggest that in January 2003 prices dropped back to approximately 50,000 VND (US$ 3). The exploitation of seed-stocks from the wild continues largely without control in and out of the MPA.

2.4.3.2 Use of "Trash Fish" and Shellfish as Feed

Formulated diets are not commercially available for lobster and marine fish culture. Artificial feed trials are underway for grouper culture within the MPA; however, research into formulated diets for lobster culture have only just entered the research phase. Instead, "trash fish", including lizard fish, red big-eye and pony fish, are used extensively as feed. On a wet weight basis, the food conversion ratio (FCR) for trash fish is approximately 28 for lobster and ranges from 6-10 for grouper.

The cost of trash fish increases significantly (normally 3-4,000 VND/kg) during the northeast monsoon season (October to early January), when fishing activity is restricted by weather conditions. However, there also seems to be a general upward trend in prices, which has reduced profit margins to the point at which production of grouper can be considered marginal.

Reduced profit margins also encourage the collection of low-value shellfish and crustaceans (including cockles, oysters, snails and small crabs), which are used as a supplement to trash fish. Shellfish comprise up to 30% of feed for lobster and grouper culture.

2.4.3.3 Aquaculture Techniques and Systems

The present systems for the culture of marine fish and lobsters consist of nets and cages supported by simple wooden frames on floats. These systems are unable to withstand hyperdynamic areas with strong currents and wave action. Culture areas are therefore restricted to inshore waters and protected bays, mostly within 100 m of shore and typically close to island villages.

With rapid unregulated aquaculture development, areas such as Vung Me and Tri Nguyen are at, or close to, their carrying capacity. Similarly, other areas are experiencing increased aquaculture development, with investments by both local and outside investors. This is occurring without coordinated planning or regulation.

2.4.3.4 Space Limitation and Conflict with Other MPA Users

Suitable areas for aquaculture, such as those at Vung Me and Tri Nguyen, are now fully occupied by cage culture, while new operations are emerging at Dam Bay and Bich Dam (Figure 1). These areas are close to the Hon Mun-Hon Rom and Hon Noc core zones (Figure 1) and will impact on the surrounding environment if not developed with adequate planning and management. With episodically rough seas outside the sheltered bays, and with establishment of the Hon Mun MPA (particularly the core zone around Hon Mun-Hon Rom), areas suitable for further development using existing aquaculture systems are limited.

Because Nha Trang is a major tourist destination with 350,000 tourists entering Hon Mun MPA in 2002 (projected at one million for 2003), some level of conflict between tourism and aquaculture is considered inevitable. Aquaculture takes up space, particularly sheltered areas suited to tourism, and also impacts on visual amenity. Conflict may therefore arise over access rights for use of the water surface. Similarly, the expansion of the port at Cau Da heralds an increase in shipping in and out of Nha Trang Bay, further limiting areas that can be used for aquaculture.

2.4.3.5 Self-pollution Due to Clustering Effects

The use of trash fish and shellfish as feed can easily lead to degradation of surrounding water and sediment quality, especially in sheltered areas with little water flow and tidal flushing, and particularly where aquaculture development is close to or above carrying capacity. Self-pollution due to clustering effects has already occurred in developed areas such as Vung Me and Tri Nguyen. This is essentially a management issue brought about by the lack of adequate planning and appropriate zoning and the application of inappropriate technology. An “Aquaculture Masterplan”, which will address this and the other issues raised in this case study, is under preparation.

2.4.3.6 Land-based and Maritime Pollution

Runoff from the Cua Be and Cai River catchments poses a number of threats to water quality in and around the MPA, particularly during the monsoonal wet season. Threats include increased nutrient enrichment from agricultural fertilizers and/or aquaculture, increased sediment loads resulting from land clearance, pesticides and herbicides runoff from agriculture, and runoff from chemical spills and inappropriate disposal practices. There is also concern that the various industries that discharge wastewater into these rivers are making

a significant contribution to the build-up of heavy metals within Nha Trang Bay. The two most developed aquaculture areas in the MPA, Vung Me and Tri Nguyen, are likely to be at greatest risk from these impacts due to their proximity to Nha Trang and the Cai River estuary.

Within Nha Trang Bay itself there are various sources of pollution that threaten aquaculture. These include rubbish from tourism and villages, human waste from boats and villages, and bilge water and oils from shipping. Culture of filter-feeding species may be particularly susceptible to human waste if appropriate controls are not put in place. Furthermore, the expansion of Cau Da Port will see an increase in shipping traffic in and out of Nha Trang, with associated navigation risks and chances of maritime pollution posing serious threats to nearby aquaculture farms.

2.4.3.7 Social Issues, Inequitable Opportunities, Access to Credit

Since the establishment of Hon Mun MPA, access to traditional fishing grounds has been restricted, with the associated socio-economic impacts being borne mainly by MPA residents. The majority of residents considers aquaculture among the most suitable options for alternative livelihoods and has raised concerns about access rights to areas suited to aquaculture development.

According to household surveys and other data, between 30 and 45% of aquaculture cages within the MPA are owned by non-residents; however, over the last three months "outsider" ownership has increased rapidly. While the remaining cages were reported to be owned by local islanders, this does not take into account joint ownership arrangements, which are varied and difficult to quantify. Many units are only partly owned by local islanders with investment from outsiders. It is clear from the statistics that a large proportion of the financial benefits of aquaculture are not staying within the MPA villages, but are instead flowing to investors from outside the MPA.

An increasing number of people living within the MPA rely on credit to invest in aquaculture activities, usually for the culture of lobster and grouper. The cost of an aquaculture cage ranges from 3-3.5 million VND (US$ 200-233), while loans range from 1-10 million VND (US$ 33-333). The average loan is 4.7 million VND (US$ 313) and is taken out by people who have collateral to repay the loan should they default. This limits access to loans to those people that have a good income stream, have collateral and typically have experience in larger scale businesses. The unofficial selection criteria above often make it difficult for poorer families to receive credit.

3. Addressing Issues and Proposed Actions

In summary, the issues concerning the promotion of local livelihoods through sustainable aquaculture practices can be categorized as:

1. *Technical issues*: use of wild-caught seed, trash fish and other low-value commodities for feeding; monoculture; disease; application of simple culture technologies that limit suitable areas for aquaculture
2. *Environmental planning and management issues*: inadequate planning and zoning; lack of supporting legislation (regulations) and codes of practice
3. *Economic issues*: lack of capital; unstable, developing markets, and
4. *Social issues*: poverty, inequitable opportunities for local resource users.

This section of the report addresses each of these issues in relation to Hon Mun MPA and provides a series of actions and recommendations for the development of sustainable aquaculture.

3.1 Technical Issues

3.1.1 Use of Wild-caught Seeds for Stocking

Rapid development of lobster and marine fish culture has resulted in increased demand for wild-caught seed in the MPA in recent years. The demand is also affecting areas outside the MPA as the dramatic surge of prices for juvenile lobsters recently forced local lobster farms to seek seed-stock from other provinces. The widespread use of wild-caught seed for stocking in aquaculture is unsustainable and ecologically damaging in the long term. The following activities have been considered to address this issue.

3.1.1.1 Research and Development of Hatchery-produced Seeds

As signs of depletion have already occurred, further development of lobster culture and, to a lesser extent, grouper culture may seriously compromise wild stocks within the MPA. High-quality hatchery-produced seed should therefore be used instead of wild-caught seed. The use of disease-resistant hatchery-produced seed will also limit the use of chemicals and antibiotics for disease prevention and treatment. Research and development on artificial seed production, for most potential culture species, requires substantial time and resources, and may not be possible for a number of species.

At present, artificial seed production is possible for only a limited number of grouper species such as *Epinephelus coioides* and *E. malabaricus* (Sadovy, 2000) and there is limited possibility of producing artificial seeds for spiny lobster *(Panulirus ornatus* and *P. homarus)* culture. While technically possible, the production of artificial seeds for most species of spiny lobster is not commercially viable, due to a long larval stage of up to 300 days and low survival in the nursing system.

It has been known that, although possible, the production of artificial seed for most species of spiny lobster is not commercially viable, due to long larval stage (up to 300 days depending

on species) and low survival in nursing system. As signs of depletion have occurred, further development of lobster culture and, to a lesser extent, grouper culture may seriously compromise wild stocks.

The research and development of hatchery-produced seed is beyond the Project's capability due to constraints in time and resources. But it is possible to orient research and development efforts at national aquaculture research institutions through recommendations and coordination of expertise and resources. This is in itself desirable because conservation of marine biodiversity cannot be confined to MPAs. Investment in aquaculture research and development is in the national interest, not only because it will contribute to the economy of the country, but also because it can be used to reduce pressure on wild-stocks beyond the boundaries of MPAs.

3.1.1.2 Limiting Development Scale

Limiting the development scale of aquaculture (i.e., the quantity of seed collected) to sustainable levels may be possible. However, marked inter-annual fluctuations in recruitment of juveniles for many marine species would make the setting of collection targets extremely difficult. Policing targets would be difficult as they may conflict with the perceived need for economic growth in poor coastal communities. This could also result in problems associated with equitable access (i.e., who is and who is not allowed to operate aquaculture).

3.1.1.3 Diversification of Culture Species

Diversification of culture species appears to be a practical solution. This can be done through carefully screening and introducing new species, following detailed research on their life histories, ecological impact and economic viability. To assist this process, various criteria for sustainable development of aquaculture have been developed to determine the suitability of different species. These criteria, which emphasize the need for sustainability, integrated planning and minimizing adverse environmental impacts, have been discussed with local communities, and include:

- Species that occur (or previously occurred) naturally in local waters (i.e., within known distribution ranges)
- Species with habitat requirements well represented in MPA waters
- Species whose life cycle is "closed" in the laboratory, with seed-stock readily available (no wild harvest of stock)
- Species whose food supply is ecologically sustainable (e.g., no use of "trash fish")
- Species that show strong vigor in cage culture, with resistance to disease
- Species that are easily reared in a village setting, requiring no major technological inputs
- Species that do not cause major pollution of surrounding waters, sediments or substrata
- Species that provide opportunities for multi-species aquaculture, including recycling of waste products, and

- Species that are economically viable and provide a reasonable return on investment.

Based on these criteria, 12 potential aquaculture species were identified for consideration for culture within the MPA (Dau and Nga, 2002) and three more species have since been added to the list (Table 4).

Table 4 Current Status of Seed and Feed Supply, Culture Technology and Market of 15 Candidate Species for Aquaculture in the MPA

Potential Candidates	Seed Source	Seed Quantity	Feed	Market	Demand
1. Seaweed *Kappaphycus alverezii*	Wild	abundant	-	International	high
2. Green mussel *Perna viridis*	Wild	abundant	-	Domestic	low
3. Babylone *Babylonia areolata*	Hatchery	limited	trash fish	Domestic/ International	high
4. Oyster* *Crasostrea rivularis*	Wild	abundant	-	Domestic	low
5. Pearl oyster* *Pteria martensii*	Hatchery	abundant	-	Domestic	low
6. Cobia *Rachycentron canadum*	Hatchery	limited	trash fish, pellets	Domestic/ International	low
7. Sandfish *Holothuria scabra*	Hatchery/ Wild	limited	-	International/ Domestic	high
8. Swimmer crab *Portunus pelagicus*	Hatchery	limited	trash fish	Domestic/ International	high
9. Abalone *Haliotis assanina*	Hatchery	limited	*Gracilaria***	International	high
10. Seahorse *Hippocampus* spp.	Hatchery	very limited	Under research	International/ Domestic	high
11. Grouper *Epinephelus malabaricus* and *E. tauvina*	Hatchery/ Wild	limited	trash fish, pellets	International/ Domestic	high
12. Lobster *Panulirus ornatus*	Wild	limited	trash fish, shellfish	International	high
13. Sand bass *Persammoperca waigiensis*	Hatchery	very limited	trash fish	Domestic	medium
14. Sea bass *Lates calcarifer*	Hatchery	limited	trash fish, pellets	Domestic	medium
15. Rabbit fish* *Siganus guttatus*	Wild	abundant	Pellets	Domestic	medium

* newly added
** not available locally

Among these 15 candidates, trials have been implemented for species whose seedlings are available, including seaweed *(Kappaphycus alverezii)*, green mussel *(Perna viridis)*, sandfish *(holothuria scabra)*, rabbit fish *(Siganus guttatus)* and groupers *(Epinephelus malabaricus* and *E. tauvina)* since the last quarter of 2002 (Figures 11 and 12). The first two species are "new" to local farmers, but have been cultured successfully in adjacent areas. Sandfish culture in pens is still at experimental stages globally. Rabbit fish have been cultured

intermittently by a few local farmers, but fish often died in monoculture cages due to unknown reasons (probably because of improper feeds and feeding management).

Groupers Cultured by HMMPA Project *Checking Seaweed Cultured in the MPA*

Figures 11 and 12 Groupers Cultured by Hon Mun MPA Project and Checking Condition of Seaweed Cultured in Hon Mun MPA

Hatchery-produced grouper fingerlings, produced by a Taiwanese-run hatchery in Khanh Hoa, are being trialed by the Hon Mun MPA Project. High survival and good growth of these fish have changed the perspectives over seed quality (farmers often consider wild seeds to be of superior quality) and formulated feeds. After two months of culture, survival of groupers was 100% in one trial and 80% in another. The latter trial is located in Vung Me, a well-developed area with signs of self-pollution. At this location fish were infected by parasites and bacteria.

Seaweed trials have shown great success, as farming technology (i.e., using lines) is simple and growth rate of seaweed has been high. Daily weight gain ranged between 2 and 10% per day depending on locations. Culture period is short at approximately two months. Initial results of green mussel and rabbit fish trials are also promising.

Trials indicate that there are a variety of species other than marine fish and lobster that can be cultured successfully to help improve livelihoods of local villagers. However, the limiting supply of both wild and hatchery seed-stock is an obvious barrier to culture diversification in Hon Mun MPA. As advances are made in hatchery and culture technology, new species may be added and reappraisal of the 15 identified species required.

3.1.2 Use of "Trash Fish" and Shellfish for Feeding

Because of the relatively high cost and limited availability of formulated feeds, trash fish and increasingly shellfish are used extensively as feed within Hon Mun MPA. Although clearly associated with good growth of culture species, the use of trash fish has been long considered unsustainable, with serious ecological impacts. The harvest of trash fish and shellfish may produce cascading ecological effects, as their ecological significance is not well understood. Further, some of the trawled trash fish may represent juvenile stages of target fishery species (e.g., lutjanids, serranids, lethrinids).

The use of trash fish and shellfish also results in degradation of water and sediment quality due to increased nutrients and suspended solids. A recent study of grouper culture at Vung Me and Vung Ngan showed that total suspended solids varied from 61.4 to 106.6 mg/l, exceeding the aquaculture water quality standard set by the Ministry of Fisheries of Vietnam. In general though, water quality in Hon Mun MPA is well suited to well-managed aquaculture due to high rates of exchange with oceanic waters. Estimated retention time of coastal waters in Nha Trang Bay is from six to seven days (Khanh Hoa Department of Fisheries, 2002).

The use of trash fish also increases the risk and transmission of disease in the culture species. For example, grouper cultured at Vung Me and Vung Ngan are commonly infected by a number of pathogens including parasites *(Megalocotyloides epinepheli, Benedinia spp, Pseudorhabdosunochus epinepheli)* and bacteria *(Vibrio spp.* and *Flexibacter spp.)*.

The following actions are thus proposed to eliminate the practice of using trash fish and shellfish as feed.

3.1.2.1 Development of Culture Species That Use Naturally Available Foods (i.e., filter feeders, detritus feeders)

As mentioned above, seaweed *(Kappaphycus alverezii)* and green mussel *(Perna viridis)* have been cultured successfully in areas adjacent to the MPA. These species, as well as detritus-feeding sandfish *(Holothuria scabra)*, were well accepted by farmers during the aquaculture trials.

3.1.2.2 Development of Cost Effective Commercial Pellets That Facilitate Good Growth of Culture Species

Good growth rate of groupers (i.e., daily weight gain of fish of 3.1-5.1%/day for the first two months) has been achieved using commercial pellets as the sole feed. This achievement has changed the perspective of local farmers who initially believed that groupers would not accept pellets or grow when fed pellets alone. Nonetheless, further assessment and improvement of the pellets used for feeding groupers (produced by Hai Phong Research Institute for Marine Products) is needed to ensure an acceptable food conversion ratio (FCR) and digestibility, in order to be commercialized and well accepted by aquaculture operators.

3.1.2.3 Modification of Feeding Practice

The use of artificial feeds to supplement, and thus reduce, the use of trash fish, is a practical recommendation that is likely to be accepted by local farmers if shown to be profitable. This would help reduce environmental impacts on the MPA and gradually direct aquaculture development to more sustainable practices. However, the combinations of different feed types for different culture species would require further research and development by national research institutions.

3.1.2.4 Extension Services

The introduction of any new technology – be it new culture species, feeds or methods – would require extension services for promotion among local farmers. Initially, this can be done through collating information on cost-effective, low-impact feeding practices or

availability of artificial feeds. Artificial feeds could then be introduced for consideration by local aquaculture farmers.

3.1.3 Mono-species Aquaculture and Risks of Diseases

The focus of aquaculture activities on just two groups of carnivorous species, groupers and lobsters, increases susceptibility to disease and fluctuations in the market value of seed and feed.

After the initial boom period from 1996-98, annual production of cultured marine fish in Nha Trang Bay dropped significantly from 66-73 tons to 13-19 tons in 1999-2000 (see Figure 8 above). This was largely due to disease outbreaks, and triggered a shift to lobster culture, which is considered less susceptible to disease. A recent study by the Project showed that groupers cultured in Vung Me are commonly infected by parasites *(Diplectanum spp.)* and opportunistic bacteria, which cause necrosis. According to descriptions by grouper farmers, viral diseases (Viral Nervous Necrosis) also occurred commonly in summer.

Although there have not been any rigorous studies on diseases in cultured lobsters, mortality occurs occasionally, with lobsters failing to molt or their bodies and/or gills turning red before dying. The use of trash fish for feeding is considered as one of the chief sources of these diseases, as rotting fish or fresh, pathogen-carrying fish and crustaceans can cause or transfer diseases to culture animals (SEAFDEC, 2001). Furthermore, the focus on carnivorous species introduces nutrients (i.e., leaching from trash fish) into the water column, making it more favorable for fish pathogens to grow.

These issues can be addressed through the following three ways:

3.1.3.1 Screening of Seed-stock

Screening seed-stock can be done by local qualified agencies. In this regard, the Project is helping to establish contact between these agencies and local farmers, and improving awareness of local farmers through education.

3.1.4 Limited Culture Technology/Systems

The present culture systems for lobster and grouper consist of nets and cages supported by simple wooden frames on floats. These systems are unable to withstand hyperdynamic areas with strong currents and wave action. The recently introduced culture systems for several of the new species such as seaweed (using floating draft) and green mussel (using poles) are also restricted to inshore or sheltered areas. Culture areas are therefore restricted to inshore waters and year-round protected bays (e.g., Vung Me, some areas in Bich Dam and Dam Bay), mostly within 100 m of shore and typically close to island villages.

The limitations of the present culture systems, and the lack of suitable locations, intensify ecological impacts and space conflicts by encouraging clustering of aquaculture operations in sheltered areas. With rapid unregulated development, areas such as Vung Me and Tri Nguyen are at, or close to, their carrying capacity and prone to self-pollution problems.

As Vung Me and Tri Nguyen have approached their carrying capacity, there has been increasing aquaculture development in other areas within the MPA, with investment by both

local people and outsiders. However, areas such as Dam Bay and Bich Dam, which appear suitable for existing culture systems, are in close proximity to the core zones of the MPA. Careful consideration should therefore be given to any aquaculture development in these areas due to the potential impacts they may have on sensitive core zone areas.

This issue can be addressed through the following:

3.1.4.1 Introduction of New Culture Technology/Systems

Development of new culture systems that are more durable to wind and wave action, or that can more effectively utilize the water column, would help to optimize water surface use and reduce self-pollution problems. While systems such as the Norwegian submersible cages are not affordable to local people, similar systems could be developed locally at lower costs. In addition, it may be possible to restrict aquaculture farmers from outside the MPA to more exposed areas, thus forcing them to use new, more durable systems while leaving the inshore areas for local villagers, who are by comparison financially disadvantaged.

The Project has recently initiated development of an integrated culture system with sandfish (detritus feeders) cultured beneath lobster or marine fish cages. This not only helps to reduce space conflicts, but also reduces the threat of pollution, as sandfish are able to utilize and clean sediments enriched with organic matter derived from the cage culture above. While the trial system is yet to be completed and evaluated, the concept is sound and good results are expected.

3.2 Planning and Management Issues

3.2.1 Legal, Institutional and Policy Frameworks

In Vietnam, the Ministry of Fisheries has the primary responsibility for the management of marine fishery resources and the development and management of aquaculture. The Ministry of Science and Technology currently has responsibilities for biodiversity, water quality and Environmental Impact Assessment; however, these responsibilities are being reviewed in response to the creation of a Ministry of Natural Resources and Environment in mid-2002.

