How Coral Reef Conservation and Marine Protected Areas Impact Human Well-Being: A Case Study of a Marine Protected Area and Fishing Communities in Central Vietnam

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Front cover photo: A fisherman docked at the harbor of a small fishing village in Cu Lao Cham. Photo by Ngoc Son under the creative commons license at https://www.flickr.com/photos/cutiforever/5901211934/

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February, 2017

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Quach Thi Khanh Ngoc

EXECUTIVE SUMMARY

This study evaluates the impacts of coral reef conservation and marine protected areas (MPAs) on the well-being of fishing communities in Central Vietnam. The Cu Lao Cham MPA is chosen as the case study. Coral reef health and four aspects of socioeconomic conditions (i.e., catch rate [also related to food security], access to the resource, employment, and income) are investigated. Data on the four different aspects were gathered from different sources. The results show that there is good evidence for how coral reef conservation can transfer the flow of benefits from the ecosystem to the local people. However, trade-offs also occur as a result of the development of tourism, including the degradation of fish resources and the environment. The managers of the MPA and the community should take into account trade-offs in resource management and should focus on appropriate MPA planning and fisheries management outside the MPA to achieve better outcomes for the local community from coral reef conservation.

1.0 INTRODUCTION

1.1 Background

Coral reefs in Vietnam are diverse ecosystems that support valuable ecosystem goods including marine products and services such as fisheries habitat, tourism, and coastal protection. Services from coral reef ecosystem that support people are identified by stakeholders who encompass all four types of ecosystem services including support, provisioning (food), regulating (climate, food regulation), and cultural.

Although coral reefs are one of the most productive and biologically diverse aquatic environments on Earth, they are also one of the most ecologically sensitive. Also, the people who depend on them for food and income are among the poorest people in the world. The annual value of goods and services produced by coral reefs in Vietnam is estimated to be about USD 100 million. Fish equivalent to a value of USD 10,000 (Quan, Hien, and Hien 2008) can be provided by just 1 km^2 of coral reef. However, of the 1,300 km^2 of coral reef found along the coast of Vietnam, only 1% is in good condition. Coral coverage has declined to only 30% in some areas in the period 1993–2004 (Quan, Hien, and Hien 2008).

Establishing marine protected areas (MPAs) that would limit or prohibit people's extractive activities inside their boundaries is considered to be a resource management tool that can be used to slow down and eventually reverse the degradation of coral reef and coastal ecosystems. Globally, scientists have recognized the value of MPAs, especially no-take marine reserves, in improving marine ecosystem health, including the viability of fisheries (NCEAS 2001). Furthermore, MPAs can help to support alternative livelihoods by promoting the sustainable use of coastal

resources (Agardy 1995). Science-based MPA planning is underway in many countries, with positive results for communities and the ecosystems on which they depend (Samonte, Karrer, and Orbach 2010).

Vietnam has established a network of MPAs. Currently, Vietnam has a total of nine MPAs. The main objectives of these MPAs are to conserve biodiversity and to improve the livelihoods of local people. Almost all MPAs aim to conserve coral reef and seagrass. However, despite the 15-year history of MPAs in Vietnam, there have been a limited number of separate assessments of their biological and social perspectives, and there have not been any comprehensive evaluations of the management effectiveness of MPAs and the contribution of coral reef conservation to human well-being (Ngoc, Armstrong, and Anh 2012). The impact of coral reef conservation and MPAs on human well-being is a scientific question of critical policy importance. MPAs influence the quantity and type of benefits that flow from coral reef ecosystems, as well as the distribution of these benefits among social groups (Mascial and Claus 2009). These effects include the abundance and diversity of fish, the amount of fish caught and the associated level of effort, the income earned by fishers from fishing and by other social groups that do not harvest fish, and the distribution of benefits within and amongst user groups (Hastings and Botsford 1999; Halpern 2003).

Coral reef conservation and MPAs should be evaluated both in terms of their contribution to improving ecological function and social well-being. This incorporates the relationships between MPA implementation, coral reef health, fisher responses, and consequential impacts on the geographical distribution of fishing activities and fishing income. In this study, we also quantify the level of awareness regarding MPA regulation among local communities and investigate the effectiveness of enforcement of MPA regulation.

As such, it is important to address some key, but basic, questions:

1. How does MPA regulation affect coral reef health?
2. How does coral reef conservation by MPAs affect the replacement of fishing effort to sites that are still open?
3. How do the gains in fish density from managed sites compare with the possible reduction in density in areas that attract more fishing activities?
4. What is the impact of the MPA on food security and on economic benefits?

In this study, we will focus on small-scale fisheries in Cu Lao Cham Island. The fishery sector is of most relevance to the coastal poor as it provides valuable protein and livelihood options and economic opportunities for local people. It is an important component of economic wealth and can have an important role in economic growth and poverty alleviation.

The study is organized as follows: Section 1 reviews the literature in relation to the linkage between coral reefs and human well-being and examines the research objectives and analytical framework of the study. Section 2 looks at the background of the study area. Section 3 describes the methodology of the study. Section 4 presents the data collection. Section 5 presents the key results. Lastly, Section 6 presents discussion and conclusion.

1.2 Policy Contexts

Vietnam, due to its high and globally significant biodiversity, is recognized as one of the nations where the conservation of biodiversity should be prioritized. Vietnam became a signatory to the United Nations Convention on Biological Diversity (CBD) in 1994. Since then, the

Government of Vietnam has made a substantial investment of both human and financial resources to implement its commitments and obligations under the Convention.

