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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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.

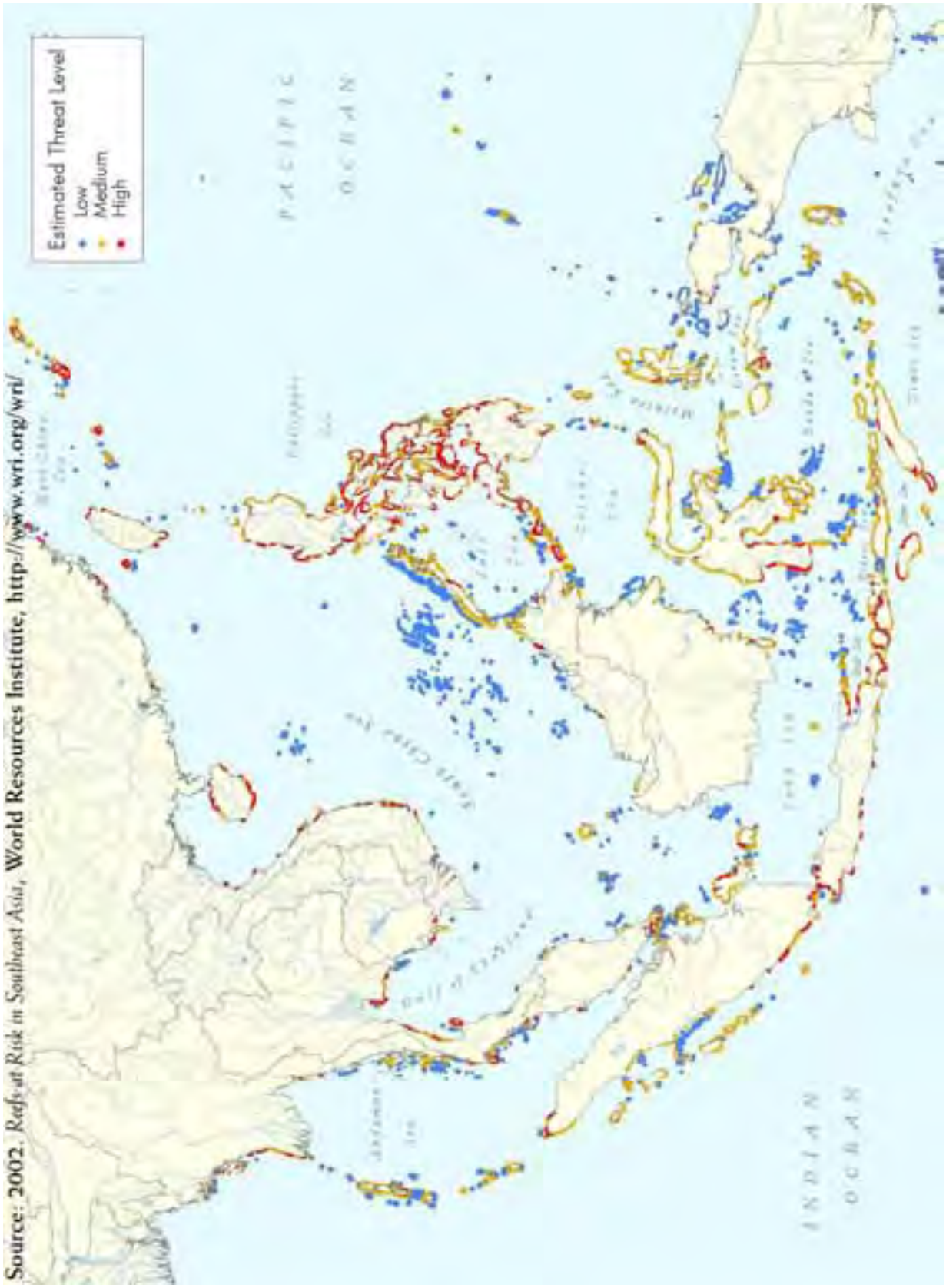

Figure 1 Estimated Threat to Southeast Asian Coral Reefs from Anthropogenic Factors