Vietnam's National Development Plan is seeking to maximize production from the coastal zone through fisheries development and other industries. The Plan recognizes the decline of coastal fisheries and seeks to reduce fishing pressure by encouraging the exploitation of off-shore fishing resources, and by promoting aquaculture development. The development of tourism is also a priority, with a particular focus on coastal tourism.

The strong aquaculture focus of the National Development Plan means that any aquaculture that is developed is seen as making a positive contribution to the national economy. However, the long-term costs of the impacts of aquaculture have not yet been incorporated into the economic analysis. There are concerns that national development planning, while seeking to address national aspirations for economic development in the short term, may in the long term, result in further degradation of coastal resources.

This issue can be addressed through the following:

3.2.1.1 Integrated Planning

There is a strong need to develop integrated planning to ensure that a comprehensive approach is adopted for future coastal development, taking environmental and resource sustainability into consideration. Integrated planning should occur at national, provincial and local levels. As such, the national aquaculture production target of one million tons by 2010 should be considered at all levels of government in the light of integrated planning.

3.2.2 Lack of Planning, Zoning and Compliance of Regulations in Aquaculture Development

Regulations of aquaculture development are defined under existing legislation. The development consent authority is determined by the area, extent and type of aquaculture development. As many of the aquaculture developments within Hon Mun MPA are small in scale, informal approval is provided at the village level. However, while one small aquaculture farm may have limited environmental impacts, the cumulative impact of the many small developments needs to be clearly identified and carefully considered.

Additionally, there is no zoning plan for the development of aquaculture within the MPA. Sites are selected by operators based on their experience and preconceived notions of the needs of culture species. No consideration is given to the location of species that pollute by adding nutrients into the system, species that are capable of directly absorbing nutrients such as seaweed, and species that remove nutrients by feeding on phytoplankton and zooplankton. There is also no consideration of potential conflicts or resource sharing with other users in the MPA.

These issues can be addressed through the following five ways:

3.2.2.1 Licensing of Aquaculture within the Hon Mun MPA

Aquaculture operations within the MPA will be permitted through a limited licensing system that regulates the type of aquaculture to be undertaken and provides strict guidance on the operation of the aquaculture. This will include seed sources, food types, waste management and minimum equipment requirements.

3.2.2.2 Hon Mun MPA Aquaculture Masterplan

It is proposed that a "Hon Mun MPA Aquaculture Masterplan" (Masterplan) be developed to guide the development and practice of aquaculture within the MPA. The Hon Mun MPA Authority, together with relevant stakeholders, will develop the plan. This comprehensive Masterplan will become an integral part of the Hon Mun MPA Regulation and Zoning Scheme, minimizing conflicts with other resource users in the MPA, and providing guidance on the areas outlined below.

3.2.2.3 Planning and Zoning

The Masterplan will establish zones for the culture of different species within the MPA. These zones will seek to balance the different culture species and form the basis of an integrated system designed to minimize nutrient inputs into surrounding waters and other

environmental impacts. An essential component of the Masterplan will be identification of the carrying capacity of each of the proposed aquaculture areas.

The balance between different feeding types – carnivores (grouper, cobia, babylone snail), filter feeders (mussels, oysters), detritus feeders (sandfish) and nutrient absorbing species (seaweeds) – will depend on the local hydrographic conditions, bottom topography and habitat, as well as market opportunities associated with each of the culture species.

To ensure that the zoning system is compatible with other resource use within the MPA, local users will be involved in the planning and zoning process. Maximum permitted areas for the culture of specific species will also be identified during the process.

3.2.2.4 Monitoring Effectiveness of the Masterplan

A monitoring program will be developed to detect environmental and social changes during the implementation of the Masterplan, and to assess its effectiveness. Local users will be involved in the interpretation of monitoring results as well as the review and subsequent revision of the Masterplan and zoning system.

3.2.2.5 Waste Management

Waste management will be a critical element of the Masterplan. Waste disposal techniques and methods for enforcement will be identified together with local users. The prevention and management of land-based and maritime pollution, which threaten aquaculture development, are beyond the scope of the Project, but will also be raised in recommendations on environmental management at provincial and national levels.

3.3 Economic Issues

3.3.1 Market Instability and Constraints

Aquaculture operators are at the mercy of market forces. Recent examples include the reduction in the price of grouper and increases in the price of trash fish. In this regard, monoculture systems are susceptible to supply and demand fluctuations and associated risks, while diversified aquaculture minimizes such risks.

3.3.1.1 Species Diversification

The concept of diversified aquaculture and the benefits of integrated systems will be developed in the Masterplan. This will be strengthened through the introduction of sound and affordable technologies for the culture of new species within the MPA, as described in section 3.1.1.3.

3.3.1.2 Market Analyses and Promotion

Introduction of new aquaculture species and innovative techniques may produce high quality products; however, suitable markets must exist for their sale. Thus, trials of new culture species must be accompanied by careful analysis of existing and potential markets. This

requires research, consultation with existing commercial operations, promotion and marketing of products, and identification of new markets.

3.4 Social Issues

3.4.1 Poverty and Destructive Fishing

One often-stated reason for destructive fishing is that it is the "poorest of the poor" undertaking these activities to meet their immediate needs. However, overall poverty levels within the MPA are not considered overwhelming by MPA residents, and while modest, standards of living are higher than in other areas in Vietnam.

Despite modest standards of living, people living within the MPA do not undertake blast fishing. It is people from mainland villages visiting the MPA who undertake this activity. The reason stated for this is poverty, which may be the case; however, it is more likely to be the result of a combination of economic incentives, the open access nature of fishery resources and the lack of enforcement.

Poison fishing for the aquarium trade is prevalent and undertaken by both MPA villagers and outsiders. Some species sell for over US$ 100/fish on the open market. Thus, although there is a good understanding of the impacts of cyanide fishing, the economic returns of this illegal practice far exceed those of traditional fishing, and with lax enforcement, continue unchecked. Additionally, investment in equipment for cyanide fishing, i.e., boat, wetsuit, compressor and diving equipment, is relatively high, re-enforcing the concept that it is not the poorest sector of the community undertaking this activity.

It is crucial that enforcement is undertaken to prevent both of these illegal activities, particularly dynamite fishing. In addition, efforts need to focus on the identification of non-destructive approaches to the collection of aquarium fish.

3.4.1.1 Alternate Income Generation (AIG)

The provision of credit to address illegal and environmentally damaging fishing activities is often incorporated into development plans. However, if this serves to promote a shift from unsustainable fishing to unsustainable aquaculture, which relies on wild stocks for both a source of seed and feed and also leads to pollution, then the AIG activities must be considered as "perverse incentives" which erode natural capital.

Alternative income generation activities must thus be closely linked to promoting aquaculture that is well planned, sustainable and in compliance with existing guidelines and regulations. The development of the Masterplan will be an important step towards the development of sustainable AIG activities.

3.4.2 Inequitable Distribution of Resource Ownership

Local resource users have a greater stake in the use of their local environment than outsiders, and issues such as deterioration in water quality will have a direct impact on their quality of life and ability to generate income. Conversely, outsiders conducting aquaculture in the MPA are often perceived to be more interested in economic returns than long-term sustainability.

Furthermore, if the area of aquaculture expands rapidly due to an influx of outside investors, there may be little area remaining for suitable aquaculture by local people. Under these conditions, local people are at risk of being marginalized because of their financial and technical disadvantages.

3.4.2.1 Priorities for Local People

In Hon Mun MPA, it is proposed that priority allocation of sites be provided to local people seeking to undertake aquaculture activities. This will be carried out through a system whereby the allocation of use rights for designated areas will be established solely for local people. Local people will then have the opportunity to lease their rights to investors from outside the MPA. The establishment of this system will be an important part of the planning process. This will not impact significantly on the aquaculture activities of outsiders, as it would be developed and introduced over a number of years.

3.4.3 Inequitable Distribution and Access to Credit Opportunities

Access to credit is often determined by the capacity to repay the loan, ability to offer collateral and experience in business operations. As a consequence, it is often wealthy people within a community who have better access to credit. The total amount of on-going loans in the MPA is estimated to be 2.7 billion VND (US$ 180,000), with nearly 60% of households having access to formal credit. Loan amounts range from 1-10 million VND (US$ 67-667), with an average of 4.7 million VND (equivalent to US$ 313). Lack of access to credit for poorer villagers reduces opportunities to invest in the development of sustainable livelihoods. In addition, links are often established between "middlemen" and aquaculture operators, whereby local operators become indebted to middlemen for the provision of seed, feed and equipment.

3.4.3.1 Revision of Current Credit Provision Systems

The current credit provision systems need to be evaluated and carefully revised to maximize access by poorer members of the community and thus provide for a more equitable form of social development. Coupled with additional technical support and supervision, it is anticipated that poorer members of communities could also develop successful aquaculture ventures in a sustainable manner.

Furthermore, aquaculture has particularly high potential for improving the income generating capacity of the large number of unemployed women in poorer communities. The majority of men continue to perceive their primary occupation as fishing, and aquaculture as a secondary activity. However, it is often women and older members of families (i.e., parents and grandparents) who are left to maintain the aquaculture operation on a daily basis. Thus, aquaculture may be a means of improving the role of women in generating income to support local livelihoods.

3.4.4 Reluctance to Change Aquaculture Systems

Aquaculture is an important livelihood activity for local people. Investments in aquaculture are often substantial and thus there is reluctance and caution when considering other options such as new species and technologies for the culture of these species. New technology and

culture species are considered to be high risk and unsustainable practices are continued through a lack of knowledge and information.

3.4.4.1 Education and Extension Services

The Project, with relevant government agencies and promoters of aquaculture, are now encouraging diversification of aquaculture through trials and demonstration. These are being undertaken with the full involvement of local people.

Conversely, risky and untested aquaculture activities should not be promoted to local people. The risks involved with such activities should be borne by the agencies. Comprehensive education and training programs, and extension services, are needed to help local aquaculture farmers and fishers who have a desire to implement sustainable aquaculture practices. It is envisaged that these would provide technical know-how and other services concerning financial support and marketing.

4. Recommendations and Concluding Remarks

Aquaculture does and will increasingly play an important role in the livelihoods of local coastal communities and may provide an alterative income source for those communities currently undertaking unsustainable and destructive fishing practices. However, there needs to be great caution in approaches to aquaculture development to ensure that it can be carried out in a sustainable manner.

Key points in the development of sustainable aquaculture for coastal communities:

- Planned aquaculture: Plans must be developed to ensure optimal use of available surface water space. This should be developed to minimize pollution and conflicts between resource uses.
- Development of integrated farming systems to minimize inputs into the environment.
- Allocation of spatial rights: Rights should be allocated to local people to ensure access to water surface areas for aquaculture. Development of aquaculture by "outsiders" needs to be carefully planned and considered.
- Seed-stock should be drawn from hatcheries and no wild seed collection should be permitted.
- Food supply should not be provided through destructive fishing methods, i.e., trash fish.
- Research and development should be encouraged to develop sustainable aquaculture.
- Providing equitable access to credit for local people, in particular the financially disadvantaged.

Sustainable coastal fisheries:

- Development of "no-take" zones to maintain the local fisheries, particular in coral reef areas.
- Elimination of all destructive fishing practices through education and enforcement.
- Consider replenishment and restoration of natural populations through aquaculture technology.

If successful, these initiatives, with the other additional income streams being developed, should help to ensure improved livelihoods for local villagers and conservation of the MPA's outstanding biodiversity attributes.

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7. Annex Table

Commercially Important Species of Fish, Mollusk and Echinoderm Absent from Hon Mun MPA in 2002 that were Previously Recorded (PR) or were Likely to Occur, Based on Known Distribution Ranges (DR) (from Vo et al. 2002d, e)

Family	Species	Previously Recorded (PR) or within Known Distribution Range (DR)
Pomacanthidae	*Pomacanthus imperator*	PR
	Pomacanthus sexstriatus	PR
Lethrinidae	*Lethrinus nebulosus*	PR
	Lethrinus miniatus	PR
	Lethrinus xanthochilus	DR
Lutjanidae	*Lutjanus kasmira*	PR
	Lutjanus monostigma	PR
	Macolor niger	PR
Serranidae	*Anyperodon leucogrammicus*	PR
	Cephalopholis cyanostigma	PR
	Cephalopholis miniata	DR
	Epinephelus tauvina	DR
	Epinephelus fasciatus	PR
	Plectropomus oligacanthus	PR
	Plectropomus leopardus	DR
	Plectropomus maculates	DR
	Cromileptes altivelis	DR
Labridae	*Chelinus undulates*	DR
Haliotidae	*Haliotis assanina*	PR
	Charonia tritonis	DR
Holothuridae	*Holothuria scabra*	PR

The STREAM Initiative
Network of Aquaculture Centres in Asia-Pacific (NACA)
Suraswadi Bldg, DOF Complex
Kasetsart University Campus
Ladyao, Jatujak
Bangkok 10900 Thailand

Tel +66-2-940-5457
Fax +66-2-561-1727
Switchboard +66-2-561-1728-9 ext 108
E-mail ghaylor@loxinfo.co.th
Website http://www.streaminitiative.org

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Annex 4

IMPROVING COASTAL LIVELIHOODS THROUGH SUSTAINABLE AQUACULTURE PRACTICES – THE CASE OF TUBIGON, BOHOL, PHILIPPINES

IMPROVING COASTAL LIVELIHOODS THROUGH SUSTAINABLE AQUACULTURE PRACTICES

A Report to the Collaborative APEC Grouper Research and Development Network (FWG/01/2001)

Ronet Santos, Erwin Pador and Meddy De La Torre

2003

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Acronyms

BATFCA	Batasan Tropical Fish Collectors Association
BFAR	Bureau of Fisheries and Aquatic Resources
CBRMP	Community Based Resource Management Project
CLUP	Comprehensive Land Use Plan
CRM	Coastal Resources Management
CRMP	Coastal Resource Management Program
CSOs	Civil Society Organizations
CY	Calendar Year
DFID	Department for International Development (UK)
FAO	Food and Agriculture Organization of the United Nations
FARMC	Fisheries and Aquatic Resource Management Council
FGD	Focus group discussion
FNRI	Food and Nutrition Research Institute
FRMP	Fisheries Resource Management Program
FTC	Feed the Children
ha	hectare
HLURB	Housing and Land Use Regulatory Board
IMA	International Marine Alliance
km	kilometer
LGU	Local Government Unit
LHC	Live hard coral
LOGODEF	Local Government Development Foundation
MAC	Marine Aquarium Council
MAO	Municipal Agricultural Office
MDC	Municipal Development Council
MFARMC	Municipal Fisheries and Aquatic Resource Management Council
MPDC	Municipal Planning and Development Coordinator
MPDO	Municipal Planning and Development Office
NGO	Non-governmental Organization
mt	metric tonne
PCRA	Participatory Coastal Resource Assessment
PLA	Participatory Learning and Action
PNP	Philippine National Police
SEAFDEC	Southeast Asian Fisheries Development Center
SPARK	Sharing and Promotion of Awareness and Regional Knowledge
SSI	Semi-structured interview
STREAM	Support to Regional Aquatic Resources Management
SUML	Silliman University Marine Laboratory
SWOC	Strengths, Weaknesses, Opportunities and Constraints
VSO	Voluntary Service Overseas
USAID	United States Agency for International Development
USPC	United States Peace Corps

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1. Background and Objectives of the Study

1.1 Background

This case study is part of STREAM's four-country research project, which is exploring how recent advances in sustainable aquaculture have helped and can help improve coastal livelihoods and prevent unsustainable fishing practices in reef fisheries.

The research team chose the level of municipality[1] (30,000 to 100,000 people) as the unit of analysis for this study. This is because most of the responsibilities for coastal resource management have been devolved to municipal governments (Rivera et al., 2002). In choosing the study site, the research team used these criteria:

a. Presence of a reef fishery at risk from unsustainable fishing practices
b. Degree of willingness of the local government unit to address the issue
c. Presence of civil society organizations (CSOs) such as non-governmental organizations (NGO) or social action centers of the Catholic church in the municipality, and
d. Potential of linking possible sustainable aquaculture projects with the private sector.

The research team chose the municipality of Tubigon in Northwestern Bohol as the study site because it satisfies all the criteria above (see Appendix 1 for location map of Tubigon). Furthermore, there had been several projects related to reef conservation, aquaculture and improvement of coastal livelihoods implemented in the area where lessons can already be gained. The success of the local government and civil society organizations in Tubigon in dramatically decreasing the practice of dynamite, cyanide and other illegal forms of fishing in the municipal waters of Tubigon is a source of inspiration and lessons for many coastal resource management (CRM) groups in the Philippines and in other parts of the world. The body of literature about the projects in the area is starting to become extensive. This study builds on this and contributes its own insights, based on recent developments, into what has been learned by previous observers.

The research team learned about the aquaculture initiatives in Tubigon through its informal links with members of a coastal resource management network in the Philippines. Particularly helpful was Stuart Green, a former Voluntary Service Overseas (VSO) volunteer in Bohol who now works for the CRMP, and facilitated the research team's entry into the study site. Stuart introduced the team to Engineer Noel Mendaña, who is the concurrent MPDC and LOGODEF Mariculture Project Director. LOGODEF is the NGO that introduced grouper, mudcrab and lobster culture projects in the area.

The research team included:

- Ronet Santos, Regional Programme Coordinator of SPARK, a VSO project encouraging local groups in the Philippines, Indonesia and Thailand to learn from

[1] The Philippines has about 1,500 municipalities; 60% of these are located in coastal areas.

each other about community-based natural resources management. Ronet's educational background is in inland fisheries, environmental decision-making and environment and natural resources management. He has more than twenty years of experience of working in development in the Philippines and in the last three years in Indonesia and Thailand.

- Erwin Pador has done studies on *Artemia salina* (brine shrimp) production in salt ponds for the FAO Bay of Bengal Programme (1989). He organized and conducted training sessions on fish pond management, extension methodologies, fisheries research and group dynamics for BFAR in Region 6 (1990-95). Recently he has been active in coastal resources management with his involvement with the FRMP, where he coordinates efforts of community organizing and capability-building along a sustainable development framework. He is also a reviewer of fisheries research undertaken at the zonal center of the Western Visayas Region and this includes the Resource and Social Assessment of Sapian Bay for the FRMP.
- Meddy de la Torre, a community development consultant and freelance researcher based in Cebu City, has over 15 years experience in community organizing and management of community development programs in the Philippines.

1.2 Objectives of the Study

The objectives of this study were to:

a. Characterize the coral reef fisheries in Tubigon, Bohol, Philippines, and
b. Derive lessons from the management interventions to eliminate unsustainable fishing practices and improve coastal livelihoods employed by various groups in Tubigon.

The key questions that this study is attempting to answer are:

- How can recent advances in aquaculture of grouper (including mudcrab and lobster) and reef fisheries help improve coastal community livelihoods and prevent unsustainable and destructive practices?
- Is there a role for the private sector in eliminating unsustainable fishing practices and improving coastal livelihoods?

2. Methods

2.1 Data Gathering

The data gathering methods used in the study were inspired by socio-economic assessment methods described in the socio-economic manual for coral reef management by Bunce et al. (2000). Other PLA-type methods that the research team is familiar with were also used. The research team focused on the "livelihoods" aspect of the projects in the area and did not conduct any form of technical resource assessment as other groups have done this.

The research team reviewed existing literature, conducted semi-structured interviews (SSI) and focus group discussions (FGDs), held informal talks with fishers who gave oral histories of fishing-related events in their villages, observed village activities and projects, and attended a workshop organized by one of the local groups in the area aimed at sharing their experiences. In most of the meetings with fishers, local government officials and NGOs, visualization techniques (such as resource mapping, matrices, ranking, seasonality diagrams and pie-charts) were used to assist in clarifying concepts and encouraging discussion to avoid the meetings becoming a one-way extractive exercise.

The research team interviewed more than 50 persons (see Appendix 2 for complete list) for the SSIs and the FGDs. The team tried to conduct SSIs and FGDs with as many groups with different perspectives within Tubigon as possible. This was, however, constrained by the non-availability of some of the people we wanted to interview during the time of our visits.

The members of the research team visited the area four times:

- 16-21 October 2002 (Meddy de la Torre)
- 24-27 October 2002 (Erwin Pador and Meddy de la Torre)
- 4-5 November 2002 (Erwin Pador, Meddy de la Torre and Dr Graham Haylor, STREAM Director)
- 17-22 November 2002 (Erwin Pador, Meddy de la Torre and Ronet Santos)

2.2 Data Collation and Analysis

The descriptive profile of the area is based on previous resource assessments. There was one done by the Silliman University Marine Laboratory (SUML) in 1997 and there were several village-based participatory coastal resource assessments (PCRA) done with the assistance of CRMP consultants and US Peace Corps (USPC) volunteers who worked with Feed the Children (FTC). Most of the descriptive analyses in this report – such as livelihood strategies employed by fishers, main sources of income, percentage contribution of each source of income, and livelihood outcomes – are based on the results of the SSIs and FGDs. These were then triangulated with existing written and unwritten information (there is not much written information) at the office of the municipal agriculturist (who is also responsible for

fisheries) and triangulated on several occasions with the fisheries technicians of LOGODEF, the municipal agriculturist[2] and fishers from other villages.

The Sustainable Livelihoods Framework developed by DFID was used throughout this case study in analyzing management interventions and results. A modified force-field analysis tool was used during some SSIs and FGDs to determine hindering and facilitating factors in the implementation of specific projects. The results of initial SSIs and FGDs were crosschecked with those done in the latter stage of the study.