Vietnam's first National Biodiversity Action Plan (NBAP) was approved by the Prime Minister in 1995. This was followed by the National Biodiversity Strategy 2010–2020, which was intended to be the means of implementing the Convention on Biodiversity and the Cartagena Protocol on Biosafety, which was approved by the Prime Minister on 31 May 2007. Its targets were considered consistent with the nation's socioeconomic development at that time. On 31 July 2013, the Prime Minister approved Decision No. 1250/QĐ-TTg, which is the National Biodiversity Strategy 2010–2030 (NBSAP). The NBSAP identifies a number of priority programs and projects aimed at preserving the biodiversity of Vietnam. The Government of Vietnam has integrated elements of both environmental protection and biodiversity conservation into these national plans, programs, and policies, such as the Poverty Alleviation Strategy, the National Sustainable Development Strategy, and the Territories Development Plan. It is recognized that the integration of biodiversity conservation into policies, strategies, plans, and programs of both ministries and agencies will be vital for long-term biodiversity conservation.

One of the targets of NBSAP 2013 was to expand and improve the quality of management of terrestrial protected areas (TPAs) and marine protected areas (MPAs), and to conserve ecosystems that are of national and international importance. In order to achieve this target, NBSAP 2013 suggested specific action plans, which include (1) conducting research; (2) developing guidelines and piloting the economic valuation of biodiversity and ecosystem services; and (3) determining the size, scope, and implementation of measures to protect and restore the ecosystems of coral reefs on a national scale, with the aim of restoring at least 15% of degraded critical ecosystems.

1.3 Review of Literature

Ecosystems contribute to well-being in various ways. Most literature strongly support the hypothesis that protecting the natural ecosystem is fundamental in sustaining and delivering ecosystem services upon which human survival and welfare depend (Díaz et al. 2006; Worm et al. 2006; Beaumont et al. 2007). Díaz et al. (2006) stated that human societies have been built on biodiversity in ecosystems. Loss of ecosystem will negatively impact human access to reliable food, clean water, and raw materials, and will likely have a greater impact on the poor and vulnerable people. However, Raudsepp-Hearne et al. (2010) noted that despite the degradation of some major ecosystem services, it is difficult to discern the impacts on well-being at the global scale. They reported that "existing global data sets strongly support the Millennium Ecosystem Assessment (MEA) (2005) finding that human well-being is increasing." Overall, there was only weak evidence of the impacts on human well-being at the global scale.

Other research has focused more on the link between coastal and marine resource conservation and poverty alleviation (Boyce 1994; Cleaver and Schreiber 1994; Lee and Barret 2001). This research provides multiple conceptualizations of this relationship. Poverty causes resource degradation, which consequently causes further poverty (Cleaver and Schreiber 1994). However, some research claims that trade-offs between poverty alleviation and environmental improvements are inevitable, whereas others suggest that win-win situations are possible under particular conditions (Lee and Barret 2001). This highlights the need for further research to help managers balance these two goals.

The question of how MPAs can impact fishing communities is also of major interest to policy makers and managers. Coral reef conservation and MPAs can impact on five indicators of human well-being: food security, resource rights, employment, community organization, and income (Mascial, Claus, and Robin 2010). The social impacts of MPAs can vary within and among

groups and across different indicators of social well-being, which can lead to trade-offs among social outcomes (Mascial and Claus 2009). By understanding why some MPAs lead to social benefits and others have social costs, we can realize their full potential as a policy instrument for biodiversity conservation and poverty alleviation.

1.4 Research Objectives

The main objective of this research is to assess how coral reef conservation and MPAs can impact the well-being of fishing communities in Central Vietnam. There are three specific objectives within the study:

1. To investigate the current and potential impacts of coral reef ecosystems and MPAs on the well-being of fishing communities in Central Vietnam;
2. To examine whether coral reef conservation due to MPAs can meet both conservation and development objectives simultaneously (coral conservation and improvements in human welfare); and
3. To promote policies that reinforce the conservation of coral reefs and connect stakeholders to the existing knowledge regarding coral value and MPAs and to ensure that they will implement the recommended solutions and policy options to achieve the sustainable development of coral and marine resources.

1.5 Analytical Framework

1.5.1 Well-being from a fisheries perspective

Improving the well-being of fishing communities is a key objective of fisheries governance (McGregor 2009; Coulthard, Johnson, and McGregor 2011). Human well-being, as defined in the MEA (2005), has five interrelated dimensions: access to basic materials, freedom and choice, human health, social relations and social capital, and security.

The MEA framework also articulates the complex ways that ecosystem services support human well-being. In assessing the well-being of fishing communities, broad-based outcomes are considered, which focus on material and nonmaterial goals. For material goals, catch, food supplies, and employment are the key indicators. Regarding nonmaterial goals, working conditions, community involvement in fisheries or the preservation of the ecological value of marine and coastal ecosystems can represent well-being (FAO 2003; Garcia and Cochrane 2005). The well-being of fishing communities should be studied through integrated assessment frameworks (Garcia et al. 2008) that combine comprehensive concepts ranging from human dimensions to ecological ones, and governance within fishery social-ecological systems. By providing a multidimensional perspective, well-being assessment can also contribute to fishery governance by informing the implementation of fishery management instruments and improving the assessment of management options.

1.5.2 Links between coral reef conservation, MPAs, and well-being

Links between coral reef conservation and MPAs can affect the well-being of fishing communities in many ways. By protecting the coral reef from human extraction, coral cover and fish abundance inside MPAs can be maintained or increased, which leads to an increase in fish abundance outside MPAs and higher catches for fishermen. A larger catch can, in turn, increase

fish consumption and income for fishing households. However, MPAs can also impact on fishing behavior due to the fact that the fishers are not allowed to fish inside the MPA; thus, they have to find new places to fish, leading to a decrease in the area they can fish.

