Annex 3

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

IMPROVING COASTAL LIVELIHOODS THROUGH SUSTAINABLE AQUACULTURE PRACTICES

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

IUCN Vietnam Program

2003

Contents

Tables and Figures

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

Executive Summary

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

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

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

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

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

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

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

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

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

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

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

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

1. Introduction

1.1 Study Area

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

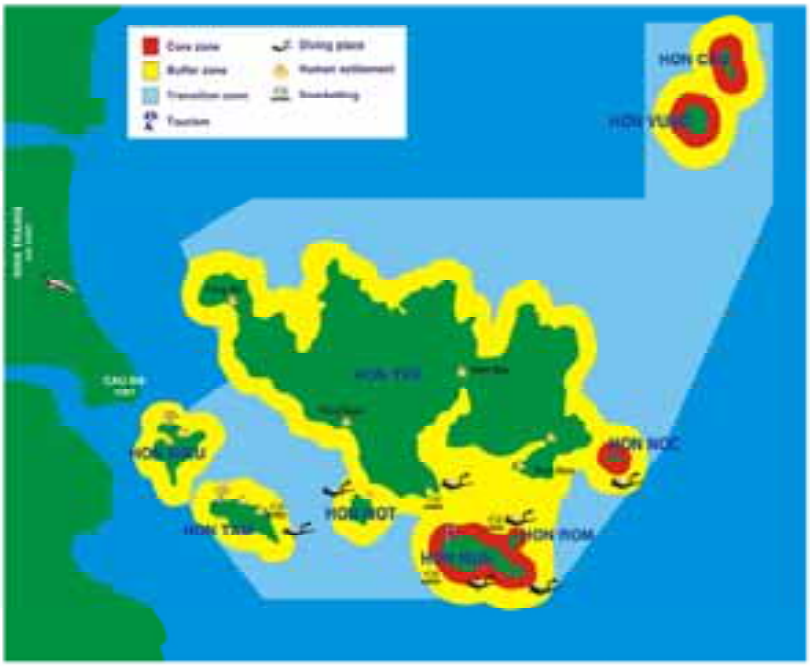

Figure 1 Map of Hon Mun MPA Showing Core, Buffer and Transition Zones

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

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

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

1.2 Coral Reef Fisheries and Aquaculture

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

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

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

1.3 Reefs at Risk

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

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

1.4 Hon Mun Marine Protected Area

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

The objective of Hon Mun MPA is:

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

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

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

1.4.1 Temporary Regulation and Zoning Scheme

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

1.4.1.1 Restating National Legislation

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

1.4.1.2 Provision of Protection Zones Restricting Fishing Activities

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

Core Zone

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

Buffer Zone

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

Transition Zone

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

1.5 Sustainable Aquaculture

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

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

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

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

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

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

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

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

Scope of Report

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

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

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

2. Current Situation

2.1 Status and Recent Declines in Biodiversity and Coral Reef Fisheries

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

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

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

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

Source: Vo et al., 2002b

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

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

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

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

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

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

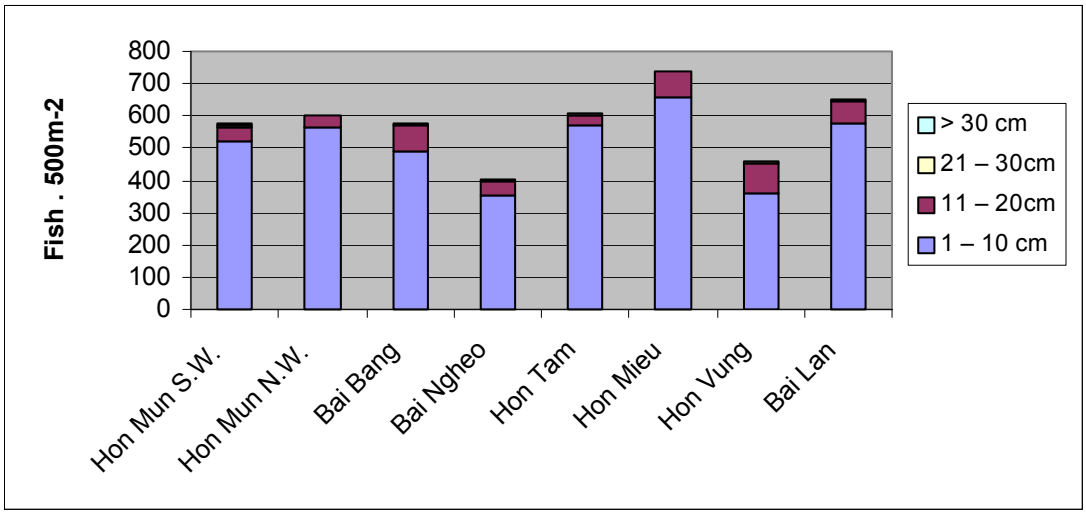

Figure 3 Size Distribution of Fish at Permanent Monitoring Locations, Hon Mun MPA (2002) (from Vo et al., 2002c)