The study started with the view that a strategy to improve coastal livelihoods would be likely to deal with asset-building and strengthening policies, institutions and processes. The research team's thesis was that the asset-building component of the strategy would likely include:

a. Building new skills, e.g., aquaculture (increasing human capital)
b. Encouraging group-building and networking (increasing social capital)
c. Providing alternative credit (increasing financial capital), and
d. Securing entitlement to reef area (increasing natural capital).

The component of the strategy related to policies, institutions and processes would likely include:

a. Formulating a clear policy with the participation of resource users
b. Communicating this policy clearly
c. Enforcement of the policy, and
d. Building the capacity of local governments for resource governance.

The research team also got inspiration from the evolutionary approach to documenting learning (through "significant change" stories) developed by Rick Davies (1998) of the Centre for Development Studies of the University of Wales in Swansea, United Kingdom. Change stories of specific persons are presented in boxes throughout this report.

[2] The municipal agriculturist knows a lot about the area but does not have the information properly documented and filed for easy retrieval in his office, a clear case of non-separation of knowledge from people, which is common in the Philippines. This becomes a problem when the person leaves the organization, as the knowledge goes with him.

3. Characterizing the Reef Fisheries of Tubigon

3.1 Coastal Resources

Silliman University Marine Laboratory (SUML) did the latest documented assessment[3] of the coastal resources in Northwestern Bohol[4] in 1997. The CRMP and FTC also conducted several municipal-wide and village-level PCRAs, some results of which appear in portions of this case study.

Tubigon has a coastal area of 133.3 km^2, which is much bigger than its land area of 81.87 km^2. Apart from coral reefs, the other coastal resources and marine habitats found in Tubigon are shown in Table 1.

Table 1 Status of Marine Habitats in Tubigon (based on participatory mapping)

Habitat	Area (ha)	Area (sq km)
Sandy Beaches	33	0.33
Rocky Shoreline	110	1.10
Inshore Flat	27	0.27
Seagrass Beds	219	2.19
Coral Reef	156	1.56
Estuary	7	0.07
Passes/Channels	82	0.82
Mangrove	335	3.35
Mudflat	59	0.59
Offshore Sandbar	14	0.14
Total Area - Terrestial (including islands) (excluding islands)	 6,195 6,148	 62 61
Length of Shoreline	13,273 m.	133 km
(including islands)	22,072 m.	220 km

Source: LOGODEF in Calara (2001)

3.1.1 Coral Reef Resources

The coral reef area of Tubigon is 156 ha (Calara, 2001). The specific location of the reefs is shown in Appendix 4. The live hard coral (LHC) cover of Tubigon was placed by SUML in 1997 at 40%, considered fair condition. The mean LHC cover in the Northwestern Bohol area, where Tubigon belongs, is 31.35%. SUML identified 63 coral species; this number is considered low by Philippine standards. The relatively low coral diversity and the high coral

[3] A group called Reef Check, an NGO, did the latest assessment in October 2002 but they had not come up with their report yet.

[4] Northwestern Bohol is composed of seven municipalities: Buenavista, Calape, Clarin, Jetafe (sometimes Getafe), Inabanga, Loon and Tubigon. See Appendix 3 for map of Nortwestern Bohol.

rubble indicate physical destruction of the reef from various destructive fishing methods and other natural factors such as typhoons. (See Appendices 5a and 5b for a more detailed description of the coral reef resources of Northwestern Bohol.)

3.1.2 Mangroves

Tubigon has a mangrove cover of 335 hectare (SUML, 1997). The area has mean sampling densities of 5,520 and 9,375 stems of *Avicennia marina* and *Rhizophora mucronata* respectively per ha (SUML, 1997). Tubigon shares with the neighboring town, Clarin, the distinction of having the densest overall mangrove saplings reported by Silliman University Marine Laboratory (SUML). Of the 27 mangrove and mangrove-associated species found in Northwestern Bohol, eight are found in Tubigon.

Table 2 Mangrove and Associated Species in Tubigon
(SUML, 1997, as cited in Green et al., 2002)

Families/Scientific name	Common Name	Present in Tubigon
1. RHIZOPHORACEAE		
Rhizophora mucronata	*bakhaw baye*	x
Ceriops decandra	*hangalay, lapis-lapis*	x
Bruguiera gymnorrhiza	*busaing*	x
Rhizophora apiculata	*bakhaw lake*	
Rhizophora stylosa	*bakhaw tigre*	
Ceriops tagal	*tungog, tangal*	
2. AVICENNIACEAE		
Avicennia marina	*piyape baye*	x
Avicennia officianalis	*piyape lake*	x
Avicennia alba	*piyape lake*	
Avicennia lanata	*piyape*	x
3. SONNERATIACEAE		
Sonneratia alba	*pagatpat*	
Sonneratia caseolaris	*pedada*	
4. COMBRETACEAE		
Lumnitzera littorea	*mayoro*	
Lumnitzera racemosa	*sagasa*	
Terminalia catappa	*talisay*	
5. MYRSINACEAE		
Aegiceras corniculatum	*saging-saging*	
6. PALMAE		
Nypa fruticans	*nipa*	x
7. EUPHORBIACEAE		
Excoecaria agallocha	*alipata, buta-buta*	x
8. MELIACEAE		
Xylocarpus granatum	*tabigi*	
Xylocarpus moluccanencis	*piyagaw*	
9. LYTHRACEAE		
Pemphis acidula	*bantigi*	
10. MYRTACEAE		
Osbornia octodonta	*tualis*	
11. BIGNONIACEAE		
Dolinchandrone spathacea	*tui*	
12. LECYTHIDACEAE		
Barringtonia asiatica	*bito-bitoon*	
13. FABACEAE		
Prosopis vidaliana	*aroma*	
14. GOODENIACEAE		
Scaveola frutescens		
15. PANDANACEAE		
Pandanus sp.	*pandan*	

3.1.3 Seagrass and Algal Beds

SUML (1997) identified six species of seagrasses in Northwestern Bohol at depths 0-3 meters and comprising approximately 555 ha. These species are *Cymnodocea rotundata, Enhalus acoroides, Halophila ovalis, Haloduli pinifolia, Halodule uninervis* and *Thalassia hemprichii. Sargassum* beds dominate at deeper depths with a biomass of approximately 37.25 g dry weight/m^2.

Forty-nine species of algae in 16 families also inhabit Northwestern Bohol. Twelve species are green algae *(Chlorophyta)*, 20 are red *(Rhodophyta)*, 15 are brown *(Phaeophyta)* and 2 blue-green *(Cyanophyta)*.

3.1.4 Nearshore Areas

Sites on the mainland of Northwestern Bohol are primarily composed of fine-textured sand, while island sites are composed of coarse sand (SUML, 1997). The soft-bottom areas are dominated by polychaetes. Other organisms include crustaceans. Of the polychaetes, spionids are the most represented families in terms of number of species and density.

3.1.5 Open Waters

Plankton composition of open waters off Northwestern Bohol is dominated by zooplankton (SUML, 1997). The zooplankton community consists of tintinnids, nauplii, copepods, larvaceans, gastropods and bivalves. Other groups include diatoms (31.5%), dinoflagellates (7.13%) and other algae (0.24%).

The phytoplankton community is mainly made up of diatoms, blue-green algae and dinoflagellates. The diatoms are composed of 58 species. Forty-seven species of dinoflagellates belonging to 20 genera are present, including some species that cause red tide. Most of the identified dinoflagellates are not toxic, but their potential blooms can result to lowering of water quality.

3.1.6 Fish Diversity and Abundance

The visual census conducted by SUML (1997) in Northwestern Bohol yielded 130 species belonging to 26 families. All the species were reef, or reef-associated. Two families with the most number of species are *Pomacentridae* (Damselfish, 33 species) and *Labridae* (Wrasse, 20 species). These are not typically targeted as food by fishers. Pomacentrids belong to the lower trophic levels, feeding mostly on benthic algae and plankton. Larbrids also belong to the lower trophic levels.

The only large predatory species observed by SUML in 1997 was *Lutjanus decussatus* (Snapper). Its density was low (less than 1 per 500 m^2), which indicates extreme over-fishing in the area. SUML did not find other large predators, such as families of grouper *(Serranidae)*, bream *(Lethrinidae)* or jacks *(Carangidae)*. They blamed this on the rampant practice of dynamite and cyanide fishing in the area. Other fish desired by fishers include 24 target species, most of which are reef-associated.

From the 1980s to 1999, specifically in Tubigon, there has been a decrease in yearly fish production from a haul of 1,075 to 824 metric tons in 1999 (Municipality of Tubigon, 1999).

3.2 Resource Use Patterns and Stakeholders

The different resource users and their activities that have an impact on the reefs in Tubigon are shown in Table 3. This section describes the different reef-related primary resource users and secondary stakeholders[5] and reef-related resource use patterns in Tubigon. The relevant organizations that have a presence in the area are described in Appendix 6.

Table 3 Reef-related Activities in Tubigon and Different Stakeholders (source: SSIs and FGDs of the research team, November 2002)

Reef-related Activities	Primary Stakeholders	Secondary Stakeholders	Relevant Organisations (at the Local Level)
Grouper fingerling collection and culture	Grouper fingerling collectors Grouper, mudcrab and lobster culturists	Buyer and supplier of fry and fingerlings Fish feed (trash fish) suppliers Hotels and restaurants who buy grouper (in the cities of Cebu, Tagbilaran and Manila)	LOGODEF Feed the Children Municipal government Village government
Fishing and gleaning	Fishers (The different gears used by the fishers in Northwestern Bohol where Tubigon is located are enumerated in Appendix 8) Gleaners (mostly women and children) Upland farmers who are part time fishers	Market vendors Fish eating public	Fishers associations Municipal government Village government FTC Haribon CBRMP
Aquarium fish collection	Fish collectors	Aquarium fish traders Aquarium fish buyers	MAC (Marine Aquarium Council) IMA Municipal government Village government
Tourism	Divers and snorkelers	Resort operators	Municipal government Village government

The 1999 CLUP of the municipality of Tubigon places the total number of marginal[6] fishers in the municipality at 1,463. There is no systematic registry of marginal fishers in Tubigon. The MAO gave us original copies of the results of the fisher registration forms that they completed in 1997. We compiled these into Table 4, which shows that there are only 467 fishers who registered and most of them are men. Our SSIs and FGDs in the communities

[5] This study used Bunce et al.'s (2000) definition of different reef management stakeholders. *Primary stakeholders:* people who directly depend on the reef for a living and who make direct use of the reef and its resources. *Secondary stakeholders:* people who do not use the reef and its resources directly, but make use of the products or services from the reef or whose actions may affect the reef. *Relevant organizations:* organizations with direct responsibility for managing activities affecting the reef or with an interest in the primary or secondary stakeholders.

[6] The Philippine government classifies fishery activities into three sectors: municipal, commercial and aquaculture. The term "marginal" here refers to municipal fishers. These are fishers who use boats with a displacement of not more than three gross tons. Fishers using boats beyond three gross tons are classified as commercial fishers.

clearly showed that there are more fishers and that there are more women fishers, although most of those who attended the SSIs and FGDs were men.

Table 4 Population of Tubigon Coastal and Island Villages[7] and Number of Fishers (based on MAO records)

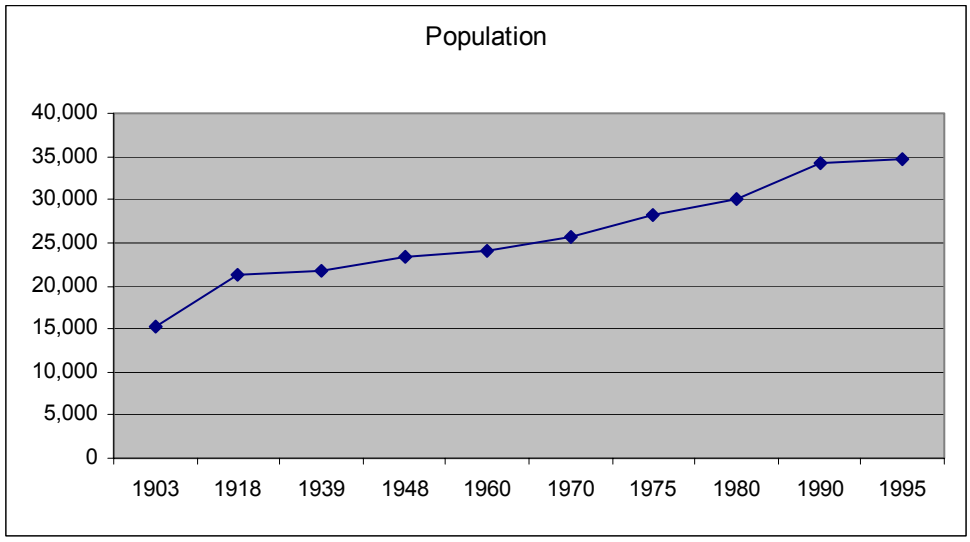
Village	Population (2000)	Number of Fishers[8] (1997)		
		Total	Men	Women
Coastal villages				
Macaas[9]	2096	25	25	
Panaytayon	2316	25	25	
Matabao	1037	30	30	
Pandan	1103	26	26	
Cabulihan	1890	25	25	
Centro Poblacion	2438	46	46	
Guiwanon	893	23	23	
Pinayagan Norte	1853			
Pinayagan Sur	2194	23	23	
Pook Occidental	1272	16	16	
Potohan	1397	23	23	
Tinangnan	2032			
Island villages				
Batasan	954	25	18	7
Bilang-bilangan	561	32	32	
Panggapasan	710	47	47	
Ubay	352	42	28	14
Mocaboc	394	34	34	
Bagong Banwa	728	25	25	
Totals	24220	467	446	21

Source: National Statistical Office (2001), MAO record of fishers

Based on the CLUP, the number of fishers declined from 1,773 in the 1980s to 1,463 in 1999. It is difficult to ascertain whether indeed the number of fishers is decreasing. The total population of Tubigon has steadily increased since 1900 (see Figure 1). A possible reason for the decline in the number of fishers, despite the steady increase in total population, is that the offspring of fishers chose to go into other lines of work. Many of the fishers we met had no offspring engaged in fishing; most of the men and some women are in Manila working in industrial parks (export processing zones) and most of the women have married non-fishers and have gone to other places.

About one-fourth (329 out of 1,463) of fishers have motorized *bancas* (boats), and another one-fourth (389 out of 1,463) have non-motorized boats, while about half do not own any *banca* at all. Fishers with motorized boats have an average production of four kilograms per day, while fishers with non-motorized boats have an average production of 1.5 kilograms per day.

[7] Tubigon has a total of 34 villages; the upland and non-coastal and island villages are not included in the table.
[8] From the MAO registration records.
[9] Villages in italics are LOGODEF project sites.



Source: Municipality of Tubigon CLUP 1999-2008

Figure 1 Population Growth in Tubigon from 1900 to 1995

3.2.1 Grouper Fingerling Collection and Culture

Green Grouper *(Ephinephelus sp.)* fingerlings are caught within Tubigon municipal waters, but the number is not enough to supply the needs of the present grouper culturists. Grouper culture in Tubigon was introduced by LOGODEF in 1998 as an alternative to unsustainable fishing methods such as the use of cyanide and dynamite in fishing. Red Snapper *(Lutjanus sp.)* is grown in the same cage together with groupers. Apart from grouper and snapper, mudcrab and lobster are also being grown, although there are no sources of seeds for these species in the area. Mussel and oyster culture were also tried but these trials failed. See Appendix 7 for background of grouper culture in the Philippines.

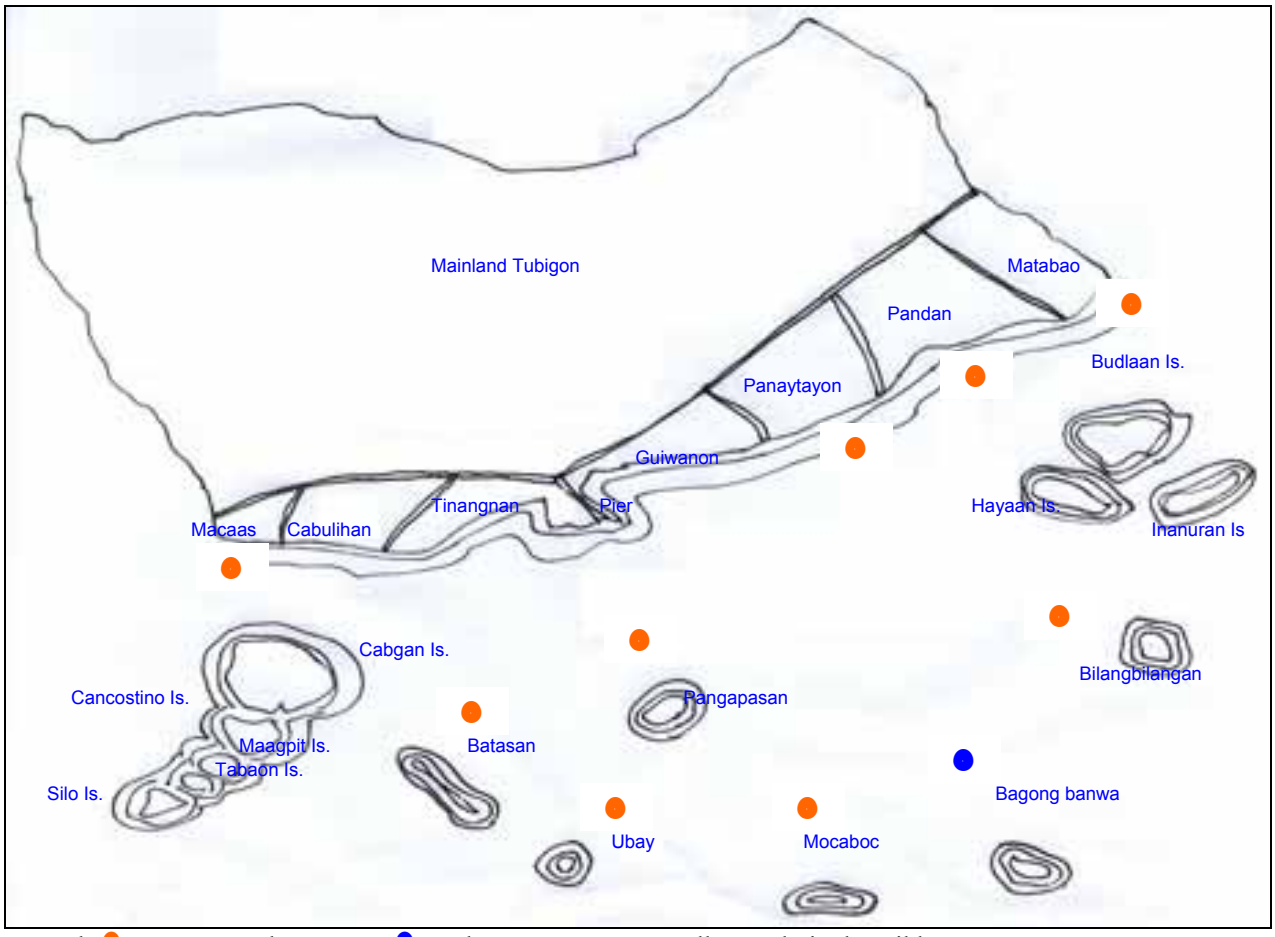
3.2.2 Grouper Fingerling Collectors

Fishers in Tubigon catch grouper fingerlings in the course of their major fishing activity; there are no full-time grouper fingerling gatherers in Tubigon. Only a small amount of grouper fingerlings are sourced from within Tubigon itself. Most fingerlings grown by culturists are caught in nearby municipalities, in other areas on the island of Bohol and as far as Bais City on the island of Negros (see map in Appendix 1). Grouper fingerling collectors sell a small number of fingerlings to "suppliers" who put the fingerlings they get from several collectors together in cages until they reach a marketable number. In their report, LOGODEF (Calara, 2001) listed 11 suppliers of fingerlings to their project, two of whom the research team was able to interview.

Grouper Culturists

There are 141 grouper culturists in Tubigon, organized into nine groups in seven villages. Seven groups are financially and technically assisted by LOGODEF while two groups are assisted by FTC. Many of the grouper culturists we interviewed were involved in some form

of illegal fishing in the past (use of dynamite, cyanide and banned active gears). Many of them are naturally hesitant to admit this, but made the admission when we promised that we would not divulge their names if they did not want us to, and midway through our informal conversation, realizing perhaps that admission does not really make a difference as the local government seems to know who the illegal fishers were in the past anyway.



Legend: ● = grouper culture areas, ● = where grouper are usually caught in the wild
Note: The distance between Pangapasan and the pier is approximately 7 kilometres, which should give a sense of distance and size of the islands. Source: SSIs and FGDs with fishers, CRMP resource maps in Green et al. (2000)

Figure 2 Map of Areas Where Grouper is Being Cultured

Fish Feed Supplier

The groupers are fed with trash fish (usually slipmouths, *parutpot* in the local language, *Leiognathus sp*.). LOGODEF identifies nine suppliers of fish feed (trash fish), eight from Bohol and one from Bais City.