In this study, based on Mascial, Calus, and Robin (2010) and the MEA (2005), we will investigate the ecological and socioeconomic issues related to MPA implementation, including coral reef health and the four aspects of human well-being: catch per unit of effort (CPUE) (also related to food security); access to resources (choice of fishing location, effort put into relocation); employment (number of fishers, changing occupation structure); and income (income earned by fishers from fishing) (Figure 1). These indicators are also considered to be the impacts of MPAs through coral reef conservation on human well-being.

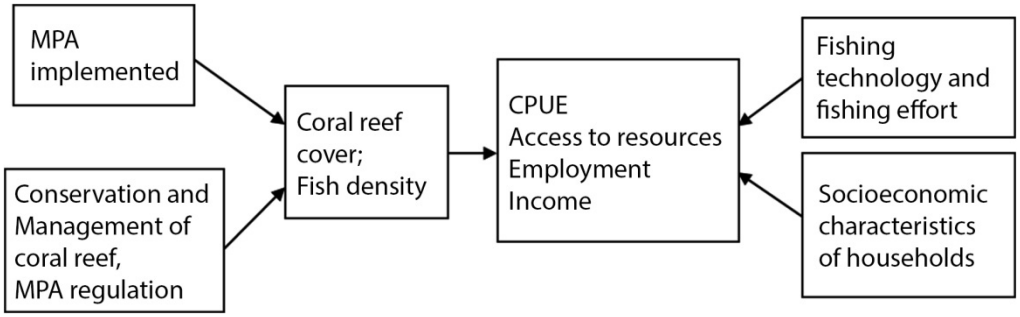

Figure 1. Analytical framework

2.0 BACKGROUND OF THE STUDY AREA AND ITS FISHERIES

2.1 Background of the Study Area

Cu Lao Cham in Quang Nam province is located in Central Vietnam. This province covers a large area compared to others in the Central Region, but has a relatively low GDP per capita (Bruun and Casse 2013). Cu Lao Cham is a small group of islands located 19 km offshore from Hoi An town. The archipelago consists of eight islands, of which the largest is Hon Lao, with a total area of 1,317 ha. This area has a tropical monsoon climate. The temperature is stable with a temperature fluctuation of 6°C–7°C throughout the year.

There are approximately 165 ha of coral reefs and 500 ha of seagrass beds in Cu Lao Cham. Coral reefs are widely distributed in the shallow waters of Cu Lao Cham, and their morphology and profile vary considerably. Overall, researchers have recorded in Cu Lao Cham's waters some 261 species of 59 genera of 15 families of Scleractinian coral, 15 species of 11 genera of six families of soft coral, three species of fire coral (Milleporidae), one species of blue coral (Helioporidae), and two species of horny coral (Antipatharia) (Tuan et al. 2004).

The Vietnamese Government has been taking steps to conserve marine biodiversity, to manage resources effectively, and to improve the livelihoods of local communities. With the support of the Danish Government, the Support to Marine Protected Area Network in Vietnam project started in 2002. Acordingly, the Cu Lao Cham MPA, which was an initial step in this process, was established in Quang Nam province in December 2005. In 2009, Hoi An and Cu Lao Cham were recognized by the UNESCO as a world biosphere reserve because of the city's unique relationship with the estuary and its reliance on local mangrove, seagrass, and coral reef habitats.

In order to manage the Cu Lao Cham MPA, the MPA zoning plan and management regulations were discussed with the local people. This community-based process had lasted for over a year, from October 2004 to December 2005, before the zoning plan and regulations were officially approved by the Quang Nam People's Committee. More than 50% of the total number of households living in the commune participated in the discussions and in the development of recommendations surrounding the plans and regulations (Trinh 2011). The Cu Lao Cham MPA Zoning Plan and Management Regulation were issued on 20 December, 2005 as Decision No. 88/2005/QD-UBND by the Provincial People's Committee of Quang Nam. This decision outlined the activities that are prohibited within the Cu Lao Cham MPA, which include:

1. Activities that disturb the environment and landscape; destroy substratum rock, coral reefs, flora beds, and other ecosystems; and negatively impact marine species, habitat, breeding and growing areas;
2. Hunting of fauna and flora species on the protected list and exploiting marine resources species on the banned list, including seasonal bans, except for research purposes permitted by the government;
3. Exploitation of marine animals smaller than specified sizes, except for catch allowed for aquaculture purposes;
4. Industrial-scale aquaculture and any kind of mining activities that cause beach erosion around the islands;
5. Activities that illegally convert land or illegally use water;
6. Activities that introduce exotic flora and fauna species that might damage the environment, natural ecosystems, and biodiversity in the MPA; and
7. Activities that pollute the environment, including noise and vibration of an intensity greater than the permitted limit.

The decision also defined the functional zones and activities for specific zones as follows:

1. the extremely protected zone (the core zone), which is defined by its coral reef ecosystem and rich marine biodiversity;
2. the ecological rehabilitation zone, which is managed, protected, and well-organized with activities in place that focus on recovering ecological habitats, biodiversity, and natural marine resources in order to economically benefit communities; and
3. the controlled development zone, which includes the tourism development zone, the community development zone, and the reasonable fishing zone (Figure 2).

Although the Cu Lao Cham archipelago is comprised of eight islands, only the main island (i.e., Hon Lao) is inhabited. The population of Cu Lao Cham is about 2,600 individuals, with around 600 households clustered in Hon Lao island (Hien 2006). The inhabitants of Cu Lao Cham are highly vulnerable as their only source of income is derived from natural resources (mostly marine). More than 85% of the households earn their living directly from marine resources or from providing services to marine exploitation activities (McEwin 2006).