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

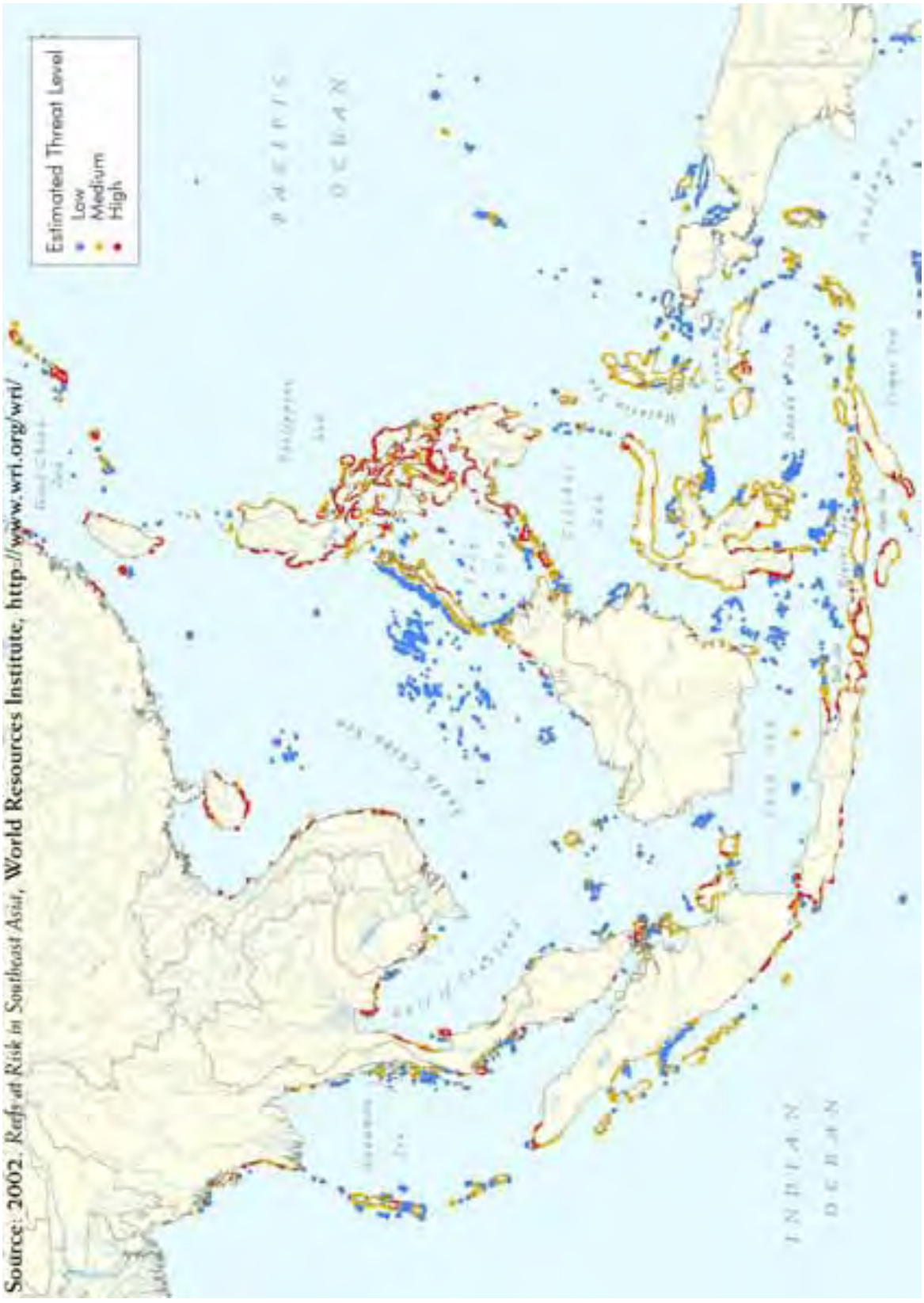

Figure 3 Estimated Threat to Southeast Asian Coral Reefs from Destructive Fishing Activities

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".