Where does the trash fish come from? "*Sa mga ilegal, lagi*," Elsa Bulasa, from the village of Clarin and a mother of 11, whose son, Paulito, is one of the fish feed suppliers in the LOGODEF report, tells us. She said she buys her trash fish from illegal fishing operators (*liba-liba* operators, see Appendix 8 for description of fishing gears used in Tubigon) from outside Tubigon. What she seems to be suggesting is that the trash fish are caught by commercial fish operators from other municipalities who encroach in municipal waters. Such

encroachment is a big issue, not only in Tubigon and nearby areas in Bohol, but also in many areas in the Philippines; although encroachment is difficult to prove.

Noel Mendaña, project director of LOGODEF and concurrent MPDC, admits that the source of trash fish is a problem, not in the sense that it may be coming from illegal fishing, but because there is just a lack of it from within nearby waters. Trash fish suppliers outside the municipality sell the fish feed to the LOGODEF fishery technicians. The technicians in turn take care of transporting the fish feed from the centre of Tubigon, where it is delivered by motorcycle to coastal villages and by boat to island villages.

Table 5 Grouper and Lobster Culturists in Tubigon

Name of Fishers Association*	Location (Village)	Contact Person	Number of Culturists	Number of culture Cycles and Status	Source of Financial and Technical Assistance
United Batasan Fishermen Association (UBFA)	Batasan Island	Mr. Cosicol Rodrigo or Mr. Fortunato Salomon	20		LOGODEF
Bilangbilangan Fishermen Association (BFA)**	Bilangbilangan Island	Mr. Rolando Obguia	18		LOGODEF
Macaas Fisherfolk Association (MFA)***	Macaas	Mr. Rolando Caba	18		LOGODEF
Pangapasan Fishermen Association**	Pangapasan	Mr. Wilfredo Millomeda and Mr. Federico	27		LOGODEF
Panaytayon Fishermen Association	Panaytayon	Mr. Estanislao Cervantes and Mr. Felix Cervantes	14		LOGODEF
Matabao Fisherfolk Association	Matabao	Mr. Polinga Martino	10	1/operation stopped	LOGODEF
Pandan Fisherfolk Association	Pandan	Mr. Melecio Renato	18	1/operation stopped	LOGODEF
	Pandan		8	1	FTC
	Panaytayon		8	1	FTC
Totals			141		

* =all the groups grow red snapper together with the grouper
** = these groups also grow lobster
*** = this group also grow mudcrab in an enclosed mangrove area

Live Grouper Buyers

Most of the live grouper are shipped to restaurants in Cebu City such as the Grand Majestic Seafood Restaurant, Seafood City and Maribago Bluewater Restaurant. The LOGODEF report (Calara, 2001) enumerates three buyers of groupers. The grouper culturists do not deal with the buyers directly. It is the LOGODEF fishery technicians who contact the buyers, negotiate the price and arrange delivery. As far as the technicians know, the buyers of their live fish have not shipped the live groupers abroad, and this is confirmed by our phone conversation with the biggest buyer of the live groupers from Tubigon (see section on the possible role of the private sector).

Table 6 Sources of Income of Selected Fishers in Batasan before Introduction of Grouper Culture Project

Source of Income	Tony[10]	Edward	Paning	Felipe	Mesiah	Dodong	Victor
Gleaning	✔	✔	✔	✔	✔	✔	✔
Gill net (*catching lambay*)	✔	✔	✔	✖	✔	✔	✔
Fish pots (*timing*)	✔	✖	✔	✖	✖	✖	✖
Fish corral (*bungsod*)	✔	✖	✔	✖	✖	✖	✖
Use of *tubli*[11]	✔	✔	✖	✔		✔	✔
Manulo (gas-fueled gauze lamp with spear)	✔	✔	✔	✔	✔	✔	✔
Dynamite fishing	✖	✖	✖	✖	✖	✖	✔
Micro-bakery (making *pan Bisaya*)	✔	✖	✖	✖	✖	✖	✖
Fish drying	✔	✔	✔	✖	✔	✔	✔
Carpentry	✖	✔	✖	✖	✖	✖	✔
Barangay tanod[12]	✖		✔	✖	✖	✖	
Aquarium fish collection using cyanide	✔	✔	✔	✔	✔	✔	✔
Pig raising	✔	✔	✔	✔	✔	✔	✔

Source: FGD with fishers in Batasan, November 19, 2002

3.2.3 Fishers and Gleaners

The coastal resource map done by CRMP through PCRA in 1997 and 1998 gives an overview of the Tubigon coastal habitats, resources, uses and issues that the local government and civil society organizations in Tubigon confront. A copy of the map is provided in Appendix 4.

Fishers

The 1997 SUML profile of Northwestern Bohol reported that, based on interviews at various landing sites, 161 species are caught in the municipal waters in the area[13], composed of 133 species of fish, 16 species of mollusks, nine of crustaceans and three of echinoderms. Of the different species caught, 28.8% are reef-associated, 54.5% are non-reef (mostly pelagic) and 16.7% are unclassified[14].

A single fisher uses different gears, sometimes all at the same time or a single fishing gear depending on a particular season, so it is difficult (if not impossible) to disaggregate the number of fishers who catch reef-associated species. Fishers in different villages do specialize in a specific gear. For example, the fishers in the island villages of Batasan and Pangapasan (see map in Figure 2) are known gill net users catching portunid crabs, *Portunus*

[10] The names belong to the head of the family but the fishing activity that yields income includes those done by the wife and the children.
[11] A kind of poison derived from the root of the derris plant. Its use in fishing is considered illegal.
[12] Person responsible for maintaining peace and order in the village. They are paid about US$ 2 per month by the village government.
[13] According to the SUML report, all the surveyed fishers in the area used non-commercial fishing gear, so it is assumed that all the fish in the landing sites were caught in municipal waters.
[14] A complete listing of the fish species captured in Northwestern Bohol can be found in Green et al. (2002).

pelagicus (called *lambay* in the Boholano language); the fishers in the coastal village of Panaytayon are known lift net (cast and scoop net) users catching anchovy, *Stolephorus sp.*

In an FGD on sources of income before the introduction of the grouper culture project in the island village of Batasan, some fishers mentioned as many as seven gears that they use in different fishing-related activities that contribute to their income (see Table 6). Take note that some of these gears are illegal (use of *tubli*, cyanide and dynamite), but they all have stopped engaging in these illegal fishing practices. Most of the fishers who joined the FGD owned motorized boats (see Table 7).

The complete list of the different types of fishing gears used by the fishers in Northwestern Bohol is shown in Appendix 8.

Table 7 Type of Fishing Boat Owned by Selected Fishers in Batasan

Type of Fishing Boat Owned	Tony	Edward	Paning	Felipe	Mesiah	Dodong	Victor
Motorized	✔	✔		✔	✔		✔
Non-motorized			✔			✔	

Source: FGD with fishers in Batasan, November 19, 2002

Gleaners

Gleaning is an important source of income, although this seems to be hugely under-valued by government and NGO planners and by the fishers themselves. In all five villages we visited, gleaning, usually done by women and children, was mentioned as a source of income. Gleaners collect shellfishes, crustaceans and seaweeds at daytime (called *panginhas)* usually done by women and children and at night (*panulo,* aided by kerosene-fueled gauze lamp and spear gun), usually done by men. Gleaning is usually done on tidal flats and along the shore and not exactly on or near the reefs, although *panulo* may be done near the reef, according to some fishers.

One gleaner we met on our way to the village of Batasan was Manang Elpidia, mother of 12. She told us she usually gets one to five *kaltek* (a one-liter capacity motor oil can reused as a container) of different sorts of shellfishes from one gleaning operation. A *kaltek* would fetch her 15 pesos (US$ 0.28). She reckons she gleans 20 days in a month, which gives an additional income to the family of 300-1,500 pesos (US$ 6-28). She then listed the shellfishes she collects, most of which are not even listed in the SUML profile of the area in 1997. The names she mentioned were *amumpong, aninikad, litog, saang, tambayang* and several others we were not able to list down. She says when she goes gleaning there are usually around 50 other women and children with her. On our way back to the mainland from the island village of Batasan, we saw six women on their way to the tidal flat as the tide was receding.

Part-time Fishers

This seems to be a totally neglected stakeholder group. We did not have time to interview a single farmer who is engaged in part-time fishing primarily to catch fish for food. The MAO does not have a record of them, although he is fully aware of their existence. The fishers we met in the coastal villages told us that it is the part-time fishers from the uplands who use

tubli, electricity and other forms of illegal fishing. We assume that these part-time fishers do not have boats, so their fishing activity may be confined to the near-shore areas and therefore their impact on the reefs is negligible. Although some fishers told us that some part-time fishers go fishing with full-time fishers who fish near the reefs.

Market Vendors

Most of the captured reef-associated fish are sold in the local market of Tubigon. The wives of the fishers are usually the ones who bring the fish to the market. However, we met Tony (see Table 6) at the Tubigon pier on his way to the market with a basket containing a few *lambay* (crab) and some reef fish. The fishers' wives sell the fish to market vendors who in turn sell the fish to the public. The local fish and meat market in Tubigon is quite small, with less than 20 market vendors.

Fish-consuming Public

Tubigon had a population of 40,385 in 2000. In 1999, using per capita food requirements recommended by the Food and Nutrition Research Institute (FNRI), and fish production (fish ponds and municipal fisheries) during that year, the MPDC reported a deficit of 280 mt in fish production against total demand. The number of fishers may be decreasing, but fishing pressure will continue to increase due to improved fishing methods to feed the growing population of Tubigon.

3.2.4 Aquarium Fish Collection

Aquarium Fish Collectors

Most of the aquarium fish collection is happening in the island village of Batasan, although this is not the only area where aquarium fishes are found. According to Monique Piquero, project staff of the Marine Aquarium Council (MAC), there are more than 100 fishers in the village (population in 2000 was 954, with 193 households) who are engaged in aquarium fish collection.

Before the entry of IMA and MAC in the island, aquarium fish used to be predominantly caught by the use of *kuskos* (cyanide) that stuns the fish, making it easier for the fisher to catch. IMA and MAC have introduced the use of barrier nets. Twenty-seven (27) of the aquarium fish collectors are certified by the MAC and organized into the Batasan Aquarium Fish Collectors Association (BATFCA).

Aquarium Fish Traders

According to Monique Piquero, most aquarium fish traders are not certified; they do not really care if fish are caught using cyanide or not (see Box 1). She reckons that only 2% of fish traders are certified by the MAC.

Box 1 Eliminating the Use of Cyanide in Aquarium Fish Collection

Monique Piquero, Marine Aquarium Council (MAC) project staff in Tubigon, recalls the first time she visited the island village of Batasan, where fishers then were notorious for using cyanide in aquarium fish collection. In 1998, the International Marine Alliance (IMA), the group that helped organize MAC, sent her to look at the situation of aquarium fish collection in Batasan, a well-known source of aquarium fish. She was shocked by what she saw. All the aquarium fish collectors, numbering close to a hundred, were using cyanide, and they seemed to be earning a lot of money from the practice.

She recalls the first time she and her colleagues at IMA organized a seminar on the negative impact of using cyanide in aquarium fish collection. The government officials of Tubigon and the local officials at the village were supportive of IMA's activities. But the fishers who were getting a lot of money from the practice naturally did not like to have anything to do with IMA and the LGU. No one wanted to admit that they were using cyanide, for fear that they would be imprisoned if found out. Some fishers even threatened Monique and her colleagues.

Monique and her colleagues persevered, explaining to the fishers that there are alternatives. Their perseverance paid off. Since 1998, she reckons they have trained about 70 fishers in the use of barrier nets, a sustainable alternative in catching aquarium fish. Of the 70, however, only 31 are "serious" about shifting. The MAC has certified these 31 fishers as sustainable aquarium fish collectors. MAC markets their catch through certified aquarium fish exporters in Manila, ensuring a fair price for the fish collectors and ensuring quality for the buyers. Their fish are sold as far as the United States and France. The group, called Batasan Tropical Fish Collectors Association (BATFCA), is the first certified fish collectors group in the Philippines.

One of the fishers trained by Monique's group is Tito Sitoy, a 29-year old notorious former user of cyanide. Tito told them he learned about the practice of using cyanide from Zambales in Luzon. The practice caught his attention because it was bringing in a lot of money to the fishers in Zambales. When he went back to Tubigon, he started using cyanide. He was using a compressor to stay longer underwater (the government is thinking of banning the use of compressors because of its negative impact on the health of the fishers who use it).

Now, Tito is one of the IMA and MAC trainers in the use of barrier nets and other sustainable forms of aquarium fish collection. He has been invited to other places such as Guiuan, Samar, another island in the Visayas notorious for cyanide use, to conduct training activities on sustainable aquarium fish collection.

Monique admits that cyanide use has not been totally eradicated even in Batasan. There are still some fishers who practice it. She says that there are only six certified exporters in the Philippines, accounting for a mere 2% of the total number of tropical fish traders in the country. She says that as long as there are exporters who continue to buy tropical fish caught through the use of cyanide and there are buyers who do not really know how the tropical fishes in their aquaria are caught, the use of cyanide will persist.

3.2.5 Diving and Snorkeling

Divers and Snorkelers

During the entire time we were in Tubigon, we only saw one white 20-foot dive boat at the pier. The boat most likely came from the beach resorts in Tagbilaran City or Cebu City. There are resorts in Tubigon but not as many as in Tagbilaran and Cebu where the quality of accommodation and services are better. The few divers and snorkelers who go to Tubigon therefore do not stay in the resorts there. As far as we could gather from interviews, there are no user fee systems in place for diving on the reefs, perhaps because the number of divers is not really that high.

Resort Owners

The beach resorts in Tubigon are found in Inanuran, Mocaboc, Matabao and Tinangnan (see map in Figure 2). At present, the resorts are mainly catering to local tourists and not yet to foreign divers and tourists like the ones frequenting Tagbilaran and Cebu. But the potential of the area as an alternative (to Tagbilaran and Cebu) tourist site is huge. Tubigon is nearer the central city of Cebu, where there is an international airport, than Tagbilaran. There are 12 one to two hour boat trips between Tubigon and Cebu daily. The LGU of Tubigon therefore plans to boost the tourism industry in the area and it is not farfetched to think that in the near future the number of divers – who supposedly are not using the reef in an extractive manner – will increase.

3.3 Resource Governance and Management Interventions

The management of the coastal resources in Tubigon is shifting away from an open-access regime, although this is proving to be difficult. The characteristics of open-access regimes (DENR/DA-BFAR/DILG/CRMP, 2001) – i.e., no exclusivity in use, no limits to use, and indeterminate physical boundaries – are still present in Tubigon, but to a lesser degree compared to other coastal municipalities. The physical boundaries of the Tubigon municipal waters are in the process of being delineated. Only 10% of non-Tubigon residents are allowed to fish within its municipal waters (difficult to enforce), and limits to use are being imposed, although almost anyone can just catch fish in Tubigon municipal waters. Nevertheless, Tubigon is advanced in coastal resource management (CRM) compared to other municipalities in the country. (See Appendix 9 for a more detailed discussion on the history of fishery management in Tubigon.)

3.3.1 Coastal Resource Management Policy

The policy framework that guides coastal resource management in Tubigon is the municipal ordinance called "Tubigon Coastal Resource Management Code of CY 2000[15]" passed by the municipal council on 11 July 2000. The code was formulated through a series of consultations with fishers, NGOs, private groups and local government, which means there is a wider ownership of it compared to other formally written policies in the Philippines that are usually formulated only by experts. The code, however, is written in English. So while those fishers (mostly members of the FARMC) who participated in its formulation are aware of its provisions, it is doubtful if the essence and content of the code is widely communicated and understood among all resource users.

Based on our interviews, it appears that many of the code's provisions are not yet implemented. For example, Section 10 of the code provides for the maintenance of a registry of all municipal fishers. Our meeting with the MAO gave us the impression that their office is having a hard time putting together this registry, much more its regular annual updating. Section 14 designated a closed season for the catching of siganids. We were told that it has been difficult to implement this particular provision. Section 30 of the code describes the schedule of license fees for all fishery activities. Again, our interviews with government

[15] The full text of this code is contained in Calara (2001). The Tubigon LGU received a lot of assistance from LOGODEF in the formulation of this code.

officials tell us that the revenue generated from these fees is negligible. Section 31 explains the coding of motorboats with a "green patch at the bow" with an inscribed letter code specifying the village from which the boat comes. The boats we used in visiting the island villages did not have this green patch.

Many groups in the Philippines regard policy formulation as an end result rather than the beginning of a process. It seems that Tubigon has not been exempted from this malady. Nevertheless, awareness of issues and concerns in policy formulation and enforcement places Tubigon in a better position to implement the code. The code will be reviewed in its third year of implementation (July 2003).

Table 8 Responsibilities of LGUs in CRM

Aspect	Responsibility
Protection and conservation	Establishing closed seasons, fish refuges and sanctuaries
Regulation	Issuing licenses and permits (except for commercial fisheries), registry system, granting of fishery privileges, establishing mechanisms for inclusion, prioritisation, etc.
Enforcement	Setting up patrolling and enforcement mechanisms through *bantay dagat (*sea wardens) and other means that involve *barangay* (village) officials and communities
Legislation	Formulating and passing ordinances that reflect the needs of improved coastal resources management
Extension/Technical assistance	Providing appropriate technology and research, credit, and production assistance to municipal fishers and communities

Source: DENR/DA-BFAR/DILG/CRMP (2001)

3.3.2 Institutions Responsible for Resource Management

The Local Government Code of 1991 (RA 7160) and the Fisheries Code of 1998 (RA 8550) devolved responsibility of managing municipal waters from the national agency, the Bureau of Fisheries and Aquatic Resources (BFAR), to the LGUs.

The specific unit within the Tubigon LGU that is primarily responsible for coastal resource management is the Municipal Agricultural Office (MAO), although the MPDO (2000) is also much involved. The MAO of Tubigon at the moment does not have a CRM section[16]. Its fisheries technician, Victor Boligao, a fisheries education graduate specializing in marine fisheries from one of the fisheries schools in Bohol, is on detailed assignment to the LOGODEF project. The LOGODEF project is wrapping up in December 2002. Its team of four fisheries technicians will be reintegrated into the MAO and will form the CRM section of this office. Victor Boligao will head this section. The project director of the LOGODEF project will return to his previous job as MPDC.

[16] The creation of the CRM section within the MAO is Section 42 in the Tubigon Coastal Resource Management Code.

Table 9 Anatomy of the Management Strategy to Eliminate Destructive Fishing in Tubigon

Component	Specifics	Results
Policy reform	Changes in national policy	Devolution of resource governance to local government units
		Declaration of municipal waters (15 kilometres from the shoreline) as exclusive zone for small fishers
	Formulation of a local policy on coastal resource management	Clear local agreements on access rights and responsibilities of various stakeholders (see table 10)
		Zones for different resource uses are established
Institutional strengthening	Capacity building for local government units	A more responsive local government delivering resource management services - such as regulation, protection, extension - to resource users
	Training policy enforcers	Greater chances that national and local policies enacted are enforced
		Near total eradication of illegal fishing practices
Asset building	Increasing resource users' human capital by introducing new skills	Diversified sources of income that now includes sustainable aquaculture activities
	Enhancing resource users' social capital by encouraging group building and networking	More confident fishers to articulate needs and represent interests in resource management bodies such as the FARMC and MDCs.
	Increasing resource users' financial capital by providing alternative credit	Ability to engage in diverse livelihood activities than before
	Increasing resource users' natural capital by securing entitlement to the area where the resource is found	Wider fishing area which leads to increase in fish catch
		Absence of competition from commercial fishers which leads to increase in fish catch
	Increasing resource users' natural capital by rehabilitating the resource	Establishment of protected areas that allow the regeneration of the resource

3.3.3 Resource Management Interventions

The resource management issues confronted by Tubigon through the years are varied, but the biggest one relates to destructive fishing. The PCRA done by CRMP in 1997 specifically locates the problem of destructive fishing in the middle of the islands of Bilangbilangan, Bagong Banwa and Pangapasan. We were told by people we interviewed that if the PCRA was done ten years ago, the key (legend) specifying the issue of destructive fishing would dot the entire map. Stuart Green, a former VSO volunteer and now CRMP consultant, who has lived in Bohol for more than eight years, told one of the authors of this report in a phone conversation that the problem of destructive fishing in Tubigon is 95% solved. Noel Mendaña agrees with this assessment, although he emphasized the fact that the problem is still there.

Many CRM-related groups in the Philippines have been struggling with the issue of how to eliminate the practice of destructive fishing. Will the practice die out only when the fisheries have totally collapsed? The experience of Tubigon shows that it is possible to eliminate destructive fishing through some management interventions. The management strategy to eliminate the practice of destructive fishing in Tubigon evolved from the myriad initiatives of several actors (such as international development agencies, local NGOs, local and national government and people's organizations). The convergence of these initiatives, seen from the

lens of the Sustainable Livelihoods Framework, seems to contain the components enumerated in Table 9.

Such a strategy is of course more easily written on paper than it is implemented. The lessons derived from the implementation of these strategies shall be discussed in later sections.