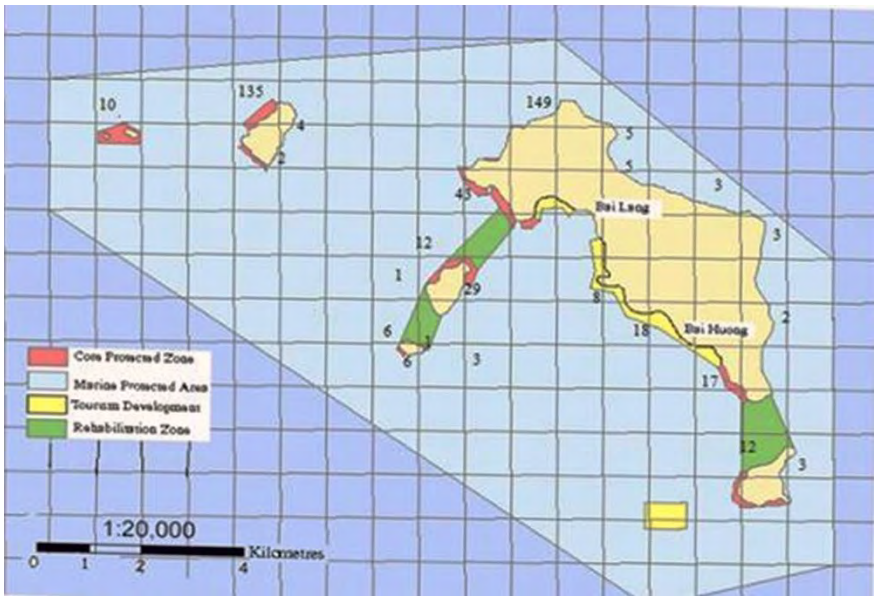

Figure 2. Cu Lao Cham MPA map

2.2 Cu Lao Cham Fisheries

Fishing is the most important socioeconomic activity in Cu Lao Cham. Over two-thirds of the households in Bai Lang community and approximately 87% in Bai Huong regard fishing as their main occupation, wheras approximately 90% of all Cu Lao Cham households derive some income from fishing (McEwin 2006). Over half of the fishing households in Cu Lao Cham own boats with engines. The average engine size of the boats is relatively low at 10 hp (McEwin 2006). This small engine fishing fleet restricts the available fishing areas to distances of about 20–30 km from the villages (within a few hours traveling time from the villages).

Fisher communities in Cu Lao Cham operate fishing activities in coastal areas with various types of gear, which can be divided into three main gear groups: gillnets, longlines, and liftnets (Table 1). Gillnets are the most commonly used nets in the community, with different types of gear targeted to different species. Fishers classify gillnets based on the size of the net mesh and the size of the target species. A small mesh gillnet has a mesh size of about 17 mm (for anchovies), a size 3 net is 20 mm wide, and a size 2 net is 40 mm wide. Longlines are used to catch fish that are exported. A liftnet is a kind of purse seine net, which is used to catch pelagic fish.

Table 1. Number of fishing vessels in Cu Lao Cham

Fishing Gear	Number (Vessels)	Percentage (%)
Gillnet	120	55.5
Liftnet	31	14.4
Longline	54	25.1
Dive	7	3.3
Others	3	1.4
Total	215	100.0

Source: Trinh (2011)

3.0 METHODOLOGY

3.1 Coral Reef Health

Coral reef health can be measured through different indicators. The most important indicators are coral reef cover and fish abundance. This study evaluates the change in coral reef cover and reef fish density. This measurement tests the impact of the MPA on the coral reef ecosystem. The data set is presented in time series graphs and compared between years and management zones.

3.2 Catch per Unit Effort

We examined the catch per unit effort (CPUE) to determine the possible effects of the implementation of the MPA on catch. The decision whether to implement MPAs to improve catch depends, to some degree, on the CPUE of the different sites and times. The CPUE, in fisheries literature, is assumed to be proportional to abundance; therefore, it can be used as a representative of relative index of fish abundance. This indicator can help to examine whether conserving coral reef can improve the catch and fish abundance outside the MPA and can provide food security. The CPUE computed from logbook data is compared across time periods from 2006 to 2015.

3.3 Access to Marine Resources

MPAs can limit the access of fishers to marine resources (Forcada et al. 2009). Small-scale fishers can lose a significant percentage of their fishing grounds, and they may have to reallocate their fishing effort to less desirable areas or aggregate near MPA boundaries. The questionnaire we conducted (see 3.6 and 4.2) provided a map with different zones marked on it, which helped the fishers define where they fish.

3.4 Employment

We consider the fishers who remain active before and after MPA implementation. The community's occupation structure and the issue of whether alternative occupations are sufficient to replace MPA-dependent fishing activity is also investigated.

The community's occupational structure can indicate the relative importance of the different uses of coastal resources. This indicator is applied to determine the percentage of people who are dependent on coastal resources for their livelihoods, any changes in occupation structure due to the creation of the MPA, and the importance of alternative livelihood activities. The statistical method is used for data analysis.

3.5 Income/Revenue

The impact of coral reef conservation and the creation of MPA on fishers' income is investigated in this study. Coral reef can be considered the stock and asset that can benefit fishers as it can enhance productivity. In order to evaluate this aspect, we conduct an analysis to identify the effects of increased coral reef due to MPA establishment on the revenue efficiency of fishers.

This step can be investigated by stochastic frontier analysis. From this analysis, we can estimate the technical efficiency (TE) of each vessel and for the whole fleet.

The model is specified as follows:

$$lnY_{it} = x'_{it}\beta + v_{it} - u_{it} \qquad \text{Equation (1)}$$

where:

Y_{it} = production of i^{th} vessel in the t^{th} time period
x_{it} = k x 1 vector of input quantities of the i^{th} vessel in the t^{th} time period; and
β = unknown parameters.