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

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

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

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

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

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

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

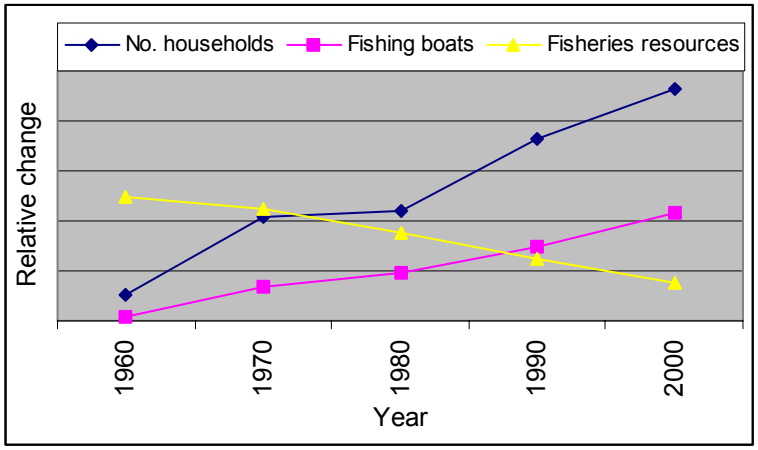

Figure 4 Perceived Changes in Population (Households), Fishing Fleet and Fisheries Resources (after Nguyen and Adrien, 2002)