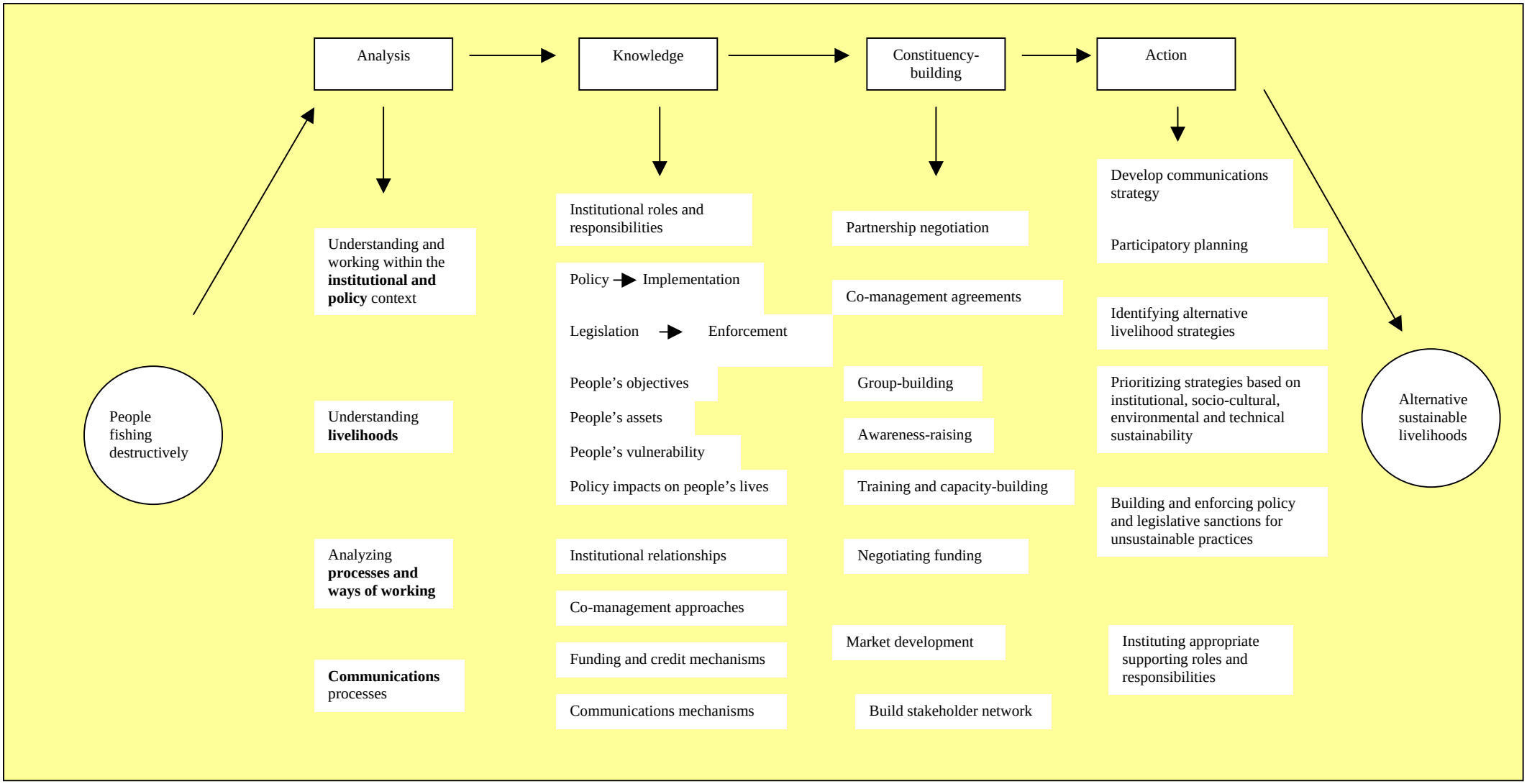

Figure 4 Generic Elements along the Road *from "Destructive Fishing Practices" to "Sustainable Livelihoods"*

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