The error term includes two components: v_{it} and u_{it}. They are distributed in different ways. The error term v_{it} is commonly assumed to be independently and identically distributed (IID), as $N(0, \sigma^2 v)$, and shows the exogenous stochastic shocks beyond the control of the fishers. It can be positive or negative.

The error term u_{it} is a non-negative random variable that is often assumed to be IID as truncations (at zero) of the normal distribution $N(\mu_{it}, \sigma^2 u)$ and captures the technical inefficiency in production. The independent distribution between u_{it} and v_{it} allows the separation of statistical noise and technical inefficiency.

The assumptions concerning the two error terms require using the maximum likelihood (ML) method to estimate parameters in the stochastic frontier model. The concept of ML estimation is based on the idea that the sample has been generated from some distributions rather than from others. Ordinary least squares (OLS) can obtain consistent estimators of the slope parameters; however, the OLS estimator of the intercept parameters is biased downwards (Coelli et al. 2005).

The model possesses the same error terms as the conventional stochastic frontier model. If we assume the u is half truncated distributed, the environmental efficiency of each fishing household is defined as follows:

$$\widehat{TE}_i = E\{exp(-u_i)/\} = \left[\emptyset\left(\frac{u_i}{\sigma_*} - \sigma_*\right) / \emptyset\left(\frac{u_i}{\sigma_*}\right)\right] exp\left\{\frac{\sigma_*^2}{2} - u_i^*\right\}. \qquad \text{Equation (2)}$$

TE_i is a relative rate with the value ranging from 0 to 1. It is estimated with respect to the most efficient fishing household.

The structure of the model needs to be confirmed by a number of tests. These require imposing restrictions on the model and on the use of the generalized likelihood ratio (LR) to determine the significance of the restriction. LR is given by

$$LR = -2\{ln[L(H_0)] - ln[L(H_1)]\} \qquad \text{Equation (3)}$$

where:

$L(H_0), L(H_1)$ = values of the log-likelihood function under null and alternative hypotheses, respectively.

LR has a Chi-squared (χ^2) distribution with the number of degrees of freedom provided by the number of restrictions imposed. This is the difference between the parameters estimated under H_1 and H_0, respectively.

3.6 Perceptions of Effective Management of the MPA and Coral Reef Conservation

To determine whether the coral reef and the MPA have been effectively managed, the research team conducted surveys of fisher households. The surveys targeted the head of each household. Specifically, the fishers were asked about the effectiveness of MPA regulation, the contribution of the MPA and coral reef conservation to their livelihoods, and suggestions for future management of the MPA.

4.0 DATA COLLECTION

To assess the effect of MPAs, most studies concentrate on the effects of MPA establishment on fish population, fish catch, and socioeconomic effects such as income, livelihoods, etc. These need data detailing results inside and outside the MPA or before and after its establishment. In this study, the lack of statistical series by vessels before the establishment of the restricted area in 2005 did not allow us to simulate the consequences of its creation or to do a comparative empirical study before and after. However, the comparison between 2006 and 2015 may indicate the change over time.

4.1 Secondary Data

The data on reef and fish condition were obtained from different agencies. Two comprehensive surveys of the reef were undertaken in 2004 (one year before the MPA was established) and one in 2008 by the Nha Trang Institution of Oceanography. A continuous assessment of reef status from 2011 to 2015 was conducted by the management board of Cu Lao Cham MPA under the guidance of the Nha Trang Institution of Oceanography. Eleven sites around Cu Lao Cham water were observed, which can supply important information for analysis regarding the biological aspects of the MPA.

4.2 Primary Data

The data came from a survey conducted with fishing households and via a logbook program. The survey questionnaire was designed to gather information on the socioeconomic characteristics and livelihoods of respondents, perceptions of the impact of the MPA on their communities, and their individual preference toward different conservation and management measures for coral reefs and MPAs. A total of 135 fishers were interviewed.

The logbook program was first implemented in Cu Lao Cham in 2006. Each month, 50 logbooks are delivered to fishers; 40 of them are accepted to participate in the logbook program regularly, and 10 others are chosen randomly, depending on the season and the fishing gear they use. Logbooks record trip-level data for fishing vessels, including information on the characteristics of the fishing vessels such as engine power, the length of the vessel, fishing gear, and other information on the fishing ground, revenue, and cost per trip. These data were provided by the management board of Cu Lao Cham and were used primarily to generate CPUE and TE scores. Trip records were summarized by vessel at the annual level for the period available, from 2006 to 2011 and from 2014 to 2015.

5.0 RESULTS

5.1 Coral Reef Health

5.1.1 Coral cover

The results of past surveys indicate that coral reef ecosystems are under increasing threat. Coral reef cover declined from 41% in 2004 to 26% in 2008. The major causes of coral reef decline are due to accumulation of stresses arising from human activities and climate conditions. In 2006, typhoon Xangsens hit Cu Lao Cham. According to the local fishers, the typhoon dragged a pile of garbage along its path, which crossed the MPA. This garbage covered the Cu Lao Cham area for a long time and had an influence on the condition of its environment. The flow of freshwater from rivers due to subsequent flooding and concentrations of sediment also killed the reefs.

In an effort to save the coral reefs, a reef recovery program was implemented in 2011. This program, aimed to cultivate and restore the coral reef, was guided and supported by experts of the Nha Trang Institution of Oceanography. Consequently, the past five years (2011–2015) have seen an increase in coral cover (see Figure 3). The MPA management plan was developed by applying the comanagement model, which promoted the participation of the local community. The comanagement plan focuses on six target resources: coral reefs, seagrass beds, beaches, lobsters, land crabs, and limpets. Based on the analysis of the status of these six target resources, a series of plans were developed to ensure protection objectives. A five-year financial plan was proposed to support these activities; funding came from different sources, including government budgets, MPA entrance fees, NGO support, and contributions from the local community via participation in conservation action.