2.2 Socio-economic Status of Island Communities

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

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

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

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

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

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

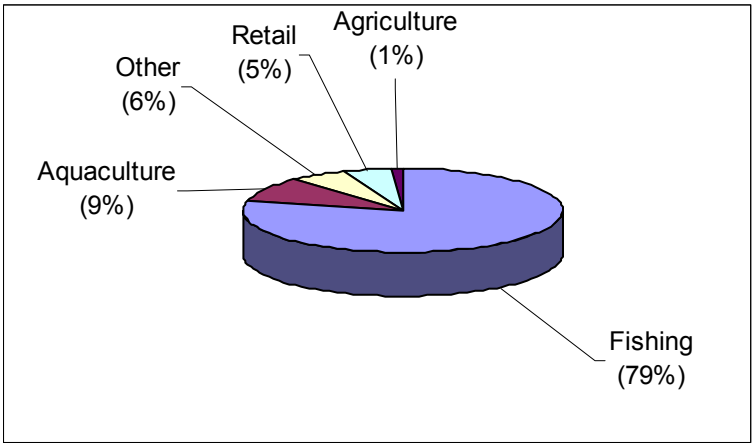

Figure 5a Distribution of Main Activities of MPA Household Heads

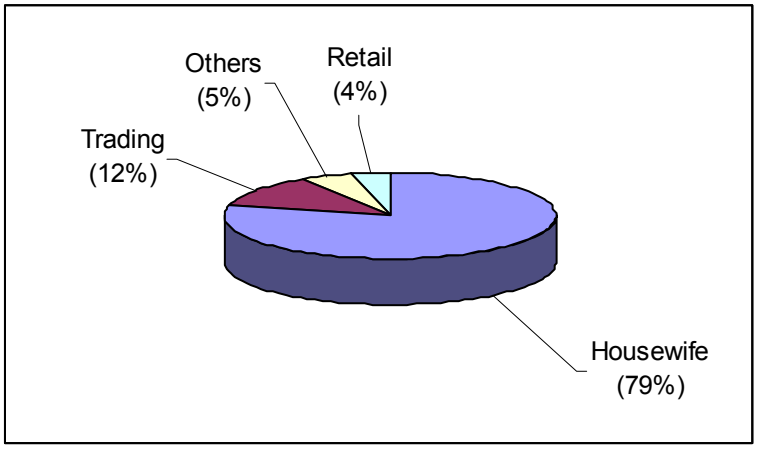

Figure 5b Distribution of Main Activities of Partners of MPA Household Heads

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

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

2.3 Coral Reef Fisheries

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

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

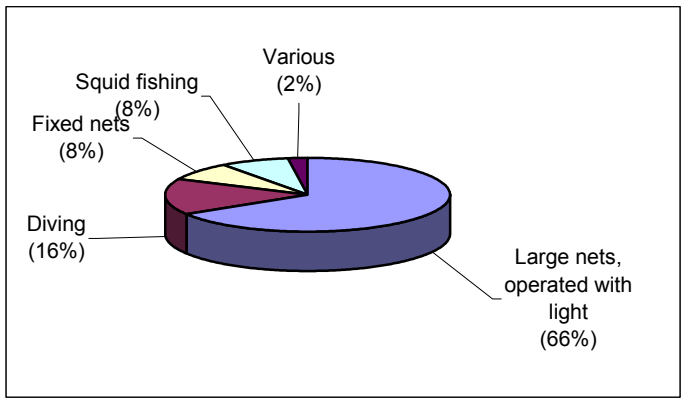

Figure 6 Distribution of Main Fishing Gears within Hon Mun MPA Fishing Fleet

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

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

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

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

2.3.1 Cost/Benefit Analysis per Type of Gear

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

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

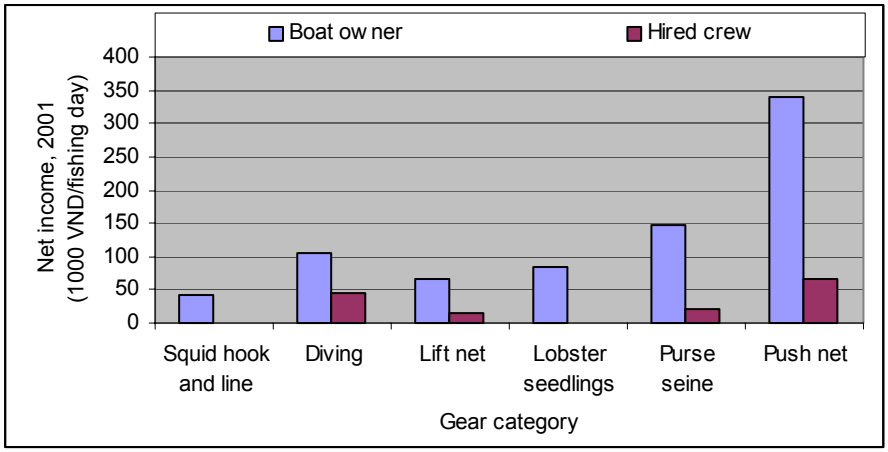

Figure 7 Estimated Income from the Different Fishing Gears Used within Hon Mun MPA

2.3.2 Recent Fisheries Investment Trends

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

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

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

2.4 Aquaculture

2.4.1 Development History of Aquaculture in Nha Trang Bay

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

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

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

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

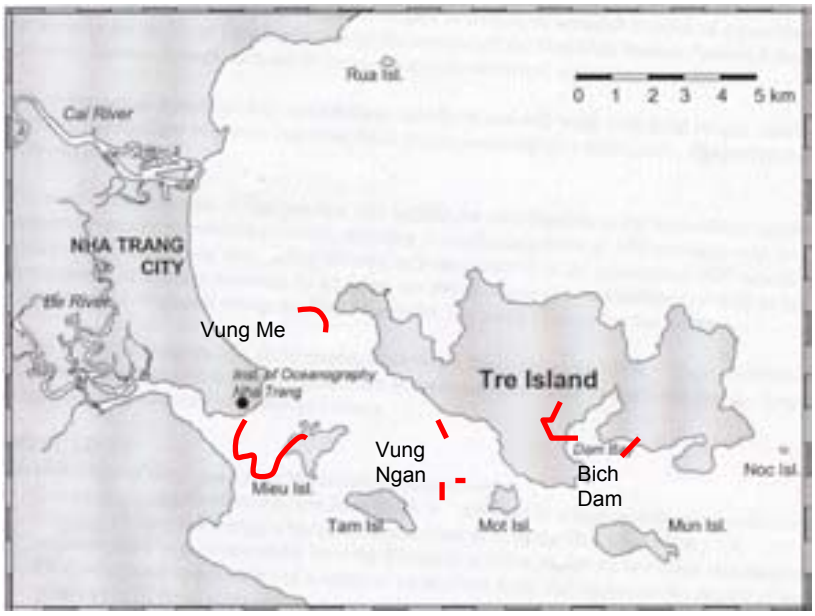

Figure 9 Existing Aquaculture Development (red lines) in Hon Mun MPA, Nha Trang Bay