Table 10 List of Marine Protected Areas (MPAs) in Tubigon

Village	Area (ha)	Management Organization	Date Approved	Legal Basis
Macaas	12.70	Macaas Fisherfolk Organization	5 September 1999	Municipal Ordinance No. 02, s. 1999
Pangapasan	6.75	Pangapasan Barangay Council and Fisherfolk Organization	December 1998	Municipal Resolution No. 98-102A
Batasan Island	21.00	Batasan Barangay Council and Fisherfolk Organization	24 February 1999	Barangay Ordinance No. 1, s 1999 Approved by Sangguniang Bayan
Bilangbilangan Island	10.50	Bilangbilangan Barangay Council and Fisherfolk Organization	June 1999	Barangay Ordinance No 1, s 1999 approved by the Sangguniang Bayan
Matabao Pandan Panaytayon	110.00	Matabao, Pandan and Panaytayon Marine Sanctuary Management Council	October 1999	Resolution No. 1 of the Joint Barangay (Matabao,Pandan and Panatayon) Council meeting.
Total	161.00			

3.4 Results of Management Interventions

In this section we will provide evidence for some of the results enumerated in Table 9 that we observed and gathered from our interviews. In terms of the livelihoods framework, these changes relate to:

a. Changes in livelihood strategies of fishers (near total eradication of illegal fishing practices and further diversified sources of income)
b. Changes in policies, institutions and processes (more responsive local government unit in terms of delivering CRM as a service to the fishers), and
c. Changes in human and social capital (more confident fishers who can articulate their needs and represent their interests who have links with various networks).

3.4.1 Dramatic Reduction in Illegal Fishing Practices

The majority of fishers we interviewed were engaged in some form of illegal fishing in the past (e.g. see table 11). All of them informed us that they have shifted to sustainable forms of fishing and many of them are now members of *bantay dagats*. Several people told us that the practice of dynamite fishing, using cyanide in collecting tropical fish and the use of *tubli* still exist, although confined to a few areas. The island of Mantatao, in the neighboring town of

Calape, according to many, remains a haven of dynamite fishers. Nevertheless, the consensus is that lots of former illegal fishers (as shown by the case stories presented in boxes) have shifted to sustainable forms of fishing.

Table 11 Sources of Income of Selected Fishers in Macaas before and after the Ban on Liba-liba (a type of pull net) until the Present

Fishing activity before	**Boy**	**Claro**	**Rodel**	**Teodoro**
Liba-liba	✔	✔	✔	✔
Hook and line	✔	✔	✔	✔
Gleaning	✔	✔	✔	✔
Fishing Activity after	**Boy**	**Claro**	**Rodel**	**Teodoro**
Palangre	✘	✔	✔	✔
Grouper culture	✔	✔	✔	✔
Mudcrab culture	✔	✔	✔	✔
Gleaning	✔	✔	✔	✔
Patrol (seaborne)	✔	✘	✘	✘
Type of boat	**Boy**	**Claro**	**Rodel**	**Teodoro**
Motorised	✔	✔	✔	✔
Non-motorised				

What made them change? We got varied answers, but many agreed that the biggest factor in their shift is the fear of being caught[17], which seems to mean the policy enforcers in the area are doing their job. Mayor Paul Lasco told us that a lot of confiscated fishing gears are now rotting in their warehouse but illegal fishing has not been totally eradicated. The remaining illegal fishers have become smarter. They have lookouts, so while the patrol boat approaches, they just cut, leave their fishing nets and escape, which is all the patrols get. The dynamite fishers now operate in teams consisting of a thrower and lookout-cum-dead fish retriever. The thrower leaves the fishing area once the dynamite has been thrown, leaving the retriever to "harvest" the dead fish. When questioned, the retriever argues that he just happened to be in the place and does not have any paraphernalia that would link him to having thrown the dynamite. Usually, the mayor adds, the dynamite fishers do not operate in their own areas. As the illegal fishers are getting smarter, the law enforcers need to think of better ways to enforce the law.

3.4.2 More Responsive Local Government Unit in Terms of Delivering Services Related to CRM

The municipality of Tubigon is considered to have the longest experience in CRM (Green et al., 2000). Its programs in the early 1990s and have been sustained by two municipal government administrations, which seems to suggest that the CRM programs in the area have been impervious to changing political leadership. Experiences elsewhere in the Philippines have shown that incumbent administrations usually disregard and do not build on the gains of programs implemented by past administrations, especially when there is no related legislated policy.

[17] The penalty for fishing with explosives and cyanide is imprisonment ranging from 5-10 years.

Box 2 A Big Shift

Wilfredo Mellomida, 39, married with five children, is the vice president of the Pangapasan Fisherfolk Association. He only finished elementary education and got married at the age of 18. In his youth, his island was noted as a haven of the dynamite fishers. Fredo, as he is fondly called by friends, became one of them. He was a member of a team of four where he acted as the compressor diver and fish retriever after each blast. Eventually, he did the practice on his own and only stopped some seven years ago.

Fredo recalled that he was scared at first but it became a habit and eventually he became an "expert" at it. He confessed fear of losing limbs, even his life, every time he was about to throw lighted dynamite. But he thought he had no choice, he does not know of any other way to feed his growing family.

He was not aware or concerned with the adverse effects of dynamite on the marine habitat then. All he was thinking was to have plenty of catch and he dreamed of owning a motorized fishing boat someday. The practice went on for ten years, and finally he acquired his dream boat. His income doubled but the massive campaign against illegal fishing activity started, and so he slowed down for fear not just for his life, but also of the penalty of imprisonment if caught.

Different programs of government agencies and NGOs on the management of coastal resources led to the delineation and declaration of a portion of the island as a protected area. The fishers were organized and, together with the Barangay Council, manage the sanctuary. These had a positive effect on Fredo: he became an active participant of the many seminars and fora in the municipality and in the province. He adopted the alternative fishing practice suggested by the programs: gill net for catching crabs. He acquired the fishing gear through a soft loan extended by the Department of Agriculture.

When the mariculture (grouper and lobster) project of the LOGODEF and the LGU was introduced, he saw this as another opportunity to augment their income. He sees the project as a part-time activity that they can do even with their usual crab gathering and anchovy fishing.

Fredo is proud to say that he helped the FTC marine biologist volunteer in the conduct of resource assessment in their area, so he knows the techniques in doing fish visual census, transects and quadrats. In October 2002, he was tapped by Reefcheck, an NGO specializing in reef assessments, as one of the team members who conducted the coral assessment in Tubigon.

Today, Fredo says he is a happy and contented man: no more fear of imprisonment or premature death, and he feels fulfilled that somehow he is helping leaving a healthier coastal environment to his children.

The local government of Tubigon is like a conductor that brings harmony to the diverse ensemble of CRM initiatives in the area. Crucial to this coordination role are the incumbent mayor, Paul Lasco; the MPDC, Noel Mendaña; the MAO, Epitacio Mumar; the four fisheries technicians who are on loan to LOGODEF; the members of the FARMC; and the eight full-time *bantay dagats* (called "sea borne patrols") and two Philippine National Police (PNP) officers who are assigned to provide support to the *bantay dagats*.

The Tubigon CRM corps, so to speak, may be a small one compared to the size of the resource that it is responsible for managing (133.3 km^2 of coastal area). Support comes from NGOs such as LOGODEF, Feed the Children, fishers associations at village level, and the volunteer *bantay dagats* at village level. The municipal government has an annual budget of 400,000 pesos (US$ 7,600) for CRM, and according to Noel, the CRM annual budget will be increased by another 400,000 pesos when the LOGODEF project has been handed over to the municipal government in January 2003. The municipality has six patrol boats, three of which were donated by FTC to the coastal villages of Panaytayon, Matabao and Pandan.

While it is clear that Tubigon is advanced compared to other Philippine municipalities, there are still some areas where we think Tubigon could improve in delivering CRM as a service to its fisher constituency. These are in:

a. Keeping and maintaining a registry of fishers and implementing a licensing system
b. Institutionalizing simple ways of resource monitoring like what the volunteers of FTC have taught the fishers of Pangapasan and Batasan, and
c. Ensuring that funds for maintenance and servicing of patrol boats are available.

These persons have attended training courses and seminars on CRM organized by the likes of CRMP; they have joined study tours to other areas, including foreign countries, which according to those who went, such as Noel, has broadened their perspective. The *bantay dagats* have received specialist training on apprehension and coastal laws from BFAR.

Box 3 Thinking of Solutions

Before we took the boat to his island (Pangapasan), Victor Boligao passed by the market. I took a picture of him buying assorted small fishes in one of the fish stalls. When I asked him what the fishes were for, he answered, "I'll test them as feed for the grouper."

Victor is trying to find a solution to the problem of lack of trash fish to feed the groupers and lobsters being grown by the fishers they are helping. He knows that some of the trash fish they buy may be coming from commercial fishing operations that are encroaching on municipal waters. It is difficult to prove this, but they need a constant supply of trash fish to sustain the mariculture project. Some fishers have suggested that they get trash fish from the fish corrals and lift nets in their own area, or they operate their own lift nets to have a constant supply of trash fish. There are suggestions that they link with commercial fishing operators in Cebu who they know are observing the law. Victor waits for more suggestions.

This is just one of the issues that he has to deal with every day as a fisheries technician of the LOGODEF project. He is responsible for providing technical support to grouper culturists in two sites. For example, he helps them source feeds, monitor the growth of the fish and seek out buyers.

Victor's father died in an accident when he was only one year old. The dynamite that his father was holding exploded before he could throw it into the water. His older brother became a fisherman like their father, but Victor persevered to become a teacher. So he took a course in fisheries education, specializing in marine fisheries. He ended up teaching not in a formal four-walled classroom but in a bigger classroom that is the fishing community of Tubigon.

Next year, when the LOGODEF project is handed over to the municipal government and when the CRM section of the municipal has been created, Victor will assume responsibility for coordinating its activities.

3.4.3 Further Diversifying Sources of Incomes

Table 5 in the previous section shows that the sources of income of fishers in Tubigon are already diversified. They are engaged in different sorts of fishing activities, and some of them also derive income from non-fishing-related activities. The introduction of aquaculture projects by LOGODEF and FTC has further diversified the sources of fishers. The fishing-related activities of many fishers of course also changed from one where the dominant source was illegal fishing to one that is diversified.

Box 4 A Changed Man

Estanislao "Tani" Cervantes is now a changed man. He grew up knowing that the food on their table came from the dynamite fishing activities of his father. Naturally, as a young man, he became a fisherman himself like his father and did the same things that his father did (being involved in dynamite fishing), but this time he was just supplying bottles to contain the ingredients for dynamites (or was he just trying to hide something from us?). He also bought and sold fish caught with dynamite.

His wanderlust brought him to many places in the country such as Palawan, Masbate and Manila Bay. In these places, the only job he could find was as a boat-hand on big commercial fishing boats, a job that is not much different from the simple fishing activity in his village. In his travels, he saw dynamite fishing everywhere!

Working with commercial fishing boats satisfied his itchy feet but it did not bring enough food to his family's table. He was already married with children when he started traveling. So he went back to his family in Panaytayon and contented himself with *pamasol* (hook and line fishing), using his small boat (until now he still uses the same non-motorized boat). Sometimes he would sell his catch to the few tourists in the resorts near his village. The tourists paid more for his fresh catch.

Manong (uncle) Tani likes to talk and is curious about anything new just like he is curious about far away places. He joined the discussions of the local government and the NGOs about CRM in their area and eventually became a *bantay dagat* that patrolled a fish sanctuary established through the Feed the Children in the middle of the three villages of Matabao, Pandan and Panaytayon. He is proud to say that the presence of the *bantay dagats* has drastically brought down illegal fishing activities.

Manong Tani is one of the grouper culturists in Panaytayon. He reckons that he spends about an hour a day for the project, but it has added about 20 percent to is income. Not bad, he says, for an additional hour of extra work, as he has not abandoned his other fishing activities. Apart from the additional income, the platform at the shed near the fish cages has provided him and his grandchildren a nice place to take *siesta* (afternoon nap) and offered him tranquil moments alone to ponder life's challenges, he jokes.

Table 12 shows the sources of income of fishers in Panaytayon who are members of the LOGODEF-assisted grouper culture project. They told us that none of them have non-fishing sources of income, which is a bit surprising for fishers living in coastal villages, where there are more opportunities to engage in non-fishing activities.

Table 12 Sources of Income of Selected Fishers in Panaytayon at Present (2002)

Sources of Income	Tani	Ricardo	Junior	Eduardo
Anchovy fishing	✗	✔	✔	✔
Squid jigging	✔	✔	✔	✔
Hook and line	✔	✔	✔	✔
Gill net (pukot)	✔	✔	✔	✔
Gleaning	✔	✔	✔	✔
Torch/kerosene-fueled gauze lamp spear gun	✔	✔	✔	✔
Grouper culture	✔	✔	✔	✔

The percentage contribution of different sources of income (fishing-related) to one fisherman in Batasan, who was open enough to share the information with us, is shown in Figure 3. Getting information on income is difficult, but one fisher in Pangapasan, *Manong* Macario, who is one of the village councilors, told us that he gets an average gross income of 5,000

pesos a month (US$ 94) from gill netting *lambay* (blue crab) and this, he estimates, constitutes 70% of his total income. He owns a motorized boat, so the net income is less after expenditures have been deducted. *Manong* Macario is not a member of the grouper culture project, but he supports it.

The income situation of fishers engaged in gill netting (mostly from island villages) who own a motorized boat may be similar to *Manong* Macario; we estimate that they are earning 60,000-70,000 pesos (US$ 1,122-1,308) a year. If they are a family of six (*Manong* Macario has five grown children), they are just under the poverty threshold.[18]

It therefore seems safe to assume that fishers with non-motorized boats and the gleaners who catch less fish and who constitute about 50% of the fishers in Tubigon live below the poverty line[19]. The municipal profile of Tubigon estimates the monthly income of anchovy fishers at 4,500 pesos (US$ 84). Fishers seem to invest a big portion of their income in housing. In the island villages of Pangapasan and Batasan, many houses are made of concrete, although unpainted and always under construction. The reason we were given for this is that these islands are perpetually visited by typhoons. Houses seem to be continually under construction because they are constructed in installments, i.e., the basic structure first, then the next room when more money has been saved.

Figure 3 Percentage Contribution of Different Fishing Activities to the Income of Tony Salomon (based on Table 6)

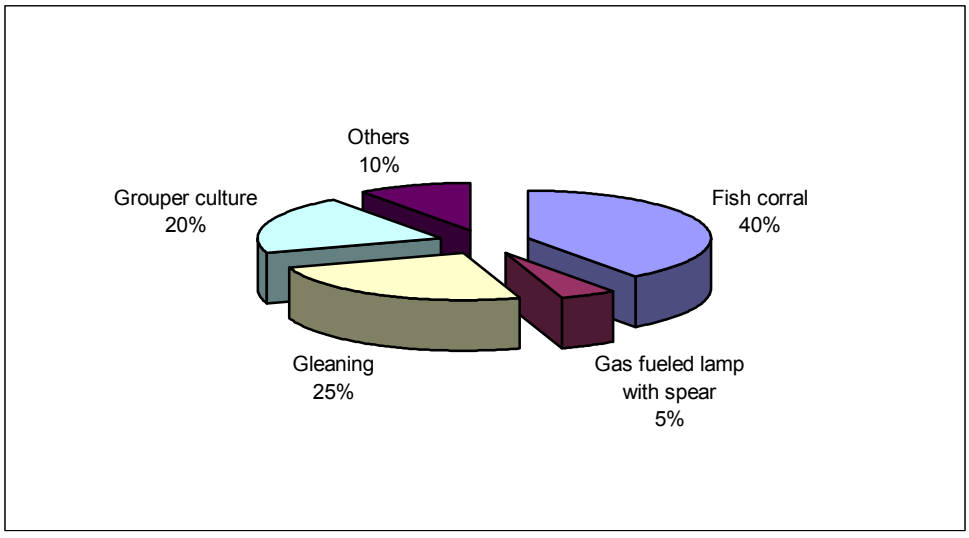
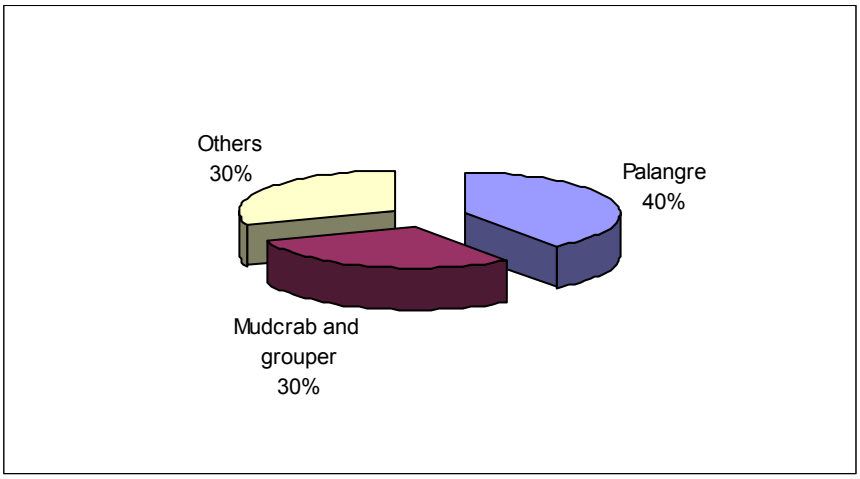


Figure 4 shows the percentage contribution of fishing activities to the income of some fishers in the coastal town of Macaas. They have not stopped or decreased their other fishing activities, so the 30% contribution from mudcrab and grouper culture is additional income, although they found it difficult to estimate their total incomes.

[18] The annual per capita poverty threshold in 2000 was 13,916 pesos or US$ 247.
[19] The national poverty incidence (proportion of families with income below the poverty line) in 2002 was 34.2%.

Figure 4 Percentage Contribution of Fishing Activities to Incomes of Some Fishers in Macaas Who are Mainly Engaged in Multiple Hook and Line Fishing (palangre) *(2002)*



The price of fish obviously fluctuates, but there seems to be no specific time of year when fishers are highly vulnerable due to adverse periods. A seasonality map drawn by fishers in the villages of Batasan and Panaytayon is shown in Tables 13-15.

Table 13 Seasonality Map for Some Selected Fishing and Other Livelihood Activities in Batasan

Fishing and Other Livelihood Activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gleaning												
Use of gill net (blue crab)												
Use of fish and crab pots												
Harvesting from fish corral												
Carpentry												
Use of lights												
Aquarium fish collection												
Grouper culture												

Legend: ■ = peak season; ■ = non-peak season

Table 14 Important Events and Occurrence of Typhoons in Batasan[20]

Event/Typhoons	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Village feasts					■							
Typhoons									■	■	■	■
Groupers prone to disease[21]								■	■	■	■	

Table 15 Seasonality of Important Fishing Activities in Panaytayon

Fishing Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anchovy fishing	■	■	■	■	■	■	■	■	■	■	■	■
Squid jigging	■	■	■	■	■	■	■	■	■	■	■	■

Legend: ■ = peak season; ■ = non-peak season

We estimate that the aquaculture projects introduced by LOGODEF and FTC bring in a net total extra income of at least 2,000,000 pesos (US$ 39,000) annually[22]. This amount is small if we consider that the support mechanisms (e.g., salaries of fishery technicians, networking with markets) to ensure the success of these aquaculture projects, in our estimate, would cost 400,000 pesos (US$ 7,477) annually. To be economically sustainable (net proceeds from aquaculture projects sustaining the operations of the mechanisms that support it), the project needs to expand. The aquaculture projects therefore are still partly subsidized by LOGODEF, FTC and the municipal government. There is, however, a big area for expansion as the projects right now occupy a small space, although there is a problem with supply of trash fish and fry and fingerlings.

3.4.4 More Confident Fishers to Articulate Their Needs and Represent Their Interests

A key thing that happened in Tubigon is that fishers' needs, perspectives and interests are represented in discussions on how the coastal resources on which they depend for their livelihood are managed. The creation of the municipal FARMC (as spelled out in RA 8550 of 1998 and Article 8 of the Tubigon CRM Code of 2000) made this possible. The FARMC is a body composed of fishers, government officials, NGOs and commercial fishers that advises and assists the municipal government in the implementation of its CRM program (see Appendix 10 for a list of the members of the FARMC).

[20] Based on Batasan grouper culturists
[21] Based on Panggapasan grouper culturists as told to the researchers
[22] 15,000 pesos estimated net income per individual per year multiplied by 141 individuals

The effectiveness of the FARMC in Tubigon to represent the interests of fishers was tested last year when the municipal government received a proposal from commercial fishers for them to be allowed to operate between 10.1-15 km in the Tubigon municipal waters (RA 8550 states that this is possible as long as the municipal government agrees) even if they are asked to pay higher fees. The FARMC in Tubigon, according to MAO Epitacio Mumar and FARMC chair, discussed and voted on the matter. The side against allowing commercial fishers in Tubigon waters won the voting.

The FARMC as a structure in itself does not really guarantee that fishers', especially poor ones, needs, perspectives and interests are properly represented in coastal resource management planning and implementation. What seems to have made it work in Tubigon is that the area has been a "learning site" for many CRM groups for almost a decade, which seems to have enhanced the overall human capital (knowledge and skills in CRM[23]) and social capital (trust in their government officials, trust between NGOs and government, networking with outside groups) of the area making it more equipped to deal with CRM issues in a more constructive sense.