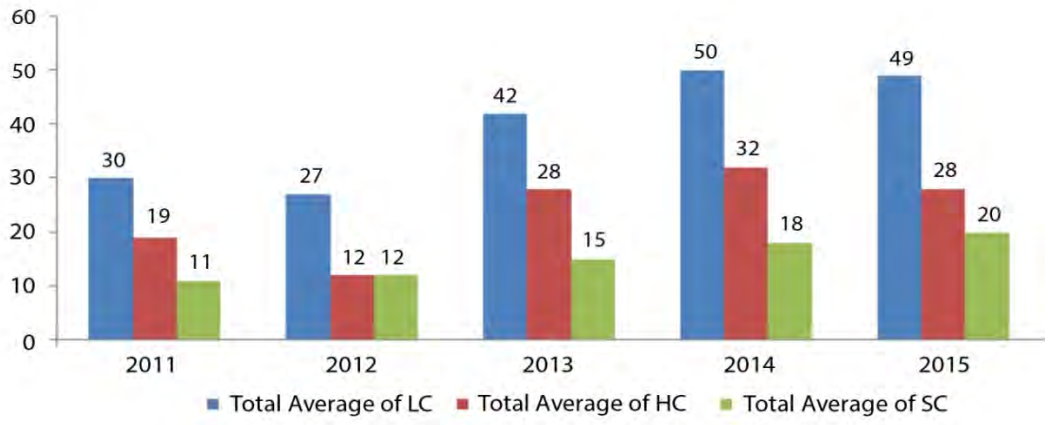

Figure 3. Coral coverage in Cu Lao Cham MPA, 2011–2015 (in percent)

Source: Management board of Cu Lao Cham MPA

Note: LC = live coral, HC = hard coral, SC = soft coral

The ecological indicators (i.e., coral reef cover) at the study sites that were located inside versus outside managed areas are also compared to examine effective coral reef conservation. Figures 4 and 5 show the percentage of coral cover from 2011–2015. A similar pattern can be observed across the core zone and the non-core zone. Coral cover assessments have shown that coral cover increased in both the core zone and the tourism zone, although the core zone generally exhibited higher coral cover than outside areas. The coral reefs in Cu Lao Cham are in good condition with 50% live coral cover in 2014 and 2015. According to Chou et al. (1996), coral cover of 25%–50% indicates coral in good condition.

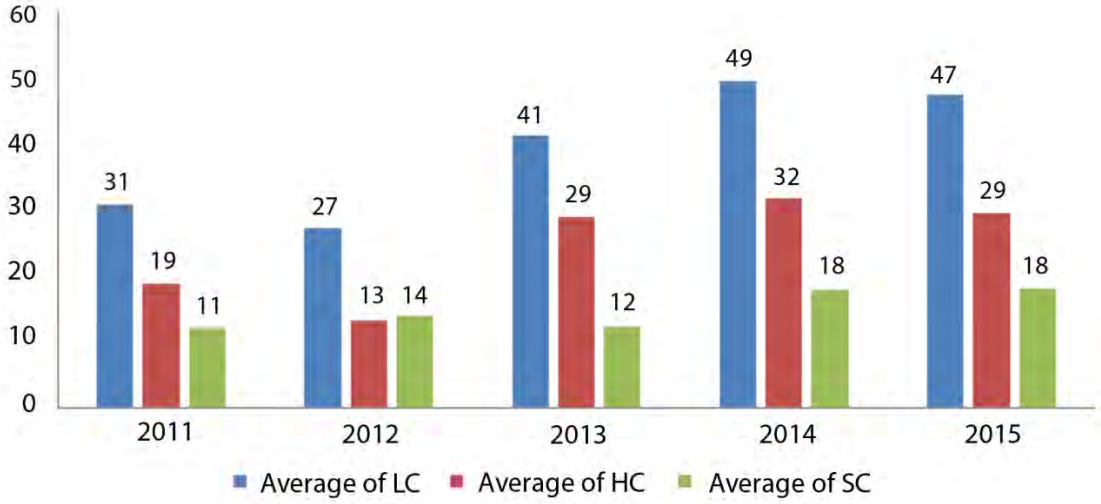

Figure 4. Coral cover in core zone of Cu Lao Cham MPA, (in percent)

Source: Cu Lao Cham MPA management board

Notes: LC = live coral, HC = hard coral, SC = soft coral

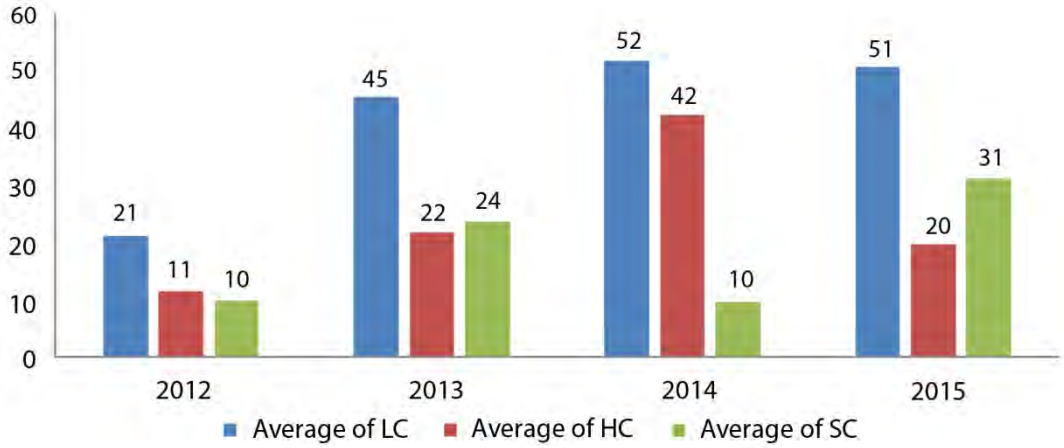

Figure 5. Coral cover in tourism zone in Cu Lao Cham MPA (in percent)