2.4.2 Current Aquaculture Practices

2.4.2.1 Extent and Spatial Distribution

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

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

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

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

2.4.2.2 Lobster Culture

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

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

2.4.2.3 Grouper Culture

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

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

2.4.2.4 Recent Aquaculture Investment Trends

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

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

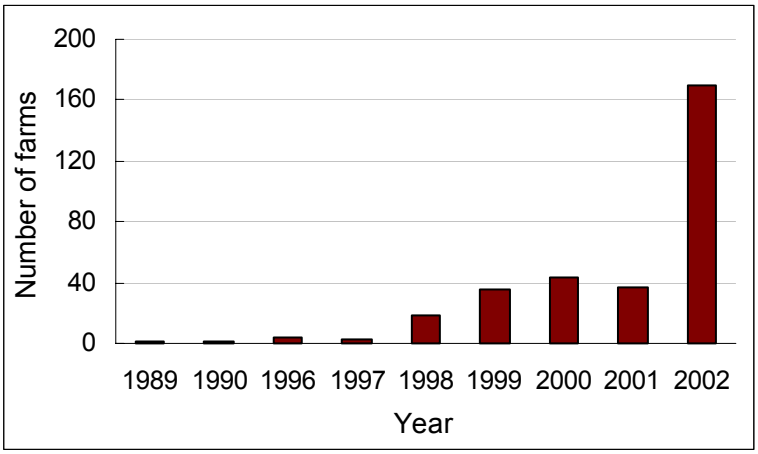

Figure 10 Recent Development of Aquaculture Farms within Hon Mun MPA

2.4.3 Current Issues and Constraints on Sustainable Aquaculture

2.4.3.1 Use of Wild-caught Seed

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

2.4.3.2 Use of "Trash Fish" and Shellfish as Feed

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

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

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

2.4.3.3 Aquaculture Techniques and Systems

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

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

2.4.3.4 Space Limitation and Conflict with Other MPA Users

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

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

2.4.3.5 Self-pollution Due to Clustering Effects

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

2.4.3.6 Land-based and Maritime Pollution

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

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

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

2.4.3.7 Social Issues, Inequitable Opportunities, Access to Credit

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

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

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

3. Addressing Issues and Proposed Actions

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

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

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

3.1 Technical Issues

3.1.1 Use of Wild-caught Seeds for Stocking

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

3.1.1.1 Research and Development of Hatchery-produced Seeds

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

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

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

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

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

3.1.1.2 Limiting Development Scale

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

3.1.1.3 Diversification of Culture Species

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

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

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

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

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

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

* newly added
** not available locally

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

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

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

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

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

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

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

3.1.2 Use of "Trash Fish" and Shellfish for Feeding

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

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

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

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

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

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

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

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

3.1.2.3 Modification of Feeding Practice

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

3.1.2.4 Extension Services

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

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

3.1.3 Mono-species Aquaculture and Risks of Diseases

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

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

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

These issues can be addressed through the following three ways:

3.1.3.1 Screening of Seed-stock

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

3.1.4 Limited Culture Technology/Systems

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

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

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

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

This issue can be addressed through the following:

3.1.4.1 Introduction of New Culture Technology/Systems

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

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

3.2 Planning and Management Issues

3.2.1 Legal, Institutional and Policy Frameworks

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

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

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

This issue can be addressed through the following:

3.2.1.1 Integrated Planning

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

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

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

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

These issues can be addressed through the following five ways:

3.2.2.1 Licensing of Aquaculture within the Hon Mun MPA

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

3.2.2.2 Hon Mun MPA Aquaculture Masterplan

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

3.2.2.3 Planning and Zoning

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

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

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

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

3.2.2.4 Monitoring Effectiveness of the Masterplan

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

3.2.2.5 Waste Management

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

3.3 Economic Issues

3.3.1 Market Instability and Constraints

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

3.3.1.1 Species Diversification

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

3.3.1.2 Market Analyses and Promotion

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

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

3.4 Social Issues

3.4.1 Poverty and Destructive Fishing

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

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

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

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

3.4.1.1 Alternate Income Generation (AIG)

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

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

3.4.2 Inequitable Distribution of Resource Ownership

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

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

3.4.2.1 Priorities for Local People

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

3.4.3 Inequitable Distribution and Access to Credit Opportunities

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

3.4.3.1 Revision of Current Credit Provision Systems

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

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

3.4.4 Reluctance to Change Aquaculture Systems

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

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

3.4.4.1 Education and Extension Services

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

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

4. Recommendations and Concluding Remarks

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

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

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

Sustainable coastal fisheries:

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

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

5. Acknowledgments

This report has been compiled by a number of people. Dr Hoang Tung, National University of Fisheries, Nha Trang, and Aquaculture Specialist of Hon Mun MPA Project, coordinated the case study. Other contributors from the Hon Mun MPA Project included Nguyen Thi Hai Yen, Bernard Adrien and Bernard O'Callaghan. Chris Gow coordinated and compiled the report. Dr Lyndon DeVantier and Catherine Cheung both contributed to and reviewed the report.