Box 5 Shifting to More Sustainable Forms of Fishing

Before, the only form of fishing that Roland "Boy" Caba knew was the use of *liba-liba* (a kind of pull net). But in 1984, *liba-liba* was banned because it was considered an active fishing gear that catches even juvenile fish. It was therefore rather hard for *Manong* Boy to shift to using another fishing gear. Besides, he does not really have the money to invest in buying new fishing gears.

Many of his fellow fishers were forced to leave fishing and went into farming; there were only 55 of them left, he remembers. The 55 were already organized into a fishers association. Together they sought an audience with the mayor to explore options. The mayor referred them to Representative Agana, who promised them a loan of 375,000 pesos (US$ 7,009) through the Department of Agriculture for them to buy gill nets. They were also given a loan of 60,000 pesos (US$ 1,121) to buy pump boats for their members who did not have this.

He says that their income dropped dramatically – from 2,000 to 5,000 pesos (US$ 38-93) individual share (*liba-liba* requires about 30 people) per fishing trip to 100 to 400 pesos (US$ 1.80-7.50) per day. But they were encouraged by the support from the government. So whenever there was a government project in their area they participated in it. In 1990, through the CVRP, they joined a mangrove reforestation program, installed artificial reefs, attended training courses to become *bantay dagats* and they helped in the establishment of a marine sanctuary. Presently they are involved in the LOGODEF mariculture project.

Manong Boy even invited representatives of the Social Security System (SSS) to come to his village so that fishers in their village could become members of the system and be entitled to pensions in their old age and to medical insurance. They may be the only fishing association in the Philippines whose members make contributions to the SSS.

Today, they have been given tenure to the mangrove area they have rehabilitated through the Community-based Forest Management Agreement (CBFMA) programme; *Manong* Boy is now a full-time *bantay dagat* earning an extra 150 pesos (US$ 2.80) a day. Most importantly, for their efforts, the association was awarded the Presidential *Gawad Saka* Award. *Manong* Boy received the certificate and the cash award from President Gloria M Arroyo herself at the presidential palace!

[23] The fishers in villages where FTC operates, for instance, have billboards showing results of the PCRA that they conducted themselves with the help of volunteer marine biologists. They told us they can now do resource assessments by themselves, but there is a need for support from government for this activity to become embedded in the systems of village governments.

4. Lessons from the Experience of Tubigon

In this section, we describe the lessons derived by the project implementers, the fishers themselves and our own interpretation of the lessons from Tubigon's experience in introducing sustainable aquaculture practices that replaced illegal fishing practices. The specific questions we are attempting to answer in this section are:

- What are the most suitable methods for the introduction of sustainable aquaculture practices?
- What is the possible role of the private sector in this?

4.1 Methods for the Introduction of Sustainable Aquaculture Practices

Our interviews with key informants point to four key lessons[24]:

1. The introduction of sustainable aquaculture practices should be part of a coherent wider program of intervention in coastal resource management
2. The participation of resource users in the design of the intervention is key, along with partnerships with relevant organizations
3. Adequate social preparation and technical support help ensure success, and
4. Programs should invest in embedding a culture of responsible resource governance.

4.1.1 Coherent Wider Program of Intervention

The failure of past programs, Noel Mendaña, Tubigon MPDO, told us, was largely due to the singular focus on regulation, without considering any other aspect. It was thought then that if an illegal fishing practice were banned, it would lead to the elimination of that practice. The story of Boy Caba (see Box 5) shows otherwise. It was the mix of financial support to engage in alternative fishing methods given by the government then and the awareness-raising programs of NGOs that made them abandon illegal fishing.

The LOGODEF mariculture project was not introduced in isolation, with the sole objective of just giving fishers an alternative and additional source of income. The mariculture project had three elements: environmental management and protection, livelihood and employment generation, and local economic development and promotion (Calara, 2001).

The first element consists of a mix of interventions that at first glance have no direct bearing on the introduction of aquaculture practices. These are policy formulation, coastal resource assessments, zonation, and coastal resource management planning. Apart from just increasing the human capital of poor resource users (by giving them knowledge on how to culture groupers, mudcrab, oysters and mussels), the project also invested in improving the local policy environment, enhancing local processes in CRM (resource assessments and zonation)

[24] A *lesson* is defined here simply as doing something differently in the light of experience.

and strengthening the capacity of local institutions (primarily local government) to plan and implement CRM programs.

The key components of an integrated program of action that the initiatives in Tubigon seem to have converged into are already listed in Table 9. If a SWOC[25] analysis was done on the CRM practice of Tubigon ten years ago and compared with the current practice, there would be clear improvements in the areas of policy environment, capacity of the local institution to implement CRM and the capital assets situation of primary resource users.

Future interventions should analyze what is already in place and build on this, rather than reinvent the wheel from scratch again.

4.1.2 Participation and Partnership

"Coastal resource management needs the cooperation of all major stakeholders in the locality," reads a caption in the LOGODEF book showcasing its experiences. This principle seems to have penetrated the core of the way the Tubigon LGU implements CRM. The formulation of the local CRM policy framework (Tubigon CRM Code) was a result of several consultations with various local stakeholders, the majority of whom are fishers and representatives of *barangay* governments. The selection of sites for marine sanctuaries was done jointly by fishers, NGOs and the LGU. The zonation of the Tubigon municipal waters is also being done in consultation with several groups; this process has not been completed (as of December 2002). The type of aquaculture projects to be tested emerged as a result of discussions with fishers associations. The selection of who should participate in the aquaculture projects was decided in consultation with *barangay* officials and the fishers associations. Fishers are even involved in carrying out participatory resource assessments and are capable of doing transects and quadrats. There is therefore local ownership of the many CRM initiatives in Tubigon.

The conduct of the participatory processes was made possible through the support of development agencies and NGOs such as CRMP, LOGODEF and FTC. The focus of support of these groups should now shift to further enhancing the capacity of persons within the institutions in the municipality to facilitate participatory processes by themselves. We felt that there is still a general lack of confidence in using the results of participatory processes for decision-making and resource management. For instance, results of PCRA in Batasan and Pangapasan are not really used by the *barangay* governments in these villages in their planning. They seem to rely on the results of a more "official" resource assessments done by academics and NGOs rather than the ones they could already do.

An area where lessons have been learned it seems is in the process of selecting beneficiaries for aquaculture projects. The grouper culture projects in Matabao and Pandan have been stopped because of high mortality and therefore the projects were losing money. There was also perceived dishonesty on the part of some beneficiaries. Pepito Flores, a member of the fishers association in Matabao, told us that he thinks the perception of dishonesty is true. Some members borrow money from LOGODEF to buy trash fish, but they use the money for something else. He also thinks that the project should not have chosen beneficiaries who are relatively well-off and therefore did not really need the additional income from the project.

[25] Strengths, Weaknesses, Opportunities and Constraints

He thinks that some members' motivations are questionable. This seems to suggest that the "Guidelines for Mariculture Financial Assistance" document of LOGODEF should include in its provision on eligibility a line about fishers who are most in need should be prioritized and not just any "active" member of the fishers association. This member should demonstrate willingness to participate in all the preparatory aspects (e.g., orientation, training) of the project. LOGODEF started its grouper culture projects in Matabao and Pandan and it seems the other succeeding sites benefited from the experience of these two villages.

Another value of partnership and participation for Tubigon is the sharing of responsibility for CRM to a wider group of actors. Noel Mendaña told us that they have long realized that their staff of four fishery technicians and six sea wardens supported by two police officers can not possibly effectively manage 133 sq km of municipal waters and attend to the needs of about 1,400 municipal fishers. This is why he said their CRM plan includes the initiatives of NGOs such as IMA, Haribon, FTC and CRMP. The LGU meets these groups regularly for purposes of coordination of efforts, helps them with their information needs, and even provides local financial counterpart to the projects they implement.

4.1.3 Adequate Social and Technical Support

Mariculture projects require investments that poor fishers in Tubigon can not afford. The investment cost for one module (two 3 x 3 meter cages) including operating costs for one cycle operated by two fishers is about 90,000 pesos (US$ 1,682), or about 45,000 pesos (US$ 841) per fisher[26]. A gill net costs only 5,000 to 6,000 pesos (US$ 93 to 112)[27] which could somehow earn for the fisher on a daily basis. Mariculture projects require more management skills than the extractive forms of fishing, although the time required for management is not really a lot (less than an hour a day). The fishers need to calculate feeding rate and monitor fish growth, water quality and fish diseases. There is also a need to watch and protect the cages from potential intruders and poachers.

The problem with the high cost of investment was addressed by the provision of LOGODEF of soft loans (8% interest per annum) to fishers. The lack of knowledge and skills of fishers in grouper aquaculture was tackled by the provision of practical training courses in grouper culture from SEAFDEC and by hiring local fishery technicians who can provide daily technical support to fishers.

The fish cages were established in a complex of eight modules – either as floating cages or permanent fixtures – in each village for the LOGODEF-assisted projects. The FTC-assisted projects had fewer modules (four only) in one complex. Except for Panaytayon, where FTC and LOGODEF are each assisting one fish cage complex (i.e., there are two complexes in the village), all other villages have only one fish cage complex. Each fisher has a module of his own but they work in pairs for feeding, monitoring growth and looking after the fish. But the entire fish cage complex in each village is managed in a cooperative way, meaning the sourcing of feeds, connecting with buyers and selling of the marketable sized fish is done by the group, not individually, with the help of the fishery technician.

[26] Based on LOGODEF calculations in 2001
[27] Based on estimates of fishers interviewed

This mode of organization ensured that each fisher gets support from other fishers, facilitated the provision of technical support from the fishery technician, and encouraged shared learning. On the other hand, it required some skills from fishers in managing people that are not needed if fish culture is done individually. For this, LOGODEF relied on the previous work of FTC and CRMP in organizing groups.

The work of the fishery technicians is funded by LOGODEF, and later this will be shouldered by the LGU. This support is crucial and the LGU and local fishers should find ways to ensure that financial support to the work of the fishery technicians is ensured. One way to do this perhaps is to ask fishers to contribute a small part of their additional income to finance the work of the technicians.

4.1.4 Embedding a Culture of Responsible Resource Governance

Resource governance is the way in which resource uses are managed by sets of rules, social norms and shared strategies. It includes enforcement mechanisms such as policing measures and punishments (Bunce et al., 2000). Perhaps of the four key lessons enumerated here, embedding a culture of responsible resource governance is the most important.

When asked what it is that makes Tubigon able to effectively implement CRM that many other municipalities in the Philippines are not able to do, Mayor Paul Lasco jokingly replied, "It is a trade secret." Noel Mendaña laughed when told about this. But he was quick to add that the "secret formula" is a simple "potion" of enhancing the character of a community's natural leaders by training them and exposing them to other projects so that they can expand their horizons and broaden their thinking and later they can serve as champions for a program such as CRM. This does not sound like a difficult formula and it seems many municipalities have done the same with less convincing results.

Maybe the fact that Tubigon is, by Philippine standards, an old municipality (it is 150 years old) has something to do with it. It has a long experience of governance and perhaps its political leaders have more experiences to draw lessons from their longer history, although it seems similarly old municipalities in the country are still embroiled in petty politics.

An interesting fact that we observed in Tubigon is that persons in power seem to have no vested interests in commercial fishing and other undertakings that are in conflict with the interests of municipal fishers who compose the majority of coastal resource users in the municipality. There are only a few commercial fishers based in the area and those who intrude in their municipal waters come from other areas. This absence of vested interests with the local government may also have something to do with its effectiveness.

Whatever it is that makes the Tubigon LGU click in terms of implementing CRM programs, fishers we interviewed are united in the perception that it is a government that they can depend on and make suggestions to. The programs implemented in the area would have not succeeded if the local government did not support them. The staff of the NGOs (IMA and FTC) we interviewed echoed the sentiments of the fishers.

The lesson that this seems to tell those from external development agencies is that any program of intervention should integrate within its component a strengthening of the local government as an institution that has the responsibility to deliver basic services, along with coastal resource management as a service, to its constituency. NGOs, for instance, should not

compete with government in delivering CRM as a service that many NGOs in the Philippines are wont to do; rather it should work together with government and strengthen it rather than undermine its mandated function.

The LGU of Tubigon admits that it owes its strength in implementing CRM to all the programs of external agencies that helped strengthen not just their capacity as an LGU but those of their constituency as well through organizing them, raising their awareness and teaching them new skills. LOGODEF, FTC, IMA, MAC, CRMP and Haribon in particular deserve most of the credit, Noel and Mayor Lasco told us in separate meetings. BFAR, in collaboration with the regional development council, is also instituting a CRM certification for municipalities that would qualify them for specific assistance in strengthening CRM services. The lesson we are getting from all this is that resource governance is a joint responsibility of government and its constituency, and external development programs should strengthen both.

4.2 Possible Role of the Private Sector

The rationale for the introduction of aquaculture projects is to reduce fishing pressure, so that reef ecosystems can be rehabilitated. Aquaculture projects are just one of many approaches to reduce fishing pressure, and its intensification can even add to fishing pressure. There should therefore be a clear limit to how much aquaculture projects can be introduced.

We noticed in our conversations with fisher families that only a few of their children go to fishing when they grow up, which partly explained the reduction in the fishing population in Tubigon. Many of these children have high school education, with some even finishing college[28]. They work in export processing zones, or in the service industries in the cities of Cebu or Manila. Some of them work as domestic helpers in Manila or abroad. *Manong* Macario, the *barangay* councillor of Pangapasan, has a son who is abroad, working as a seaman.

Apart from introducing non- or less-extractive livelihood activities such as aquaculture projects, the conflicting goals of reduction in fishing pressure and improving coastal livelihoods it seems can only be done by reducing the number of resource users. The exclusion of commercial fishers from municipal waters has significantly contributed towards reduction of fishing pressure. Alongside this, livelihood opportunities for the children of fishers in service industries within and outside Bohol should be made available. There seems to be a big role for the private sector in at least exploring this idea further. There is also a need to educate fisher families about reproductive health, so that they can make informed choices about how many children they should have. The role of the private sector in this is not so direct, but they can support programs of NGOs and LGUs who are implementing projects along this line, such as the FTC.

[28] There are 34 elementary schools in Tubigon, one for each village; there are three high schools (one privately owned) and one college (privately operated).

In relation to the introduction of aquaculture projects, we can see three possible roles for the private sector:

1. Marketing the produce of aquaculture projects
2. Providing financial support to research activities to improve aquaculture production, and
3. Helping programs related to "market denial" of fish caught through unsustainable practices.

Of these three roles, in the current state of play in the Philippines, it seems the only practical role for the private sector at the moment is the first one, i.e., help market the fish.

4.2.1 Marketing the Produce of Aquaculture Projects

The produce from the aquaculture projects (green grouper) of Tubigon are bought by established buyers (there are only three listed in the LOGODEF documents) of live grouper in Bohol and Cebu and sold to restaurants in Cebu. The current arrangement is a common one where these buyers place an order and LOGODEF delivers when the fish have reached marketable size and gets paid upon delivery. The green grouper[29] are not exported to Hong Kong, China, Taiwan or Singapore, which are known buyers of live grouper.

Juanito Ang, a businessman based in Cebu who is into buying mature groupers, selling fingerlings and one of the buyers of live grouper from Tubigon, says that businessmen like him have a stake in maintaining the health of the environment in which the fish are grown to ensure a steady supply of quality fish. He seems to suggest that this responsibility should not be borne by the fishers, the LGU and the likes of LOGODEF alone, and they should work in partnership. He laments, however, that they (businessmen) are not getting support from the Philippine national government; he feels that government is working against them rather than for them. He says that the proximity of the Philippines to Hong Kong, Singapore, China and Taiwan makes it an ideal site for grouper culture, but it presently cannot compete with Indonesia and Thailand. The government of Thailand, he pointed out, even helps live grouper exporters in that country to negotiate freight rates with airline companies, which he can not imagine the Philippine government will do for him. The price of green grouper (exported to Hongkong) he says is only 300 to 350 pesos a kilo (US$ 6 to 7), and freight costs from Manila to Hong Kong are already US$ 1.25. He was not sure about the tariff rates, but he says export of green grouper from the Philippines to the countries above is not feasible. Growers, he concludes, should look into the more expensive species.

This phone conversation with a businessman shows that one of the roles of the private sector is in promoting sustainable aquaculture (at least grouper culture) in improving coastal livelihoods. Mr Ang also showed readiness to be a partner of growers in ensuring that the environment in which the fish is grown remains healthy. The problem lies in the lack of political will of people in national government agencies to ensure that adequate support in terms of information, technical and market advice is given to businessmen and local

[29] Mr Juanito Ang, in a phone conversation, says that the green grouper is not the preferred species in the international market, so it only gets sold in Manila, Cebu and Bacolod (on the island of Negros). It is also cheaper. The grouper species from Guiuan, Samar, he says is the expensive variety. The Guiuan LGU, however, he says has not even reduced the practice of using cyanide in catching grouper fingerlings.

communities. Which unit of BFAR should focus on this is not clear. BFAR has no unit responsible for providing support to aquaculture-related businesspersons. Perhaps this is one thing that BFAR should seriously consider.

4.2.2 Financial Support to Research Activities to Improve Aquaculture Production

As is done in many "fairly traded" products, the price structure of the fish can include a small percentage to establish a development fund. This has been done in the production of raw sugar (called *muscovado*) from the island of Panay and its export to several countries in Europe and Japan[30]. The development fund can be used to fund projects that will improve aquaculture production.

But at present when the fish traders seem not to be able to penetrate the export market, it seems the logical thing to do is to convince BFAR to first extend support to fish traders.

4.2.3 Helping Programs Related to Denying Markets for Illegally-caught Fish

One of the factors for the success of the dramatic reduction in the practice of illegal forms of fishing in Tubigon is local market denial. In a workshop to discuss the experience of Tubigon held in Tagbilaran City on 24-25 October 2002, CRMP representatives mentioned that they were able to convince vendors not to sell fish caught with explosives. Buyers have also become aware and are not buying fish caught with explosives, even if these were dead cheap. This will only happen if the public's consciousness of health and environmental issues is high, and heightened public consciousness is realized by a constant dose of public environmental education. The development fund from the price structure of the fish mentioned above could help make this a reality.

[30] Ronet Santos, one of the authors of this report, was involved in a project to revive the dying *muscovado* industry in the island of Panay from 1986 to 1992. The women farmers from the small village of Pisang, in the town of Janiuay, until now are exporting *muscovado* to at least 8 countries in Europe.

5. Conclusion

The thesis that a strategy to improve coastal livelihoods would be likely to deal with *asset-building* and *strengthening policies, institutions and processes* is proven correct. All the components in both areas figured as key elements of a strategy to improve coastal livelihoods. Any management intervention in an area with the same problems Tubigon had in the past should first analyze what has been done in each of the components of the above strategy, and build on these. This means that the intervention does not have to be integrated, but the analysis that would shape the design of the intervention should be holistic.

Introduction of aquaculture projects to improve coastal livelihoods therefore should not be done in isolation but should be informed by such a strategy. Specifically, aquaculture projects should not be introduced if there is no adequate social preparation and if the rationale of the project (poverty eradication) is not clear to project beneficiaries.

The possible role of the private sector in the above can either be very or focused on supporting aquaculture projects. There is a clear role for the private sector in investing in non-fishery-related industries that can absorb human resources who would otherwise have no choice but to add themselves to the burgeoning number of people dependent on the resource. The obvious role of the private sector in promoting sustainable aquaculture projects is to assist in marketing its produce. Less obvious roles include helping with initiatives to deny a market for fish caught through illegal means and exploring possibilities of integrating within price structures of the fish a development fund that could be used to fund aquaculture-related research initiatives.

Grouper aquaculture is not a big industry in the Philippines yet, and therefore it is not yet attracting a lot of investment. In fact, businesspersons we were able to interview complained about the total absence of support from the fishery-related national agencies of the government. It seems before the private sector can be encouraged to support sustainable aquaculture initiatives, the fishery-related agencies of the national government must first demonstrate that it has the political will to craft a sustainable development framework for fisheries in the country that would provide a good balance between food production and resource protection and conservation.