Source: Cu Lao Cham MPA management board

Notes: LC = live coral, HC = hard coral, SC = soft coral

5.1.2 Fish density

MPAs can enhance coral reef biodiversity and also protect fish that are particularly susceptible to overfishing. It is therefore hoped that MPAs will promote the recovery of fish stocks and ecosystem functioning within the designated area and provide for sustainable yield through a spillover effect (NRC 2001).

Data on the density of reef fish were not available before the Cu Lao Cham MPA was created. The fish density was examined from 2011 to 2015 and was calculated by the number of individual fish per 500 m^3. Figure 6 shows the change in the mean density of some high economic value fish species and reef fish. Based on the data, the density of some fish species has been declining, in contrast to reef condition. This probably reflects overexploitation. It is thus necessary to find evidence for the role of fishing in driving the recent decline in reef fish. This will be further discussed in the sections that follow.

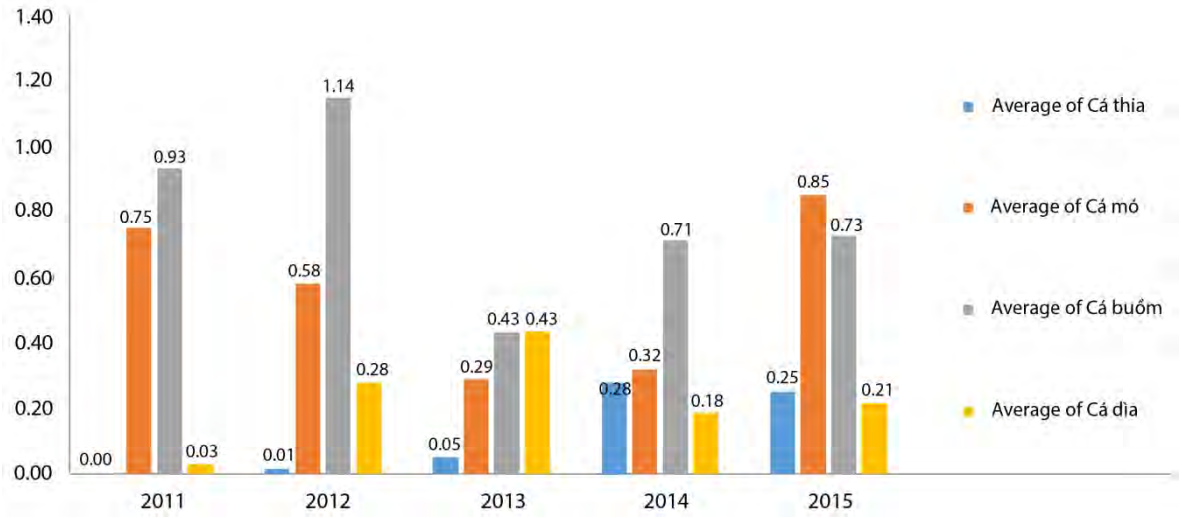

Figure 6. Average density of reef fish in Cu Lao Cham MPA

Source: Cu Lao Cham MPA management board

5.2 Catch Rate (CPUE)

5.2.1 CPUE

MPA implementation reduces the area available for fishing. For the catch to be the same as when a marine area is under conventional management, the catch in the area outside an MPA has to increase to the point where it can compensate for the reduction in the area fished. Many case studies indicate that increased CPUE commonly occurs, particularly close to the reserve boundaries. An increase in catch in the area outside an MPA consists of two components: (1) an increase in new individuals to the fish population and (2) an increase in the number of fish swimming out of the newly protected area.

The CPUE of fishing vessels in Cu Lao Cham is compared between periods from the early stages of the MPA, in 2006, to 2015 in order to examine changes to the coastal fishery. Results from logbooks reveal that CPUE has increased over time for some fishing gears such as longlines and some gillnets. However, for other fishing gears, fishers have not observed changes in fisheries in recent years. On the other hand, some fish species that are targeted for the marketplace show indications of being overfished.

The catch rates and income increases were partially associated with declining daily fishing effort. Figure 7 shows that the number of fishing vessels has continuously decreased between 2006 and 2015. The total number of fishing vessels in 2006 was 238, and this figure decreased to 215 vessels in 2011 and to 203 vessels in 2015 (Trinh 2011).