6. References

Bryant D, Burke L, McManus J and Spalding M 1998 *Reefs at Risk: A Map Based Indicator of Threats to the World's Coral Reefs*. Washington DC: WRI, ICLARM, WCMC and UNEP.

Cheung C P S and Vo S T 1993 *Survey Report on the Biodiversity, Resources Utilization and Conservation Potential of Hon Mun, Nha Trang, S. Vietnam*. Vietnam Marine Conservation Southern Survey Team. Gland, Switzerland: WWF.

FAO Fisheries Department 1997 Aquaculture Development. *FAO Technical Guidelines on Responsible Fisheries 5*.

Haiphong Institute of Oceanography 2002 *History, Socio-economics and Ecological Effects of the Dam Dang Fixed Net Fishery in Hon Mun MPA*. Technical Report to IUCN Hon Mun MPA Pilot Project.

Khanh Hoa Department of Fisheries 2002 *Planning for Coastal Aquaculture in Khanh Hoa Province 2001-2010*. Nha Trang, Vietnam.

Nguyen T H Y and Adrien B 2002 *Socio-economic Assessment of the Potential Implications of the Establishment of the Hon Mun Marine Protected Area Pilot Project, Nha Trang, Vietnam (draft)*. Technical Report to IUCN Hon Mun MPA Pilot Project.

Sadovy Y 2000 *Regional Survey of Fry/Fingerling Supply and Current Practices for Grouper Mariculture: Evaluating Current Status and Long-term Prospects for Grouper Mariculture in Southeast Asia*. Final report to the Collaborative APEC Grouper Research and Development Network (FWG 01/99).

SEAFDEC 2001 *Husbandry and Health Management of Grouper*. Aquaculture Department, Southeast Asian Fisheries Development Centre.

Spalding M, Ravilious C and Green E P 2001 *World Atlas of Coral Reefs*. United Nations Environment Programme World Conservation Monitoring Centre.

Talaue-McManus L 2000 *Transboundary Diagnostic Analysis for the South China Sea*. EAS/RCU Technical Report Series No. 14. Bangkok, Thailand: UNEP.

Veron J E N 2000 *Corals of the World*. Australian Institute of Marine Science.

Vo S T, Hua T T, Nguyen X H and DeVantier L M 2002a Shallow Water Habitats of Hon Mun Marine Protected Area, Nha Trang Bay, Vietnam: Distribution, Extent and Status 2002. In *Collection of Marine Works Special Issue on the Occasion of the 80th Anniversary of the Institute of Oceanography (1922-2002), Vol. 12* (pp 179-204). Science and Technique Publishing House.

Vo S T, Hua T T, Nguyen X H and DeVantier L M 2002b *Marine and Coastal Habitats of Hon Mun Marine Protected Area, Nha Trang Bay, Vietnam Baseline Survey, March-April 2002.* Technical Report to IUCN Hon Mun MPA Pilot Project.

Vo S T, Nguyen V L, Hoang X B, Phan K H and DeVantier L M 2002c *Coral Reef Monitoring of Hon Mun Marine Protected Area, Nha Trang Bay, Vietnam, 2002: Baseline Assessment and Training of the Community-based Monitoring Team.* Technical Report to IUCN Hon Mun MPA Pilot Project.

Vo S T, Nguyen V L, Nguyen X H, Hua T T, Phan K H and DeVantier L M 2002d *Biodiversity of Marine Flora and Fauna of Nha Trang Bay and Hon Mun Marine Protected Area, Khanh Hoa Province, South-Central Vietnam: Review of Taxonomic Studies 1930-2001.* Technical Report to IUCN Hon Mun MPA Pilot Project.

Vo S T, Nguyen V L, Nguyen X H, Hua T T, Phan K H and DeVantier L M 2002e *Coral Reefs of the Hon Mun Marine Protected Area, Nha Trang Bay, Vietnam, 2002: Species Composition, Community*

Structure, Status and Management Recommendations. Technical Report to IUCN Hon Mun MPA Pilot Project.

WCED (World Commission on Environment and Development) 1987 *Our Common Future*. Oxford UK: Oxford University Press.

7. Annex Table

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

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

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

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

APEC Publication Number APEC#203-FS-01.1
ISBN