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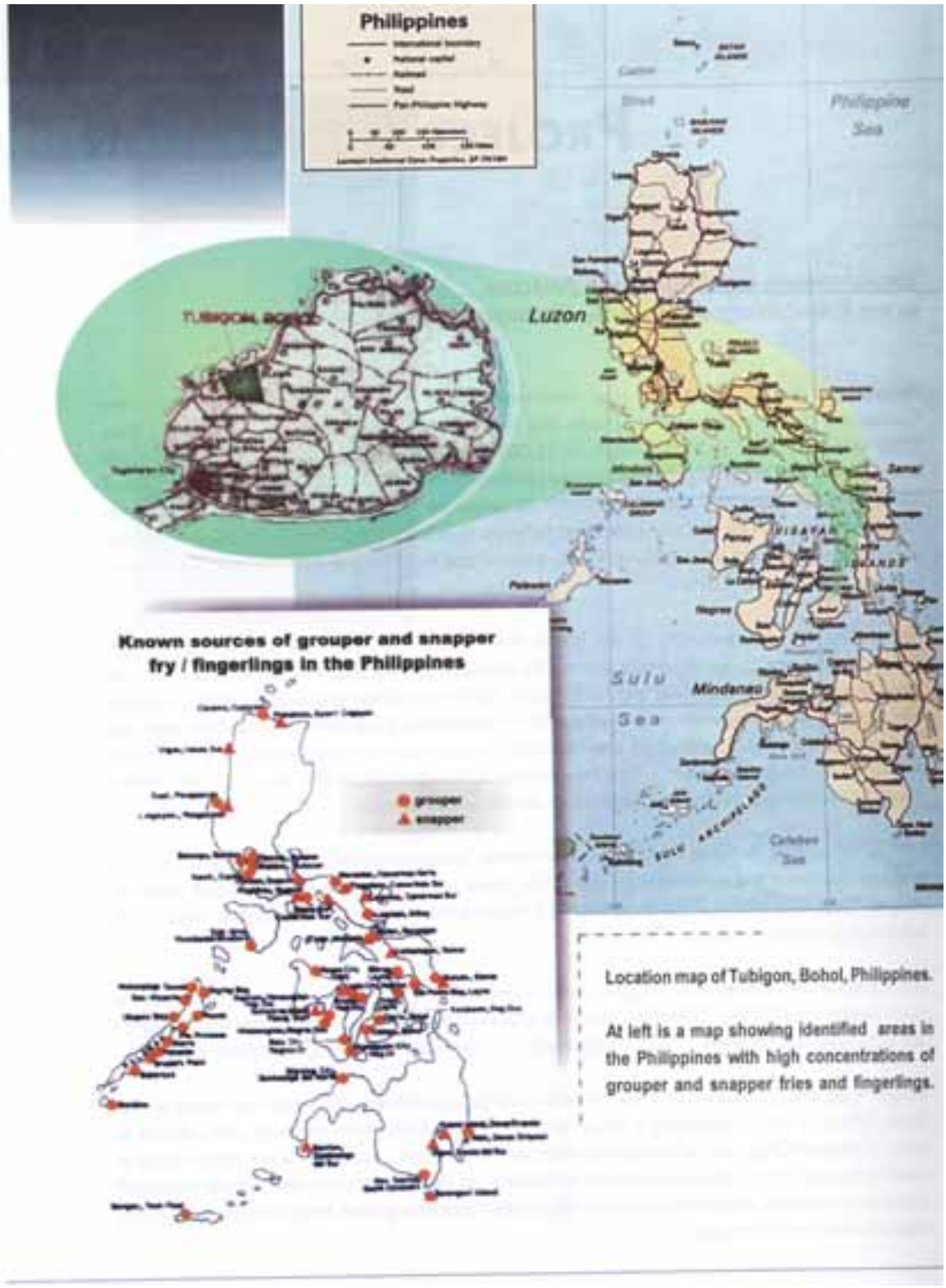
Appendix 1 Location Map of Tubigon

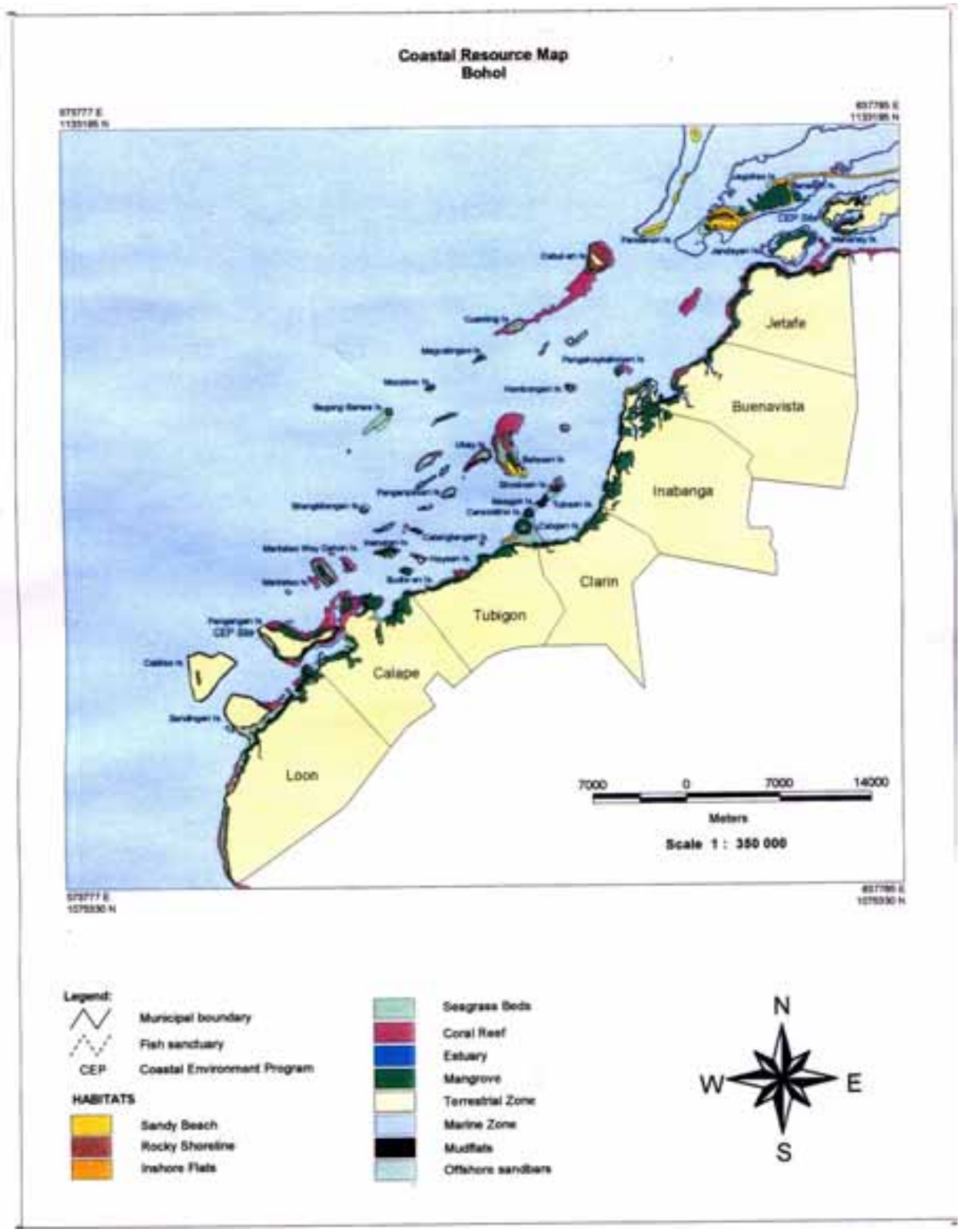


Appendix 2 List of Key Informants

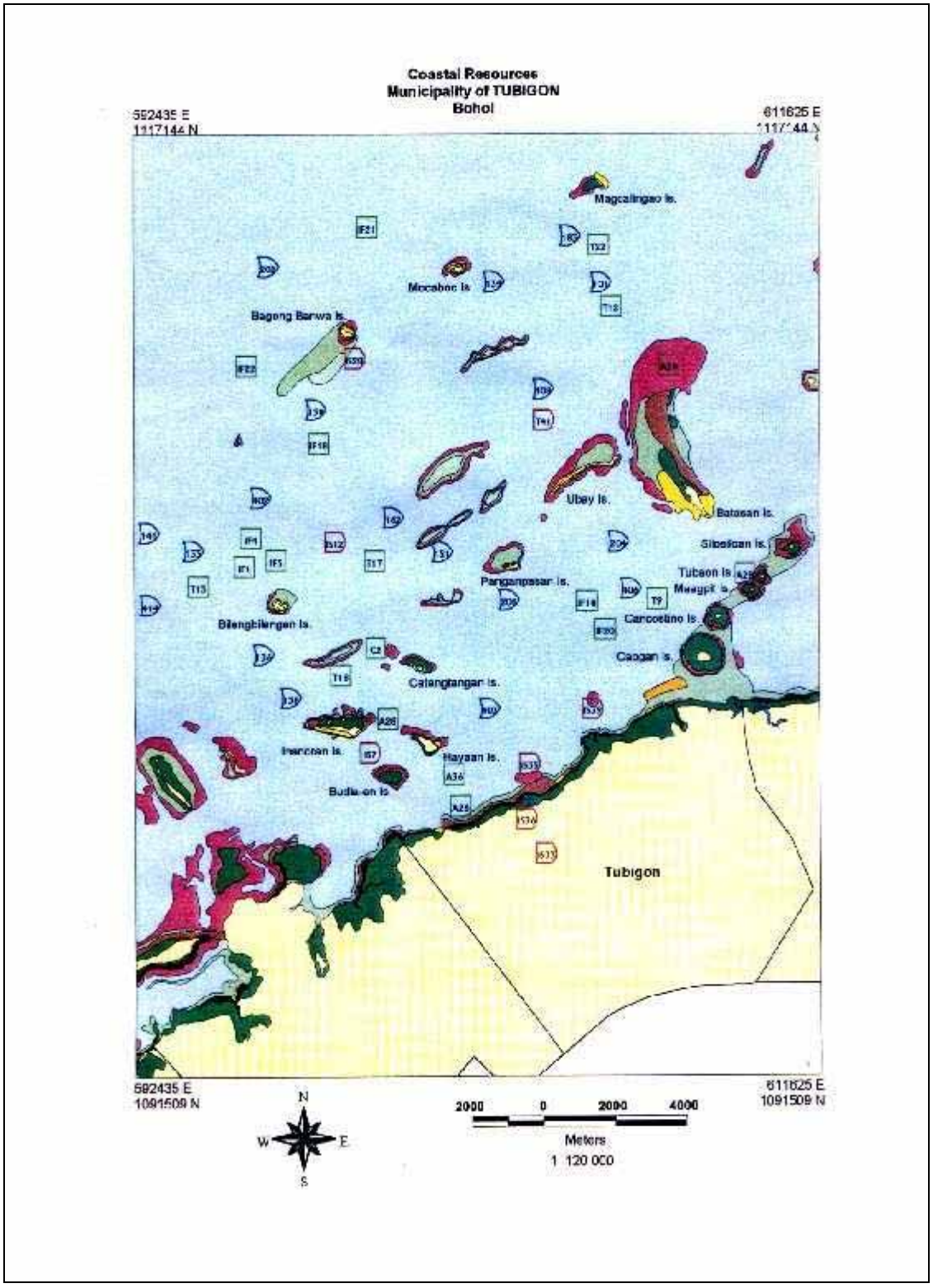
Name	Organization	Date of SSI/FGD
Noel Mendaña	MPDC and LOGODEF Project Director	16-21 October 2002, 18-22 November 2002
Victor Boligao	LOGODEF Fisheries Technician	16-21 October 2002, 18-22 November 2002
Renato Bagsac	LOGODEF Fisheries Technician	16-21 October 2002, 18-22 November 2002
Epitacio Mumar	MAO	16-21 October 2002, 18-22 November 2002
Hon Paulo Lasco	Municipal Mayor	18 November 2002
Cesar Boligao	Member, Pangapasan Fishers Association	21 November 2002
Macario Abapo	Member, Pangapasan Fishers Association	21 November 2002
Manuel Cantones	Member, Pangapasan Fishers Association	21 November 2002
Wilfredo Millomeda	Member, Pangapasan Fishers Association	16-21 October 2002 21 November 2002
Renato Gutierez	Barangay Councillor, Chair Agriculture and Fisheries Committee	21 November 2002
Gerardo Bayon	Member, Pangapasan Fishers Association	21 November 2002
Rogelio Cantones	Member, Pangapasan Fishers Association	21 November 2002
Florante Cantones	Member, Pangapasan Fishers Association	21 November 2002
Antonio Espra	Member, Pangapasan Fishers Association	21 November 2002
Federico Augis	Member, Pangapasan Fishers Association	21 November 2002
Carlos Cantones	Member, Pangapasan Fishers Association	21 November 2002
Bernardo Cantones	Member, Pangapasan Fishers Association	21 November 2002
Jacinto Cabiso	Member, Pangapasan Fishers Association	21 November 2002
Alex Rallos	Barangay Councillor, Pangapasan	21 November 2002
Ethel Torijano	Feed the Children, IPOPCORM	20 November 2002
Giselle Bacyar	Feed the Children, Community Banking Micro-Finance Project	20 November 2002
Boy Caba	Seaborne Patrol member, Macaas	16-21 October 2002 18-22 November 2002
Claro	Member, Macaas Mudcrab Project	18 November 2002
Rodel	Member, Macaas Mudcrab Project	18 November 2002
Teodoro	Member, Macaas Mudcrab Project	18 November 2002
Rodrigo Cosicol	Barangay Captain, Batasan	16-21 October 2002
Rufina Guiterez	Barangay Secretary	16-21 October 2002
Fortunato Salomon	Grouper Culture Project Coordinator in Batasan	16-21 October 2002 19 November 2002
Edward	Member, Batasan Fishers Association	19 November 2002
Paning	Member, Batasan Fishers Association	19 November 2002
Felipe	Member, Batasan Fishers Association	19 November 2002
Mesiah	Member, Batasan Fishers Association	19 November 2002
Dodong	Member, Batasan Fishers Association	19 November 2002
Victor	Member, Batasan Fishers Association	19 November 2002
Estanislao Cervantes	President, Panaytayon Fishers Association	16-21 October 2002 20 November 2002
George Honteras	Member, Panaytayon Fishers Association	20 November 2002
Felix Cervantes	Member, Panaytayon Fishers Association	20 November 2002
Junior	Member, Panaytayon Fishers Association	20 November 2002
Eduardo	Member, Panaytayon Fishers Association	20 November 2002
Pepito Flores	Member, Matabao Fishers Associaton	21 November 2002
Chris Mante	President, Matabao Fishers Association	21 November 2002

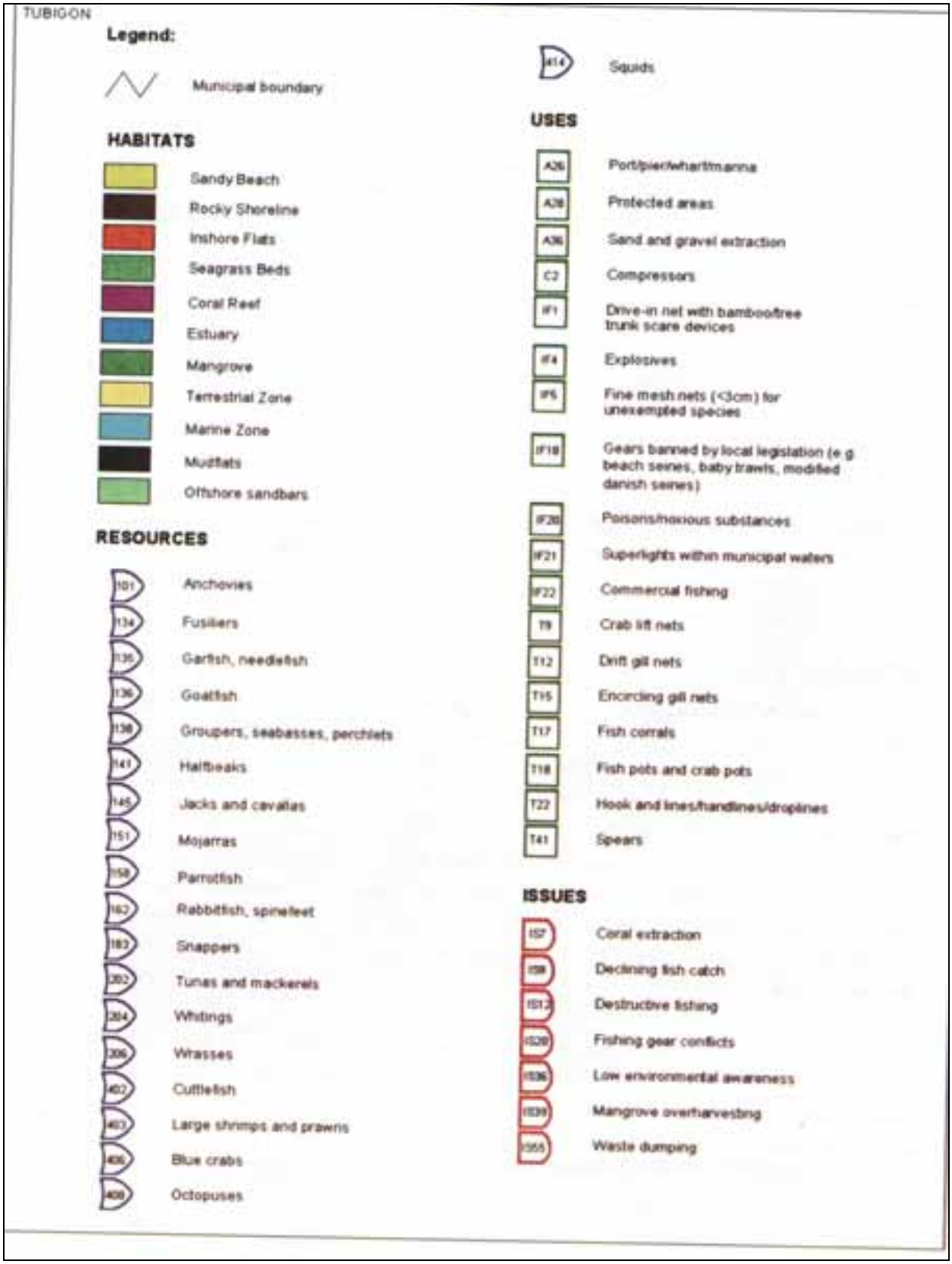
Name	Organization	Date of SSI/FGD
Rolando Obquia	President, Bilangbilangan Fishers Association	16-21 October 2002
Juanito Ang	Businessman	2 December 2002
Monique Piquero	Project Staff, MAC in Tubigon	20 November 2002
Dionisio de la Peña	Assistant Regional Director, BFAR 7	4 November 2002
Jocel Corrales	Planning Staff, BFAR 7	25 October 2002
Esdel Ensomo	Technical Staff, BFAR 7	4 November 2002
Elsa Bulasa	Fish feed supplier	18 November 2002
Jovito Josol	Fish feed supplier	18 November 2002
Manang Elpidia	Fish gleaner from Batasan	19 November 2002
Liza Cuyno	Barangay Treasurer, Pandan	22 November 2002
Felipe Reserva	Barangay Captain, Pandan	22 November 2002
Octavio Cuyno	Member of grouper culture group, Pandan	22 November 2002

Appendix 3 Map of Northwestern Bohol



Appendix 4 Tubigon Coastal Resources, Uses and Issues




TUBIGON
Legend:
Municipal boundary
HABITATS
Sandy Beach
Rocky Shoreline
Inshore Flats
Seagrass Beds
Coral Reef
Estuary
Mangrove
Terrestrial Zone
Marine Zone
Mudflats
Offshore sandbars
RESOURCES
101 Anchovies
134 Fusiliers
135 Garfish, needlefish
136 Goatfish
138 Groupers, seabasses, perchlets
141 Halfbeaks
145 Jacks and cavallas
151 Mojarras
158 Parrotfish
162 Rabbitfish, spinefeet
183 Snappers
302 Tunas and mackerels
304 Whitings
305 Wrasses
402 Cuttlefish
403 Large shrimps and prawns
406 Blue crabs
408 Octopuses
414 Squids
USES
A26 Port/pier/wharf/marina
A28 Protected areas
A36 Sand and gravel extraction
C2 Compressors
IF1 Drive-in net with bamboo/tree trunk scare devices
IF4 Explosives
IF5 Fine mesh nets (<3cm) for unexempted species
IF18 Gears banned by local legislation (e.g beach seines, baby trawls, modified danish seines)
IF20 Poisons/noxious substances
IF21 Superlights within municipal waters
IF22 Commercial fishing
T9 Crab lift nets
T12 Drift gill nets
T15 Encircling gill nets
T17 Fish corrals
T18 Fish pots and crab pots
T22 Hook and lines/handlines/droplines
T41 Spears
ISSUES
I57 Coral extraction
I59 Declining fish catch
I51,2 Destructive fishing
I520 Fishing gear conflicts
I536 Low environmental awareness
I539 Mangrove overharvesting
I555 Waste dumping

Appendix 5a Status of Coral Resources of Northwestern Bohol (Jetafe to Calape)[31]

The reefs are characterized as steep and gently sloping, with reef widths ranging from 100-200 m. Substrate composition was mostly rubble, sand and rock. High silt cover was observed in Banacon and Inanoran where seagrasses were found in the shallower portions of the reef. During the survey, Crown-of-Thorns starfishes *(Acanthanster planci)* were encountered in Cabul-an (four individuals), Ambongan (14 individuals) and Pangangan (three individuals).

One hundred eleven (111) taxa (genera/species) of scleractinian corals in 14 families were documented. Ambongan (65) and Inanoran (63) recorded the highest number of genera and species. Pangangan had 53 species, Banacon 45, Coamen 41 and Cabul-an 31. The non-scleractinian *Millepora* (fire coral) and certain soft coral genera were also noted in some areas.

All deep stations showed higher hard coral cover than the shallow stations except in Banacon and Inanoran. Good coral growths were concentrated on the reef slope, particularly in Amboangan, Coamen and Inanoran.

Results of random quadrat sampling revealed highest total coral cover in Ambongan (58.75%) and Inanoran (40%). Dominant hard coral growths on Ambongan were represented by the branching *non-Acropora* represented by *Porites nigrenses* and massive corals, while the branching *stylophora pistillata* and massive *Porites* and *coeloseris mayeri* were the common forms in Banacon. Inanoran had 40% total coral cover, dominated mostly by the branching *Montipora stellata* and *Porites nigrescens,* encrusting *Montipora*, massive *Porites* and faviids and *Millepora.* Total coral cover for Coamen was 31% with the branching *echinopora mammiformis* and *Porites negriscens* and massive *Porites* as dominant hard corals. The lowest total coral cover was observed in Cabul-an and Pangangan, both of which has 15%. They also had the highest cover of abiotic components (rubble, sand and rock, 53.13% and 59.07% respectively). Furthermore, Pangangan showed the highest dead coral (11.88%). Common hard corals in these areas were massive *Porites* and faviids.

Overall, Bohol exhibited a mean total coral cover of 35.04% (31.35% hard corals and 3.69% soft coral), dead corals 5.99%, seagrasses 4.05%, other fauna 10.21% and abiotic components 44.71%.

[31] (SUML, 1997)

Appendix 5b Coral Reef Areas, Reef Flat Extent and Other Descriptions of the Stations in Northwestern Bohol[32]

Stations	Coral Reef Area	Reef Flat Extent (width)	Slope (degrees)	Substrate	Remarks
Banacon Island Jetafe	Reef is part of Calituban Reef = 7,202.80 ha (Pichon, 1977)	100 m from shoreline, coral reef width is 30 m at 3-5 m deep	20	Mostly sand/silt, little rubble and rock	Seagrasses abound in the shallow area; high cover of soft corals, sea whips and sponges; beyond 5 m deep, substrate composed primarily of sand and patches of corals
Cabul-an Island Buenavista	Reefs of both islands are part of single unit = 1,040 ha	200 m from shoreline	20	Sand,rubble, rock	Seagrasses abound in the shallow area; starfishes and sea urchins were numerous; four Crown-of-Thorns starfishes *Acanthaster plancii* were found
Coamen Island Inabanga		200 m from shoreline	45-50 at 13 m deep	Sand, rubble rock, a little silt	Seagrasses abound in the shallow area; sea urchins were numerous; beyond 20 m deep, substrate is primarily sandy; four Crown-of-Thorns starfishes *Acanthaster plancii* were found
Ambongan Island Inabanga	76.18 ha	150 m	60-70 at 10 m deep	Sand, rubble, rock	Seagrasses abound in the shallow area; high cover of *Anacropora puertogalerae* in deep station; 14 Crown-of-Thorns starfishes *Acanthaster plancii* were found
Inanoran Island Tubigon	115.65 ha	150 m from shoreline	20 at 3 m deep, 60 at 10 m deep	Sand, rubble, silt, rock	Seagrasses abound in the shallow area
Pangangan Island Calape	240 ha	100 m from shoreline, coral reef extent is 20 m from the sargassum bed at 10 m deep	45 at 7 m deep	Sand, rubble, rock, little silt	Sargassum bed in the shallow area; three Crown-of-Thorns starfishes *Acanthaster plancii* were found

[32] (SUML, 1997)

Appendix 6 Relevant Organizations in Tubigon (other than primary and secondary stakeholders)

Organization	Description of Activities	Contact Persons and Addresses
Municipal government (through the Municipal Agriculturist's Office)	The municipal government has these responsibilities related to CRM[33]: a. Legislation b. Impose penalties for acts which endanger the environment c. Grant permits for fish corrals, fish pens, aquatic beds, taking of fish and prawn fry d. Adopt measures for conservation e. Enforce fishery laws in municipal waters f. Provide research services and facilities related to fishery activities g. Initiate activities for the conservation of mangroves h. Give exclusive authority to grant fishery privileges in municipal waters i. Issue permits to construct fish cages in municipal waters j. Issue licenses to fishing vessels weighing three tons or less k. Issue permits to gather aquarium fishes within municipal waters l. Establish fishing seasons in municipal waters m. Issue permits to collect mollusks n. Issue licenses for seaweed farms within municipal boundaries, and o. Issue auxiliary invoices for transport of fishery products	Noel Mendana, MPDC Tubigon Cultural Centre Building, Tubigon, Bohol Philippines Tel: 063 38 2372456 E-mail: ncmmpdc@yahoo.com
Haribon Foundation	Haribon is a Manila-based NGO involved mainly in conservation work. It conducted research on seahorses in Bohol. It also worked with the social component of CRMPs in five municipalities, including Tubigon.	9 Malingap Corner Malumanay Streets Teachers Village, Diliman Quezon City, Philippines Tel: 063 2 9253332, 0632 4362756 E-mail: director@haribon.org

[33] These are responsibilities spelled out in the law, but this does not mean that the municipalities have the capacity to carry them out.

Organization	Description of Activities	Contact Persons and Addresses
Feed the Children	FTC has been in Bohol for more than ten years. Its work has four components: a) community-based coastal resource management, b) integrated population and coastal resource management, c) integrated child family development, and d) community banking and micro-financing.	Field Office: Barangay Matabao Tubigon, Bohol, Philippines Tel: 063 38 5080015
LOGODEF	LOGODEF collaborates with the Konrad-Adenauer Stiftung in the implementation of a livelihood program for coastal communities in Tubigon. LOGODEF introduced grouper, mudcrab, oyster and mussel culture in Tubigon.	Dr Gaudisio Sosmena Suite 333 & 334, Secretariat Building, PICC Complex Roxas Boulevard, Manila, Philippines Tel: 0632 8313866 E-mail: logodef@info.com.ph
International Marinelife Alliance	The focus of IMA's work is to reform cyanide users by introducing them to non-destructive fishing methods and alternative livelihood programs. It is working in at least four municipalities in Northwestern Bohol.	Jean Caleda Tel: 063 2 6353530; 063 2 638 1119 E-mail: mjac@marine.org
Marine Aquarium Council	MAC is an international, not-for-profit organization that brings marine aquarium animal collectors, exporters, importers and retailers together with aquarium keepers, public aquariums, conservation organizations and government agencies. MAC's mission is to conserve coral reefs and other marine ecosystems by creating standards and certification for those engaged in the collection and care of ornamental marine life from reef to aquarium.	In Tubigon: Monique Piquero, project staff Clarin, Tubigon, Bohol, Philippines In Hawaii: 923 Nu'uanu Avenue Honolulu, Hawaii 96817 USA Phone: +1 808 550 8217 Fax: +1 808 550 8317 E-mail: info@aquariumcouncil.org
CRMP	CRMP is a seven-year (1996-2001) project – extended up to 2004 – that provides technical assistance and training to local governments and communities in coastal resource management. It is funded by the US Agency for International Development (USAID).	5F Cebu International Finance Towers J Luna and JL Briones Streets, North Reclamation Area, Cebu City Tel: 06 32 232 1821-22 E-mail: crmp@oneocean.org www.oneocean.org

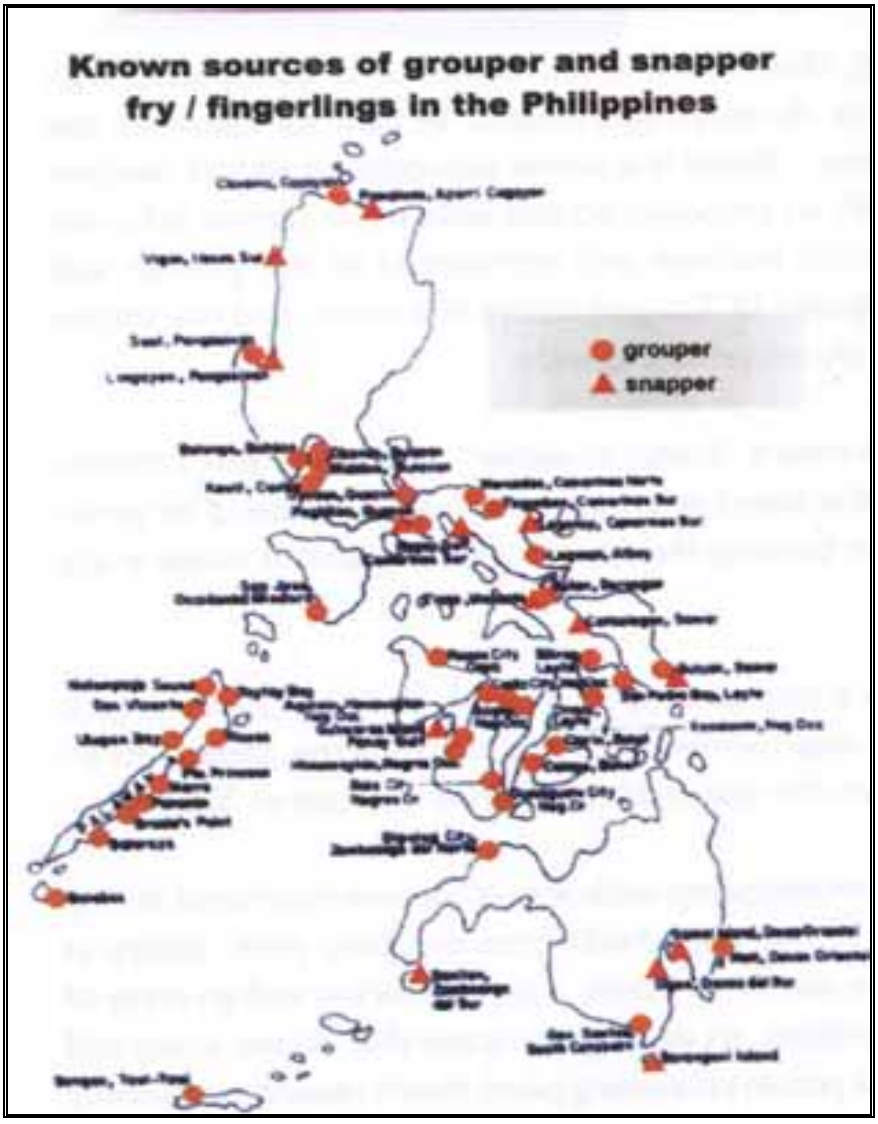
Appendix 7 General Background of Seafarming in the Philippines

Seafarming activities have been identified as an appropriate fish culture technology in the vast coastal waters of the Philippines (Agbayani, 2000). Seafarming, or mariculture, contributed 681,397 mt to fishery production in 1998, accounting for 25% of total fishery production in that year (Agbayani, 2000; Rivera-Guieb et al., 2002, citing BAS figures). Seaweed production, however, comprised 97.8% of this production.

Grouper production in fish cages in the same year totaled only 33 mt. The main reason for the low production was lack of fry and fingerlings (Agbayani, 2000).

The known sources of grouper fry and fingerling and culture sites in the Philippines are shown in Figure 5 (below), which is a bigger version of the inset in Appendix 1.

Figure 5 Known Sources of Grouper and Snapper Fry and Fingerlings in the Philippines (Calara, 2001)



Appendix 8 Fishing Gears Used in Northwestern Bohol[34]

Classification	Gear Type	Local Name
Lift nets	Cast nets	*yabyab*
	Fish nets	*bilaw*
	Scoop nets	*sikpaw, papyaw*
Pull nets	Baby trawl	*palakaya*
	Push nets	*sudsud, dosdos*
	Seine net with scaring devices	*liba-liba, ring-ring, kubkob, de-ring*
	Ring nets	*lawag*
Entangling nets	Bottom set gill nets	*pukot*
	Drift gill nets	*pangasa, pamo*
	Gill nets	*pukot*
	Set gill nets	*pukot*
	Squid nets	*pang-nokos*
	Two-ply	double net
	Fish corral	*bunsod*
Barriers and traps	Fish pot	*panggal*
	Fish trap	*bobo*
	Bamboo structure with lift net	new look
Line	Jigger	*sarangat, panglabyog*
	Single hook and line	*pasol, latak, subid*
	Multiple hook and line	*palangre, kitang*
	Line with no hook	*rentex*
	Troll lines	*subid, subid-subid*
Hand instrument	Spear gun	*pana*
	Spear gun with compressor	*buso*
	Gleaning	*panginhas*
	Bare hands	*panalum*
	Torch and kerosene fueled lamp	*panulo*
	Torch with scoop nets	*panulo*
Others	Dynamite	*tiro, dinamita*
	Sodium cyanide	cyanide, *kuskos*
	Poison seeds	*lagtang*
	Poison vine	*tubli*
	Pesticide	*indrin,* malathion, muriatic acid
	Electricity fishing	*kuryente*
	Tobacco and tobacco-chili mix for small octopus	
	Purse seine	
	Drag seine	*likom-likom*
	Baby ring net	*basnig*
	Bag net for schooling fish	*sinsoro*
	Drive-in net with scaring device	*baling*
	Small drag seine, beach seine	
	Fine-mesh gill net	
	Small barrier nets	

[34] (SUML, 1997, as cited in Green, 2000)

Appendix 9 History of Reef Fishery and Coastal Resources Management in Bohol[35]

Unsustainable fishing practices in Tubigon can be traced back to the late 1940s after the Second World War. Gunpowder left during the war was used in making dynamite for blast fishing. It was not really clear who introduced the practice, but it instantly became popular as it can bring in a lot of catch. The practice persisted, as there was no regulation then against its use. When the leftover gunpowder was used up, fishers resorted to using fertilizer, which is still being used up to the present.

In 1975, President Ferdinand Marcos enacted Presidential Decree (PD) 704 or the "Fisheries Decree of 1975". This degree encouraged the full exploitation of the Philippines coastal resources to increase fishery production. The effect of this decree in Tubigon was the proliferation of baby trawl operations, which required less capital than fish pond operation. Many marginal fishers became workers in baby trawl operations. The use of dynamite and poisonous substances continued to proliferate, because, although there is law penalizing these illegal-fishing practices, law enforcement was poor.

In the 1980s, the use of sodium cyanide to catch tropical aquarium fishes and *lapu-lapu* (grouper) fingerlings emerged in Tubigon. International market demand for tropical fish was high, and *lapu-lapu* fingerlings were also highly in demand. The adverse effects of the different forms of illegal fishing, lower fish catch and destroyed reefs, were already being felt in the late 1980s.

In 1991, Republic Act (RA) 7160, or the Local Government Code, was passed. The central tenet of the code is decentralization of governance. Most of the municipal[36] fisheries management responsibilities were devolved from the Bureau of Fisheries to LGUs. In 1992, the LGU of Tubigon passed an ordinance prohibiting the use of *hulbot-hulbot* (trawls) and *liba-liba* (a kind of pull net), dynamite and cyanide, that were then rampant in their municipal waters. The responsibility to enforce the ordinance was given to the local Philippine National Police (PNP) and deputized sea wardens (*bantay dagats*). Enforcement was weak because of lack of equipment and, according to some, the inability of police to stand up to influential personalities who were financing these illegal activities. The strategy to eliminate illegal fishing practices was then anchored on regulation.

In 1993, the Department of Agriculture (DA) and the Department of Environment and Natural Resources (DENR) launched a campaign for sustainable fishing practices and marine conservation. Through the Central Visayas Regional Project (CVRP), funded by the World Bank, these departments launched Information and Education Campaigns (IECs) and promoted the installation of artificial reefs[37]. The strategy this time was now moving towards information and education and conservation.

[35] This section was based on different timelines produced during the SSIs and FGDs.
[36] Municipal waters refer to those within 15 kilometers of the shore.
[37] Sometime in the middle to late 1990s the DA banned the installation of artificial reefs because these are found to be ineffective in restoring reef habitats as they only act as fish aggregating devices that facilitate the capture of more fish.

As early as June 1996, the Municipality of Tubigon had already taken initial steps in the formulation of the Tubigon Environment Code. The process began with a series of consultations between and among the Municipal Government, LOGODEF and the Federation of Canadian Municipalities (FCM) that provided technical and financial support. These agencies agreed that all environment-related ordinances and pertinent regulations of Tubigon should be compiled into a code. The consultations resulted in the creation of a Technical Working Group with multi-sectoral representation from the *Sangguniang Bayan* (municipal council), NGOs, fisherfolk associations and the Fisheries and Aquatic Resources Management Council (FARMC).

In 1997, the Coastal Resource Management Project (1996-2003), funded by USAID, started their project activities in Tubigon, which is one of their "learning sites". The main difference of the CRMP strategy with previous strategies is that it focused on improving policy, capacity-building for those enforcing the policy (the LGUs) and institutionalizing CRM systems and processes.

On 25 March 1998, the Tubigon Environment Code was approved and formed the basis for the formulation of the Tubigon CRM Code that was discussed with various stakeholders as early as 1999 and eventually approved by the municipal council on 11 July 2000. With the code in place, Noel Mendaña says that it was easy for the municipality to coordinate the efforts of the different external organizations who are providing assistance to their CRM efforts; most of these groups were involved in the formulation of the code.

In 1999, the municipal government realized that, apart from having a good policy in place and making fishers realize the importance of conserving and protecting the coastal resources through information and education, alternatives to unsustainable fishing practices are needed. Without these alternatives, fishers do not have anything to maintain their livelihoods. Consultations with the *liba-liba* operators resulted in putting down their unsustainable fishing practice and embraced the fishing alternative that was sponsored by the local government. Funds from the congressman and municipality for the purchase of pump boats and fish net were extended as soft loans. Cyanide fishers were given training on proper ways of catching and handling tropical aquarium fishes and were also assisted to market their catch. Another breakthrough in coastal resource management was the integration of the CRM Plan in the Municipal and Barangay Development Plan, and the introduction of the Mariculture Project.

Many of the fishers who had been involved in unsustainable fishing practices are the very people protecting, patrolling and guarding their reserves and sanctuaries, and the resources therein. However, they occasionally complain about commercial fishing boats using purse seine and super lights, apparently coming from Cebu, and some baby trawls that they suspect come from neighboring villages that sometimes are seen operating in Tubigon waters.

Appendix 10 Members of the FARMC in Tubigon (2001)

Name	Position in the MFARMC	Sector or Group Represented
Engineer Noel Mendaña		Municipal Planning and Development Council (MPDC)
Dennis Arcamo (R)		*Sangguniang Bayan*[38], Committee on Fisheries and Agriculture
Martino Floinga		Municipal Development Council (MDC)
		NGO representative, Feed the Children (FTC)
		NGO representative, Haribon Foundation
Armando Reserva	Secretary	Private sector representative
Epitacio Mumar	Chair	Municipal Agriculture Office
Rodrigo Calunia	Sergeant at arms	Fisher representative
Mansueto Guitierrez (R)	PRO	Fisher representative
Rogelio Ybañez		Fisher representative
Victor Lagurin		Fisher representative
Christopher Alampayan		Commercial fisher representative
Rolando Obguia		Commercial fisher representative
Flaviano Adtoon	Treasurer	Fisher representative
Batana		Fisher representative
Cesario Cabangbang (R)		Fisher representative
Rodrigo Cosicol		Fisher representative
Maximo Heluano		Fisher representative
Angel Sevilla	Auditor	Fisher representative
Eugenio Abella		Fisher representative
Tito Obquia (R)	Sergeant at arms	Fisher representative
Roy Ladra (R)	Vice-chair	Fisher representative
Romulo Bautista	Sergeant at arms	Fisher representative
Perfecto Notarte		Fisher representative
Rosauro Yosoya		Fisher representative
Cornilio Albura		Commercial fisher representative

Source: MAO records
R = replaced

[38] Municipal Council

Photos

Photo 1 The Fish Cages (floating method) in Batasan

Photo 2 Women Gleaning in Batasan

Photo 3 Fishers Using Gill Net

Photo 4 Boats of Municipal Fishers in Panaytayon

Photo 5 Fishpot in Panaytayon

Photo 6 A Smaller Fish Pot in Panaytayon

Photo 7 The Fish Cage (stalking method) in Panaytayon

Photo 8 Another Form of Fish Pot in Macaas

Photo 11 Raising Pigs for the Annual Feast

Photo 9 Trash Fish (mostly slipmouths)

Photo 12 Typical House of a Fisher with a Non-motorised Boat

Photo 10 Victor Boligao, Fisheries Technician, Buying Fish at the Tubigon Market

Photo 13 Getting Ready to Set the Fish Pots (Batasan)

Photo 14 Fixing the Net in Panaytayon

Photo 15 Bamboo Bridge inside Mudcrab Culture Project (Macaas)

Photo 18 PCRA Results in Pangapasan

Photo 16 Fredo Tells Us His Story (Pangapasan)

Photo 19 Tidal Flat in Pangapasan (take note of mangrove reforestation)

Photo 17 Manong Tanny Draws on a Resource Map (Panaytayon)

Photo 20 Women Cleaning Sea Cucumber (Pangapasan)

Photo 21 Barangay Captain Felipe Reserva and Treasurer Liza Cuyno Share with Us Their Experience in Barangay Governance (Pandan)

The STREAM Initiative
Network of Aquaculture Centres in Asia-Pacific (NACA)
Suraswadi Bldg, DOF Complex
Kasetsart University Campus
Ladyao, Jatujak
Bangkok 10900 Thailand

Tel +66-2-940-5457
Fax +66-2-561-1727
Switchboard +66-2-561-1728-9 ext 108
E-mail ghaylor@loxinfo.co.th
Website http://www.streaminitiative.org

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