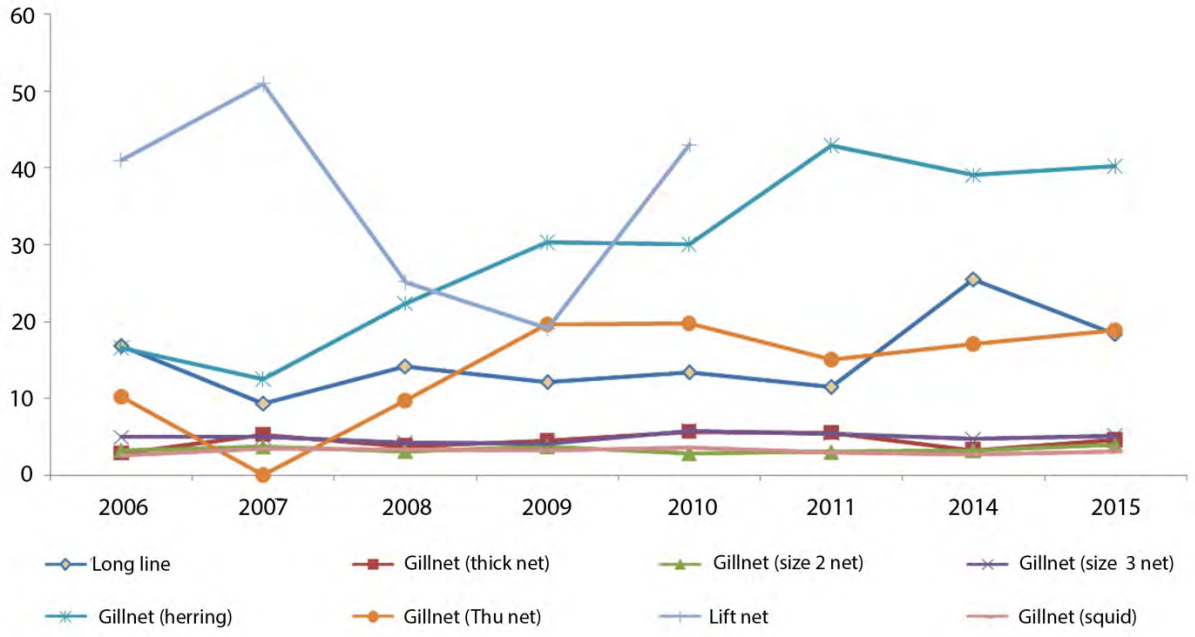

Figure 7. CPUE (kg/day/fishing trip) of fishing gear in Cu Lao Cham, 2006–2015

5.2.2 Composition of fish caught

The composition of fish caught is shown in Table 2. Fish contribute 90% of catch composition, while other species contribute less than 10%. However, the percentage of the catch of shrimp and crab tends to be in decline within the total catch of fishers in Cu Lao Cham. Tourism has increased the demand for seafood and has an impact on resource status. In Cu Lao Cham, shrimp, squid, and swimming crab are the preferred food in restaurants and are sold at a premium price compared to other fish species. These species are targeted for exploitation. Demand from tourism may affect catch distribution—and thus population abundance, harvest, and revenue—through economic incentives rather than through regulation. Without MPA enforcement and management, overfishing will take place.

Table 2. Percentage (%) of catch composition

Year	Fish	Squid, Octopus	Crab and Swimming Crab	Shrimp	Other	Total (%)
2006	85.92	11.51	0.56	0.18	1.770	100
2007	97.33	1.49	0.59	0.04	0.540	100
2008	95.37	3.28	1.25	0.08	0.009	100
2009	83.70	15.59	0.54	0.11	0.020	100
2010	99.05	0.49	0.41	0.03	0.010	100
2011	90.37	9.27	0.31	0.03	0.020	100
2014	91.02	8.47	0.49	0.01	0.010	100
2015	90.12	9.42	0.43	0.02	0.010	100

Source: Management board of Cu Lao Cham MPA

5.3 Access to Marine Resources

5.3.1 Fishing effort distribution

The creation of Cu Lao Cham MPA has led to the displacement of fishing and fishing grounds, which have economic, social, and environmental consequences. Cu Lao Cham fishers use about 15 different types of fishing gear, and each adopt different fishing strategies; they use different combinations of gear and target different species. The establishment of an MPA generally induces shifts in resource access and use that vary within and among social groups. Since most vessels are small scale with an engine power of less than 20 CV, the fishers often fish in nearshore fishing grounds.

Prior to the creation of the MPA, fishers concentrated their fishing effort close to the village, predominately using gillnets. In 2006, fishing effort was spread farther from the village. Fishers traveled to other, sometimes more distant, fishing grounds. The economic effects of these moves further afield include higher fuel bills and other operating costs and potentially increasing capital expenditures in the fishery.

After the establishment of the MPA, the fishing grounds were divided into three different areas. The spatial distribution of effort of vessels was analyzed based on the analysis of the logbooks and on the survey. Fishing grounds 0.0–0.3 km from shore were occupied by dive fisheries and traditional gillnet fishers (called "Kinh" net and "Bi" net by local people). Fishing locations 0.3–2.0 km from shore were reserved for other gillnet users and hand line users. Longline and liftnet vessels were allowed to fish 2–20 km from shore. These new fishing grounds indicate substantial changes in the distribution of fishing effort before and after the implementation of the MPA.

Has fishing effort become concentrated in these closed-area boundaries as a result of the imposition of the MPA? Table 3 and Figure 8 show a general picture of resource space accessed at Cu Lao Cham. About 68.92% of the fishing effort of vessels is concentrated in the fishing ground at a distance of 0.3–2.0 km. This location surrounds the community development zone and is a reasonable fishing zone. It indicates that there are perceived benefits in terms of catch associated with fishing near the closed-area boundary. This fact also implies that if coral reefs are conserved in good condition, then the development of fish inside the core zone can lead to a spillover effect that can benefit a number of fishers. The spillover generated from the MPA can also contribute to poverty alleviation for local communities.

Table 3. Fishing effort distribution

Fishing Grounds	Fishing Gear	Effort Distribution (%)
0.0– 0.3 km	Dive	13.94
	Bi net (gillnet)	
	Di net (gillnet)	
	Kinh net (gillnet)	
0.3– 2.0 km	Gillnet (herring)	68.92
	Gillnet (thick net)	
	Gillnet (2 size net)	
	Gillnet (3 size net)	
	Handline	
2 – 20 km	Liftnet (with light attraction)	17.14
	Liftnet (squid)	
	Longline	

Source: Trinh management board of Cu Lao Cham MPA (2011)

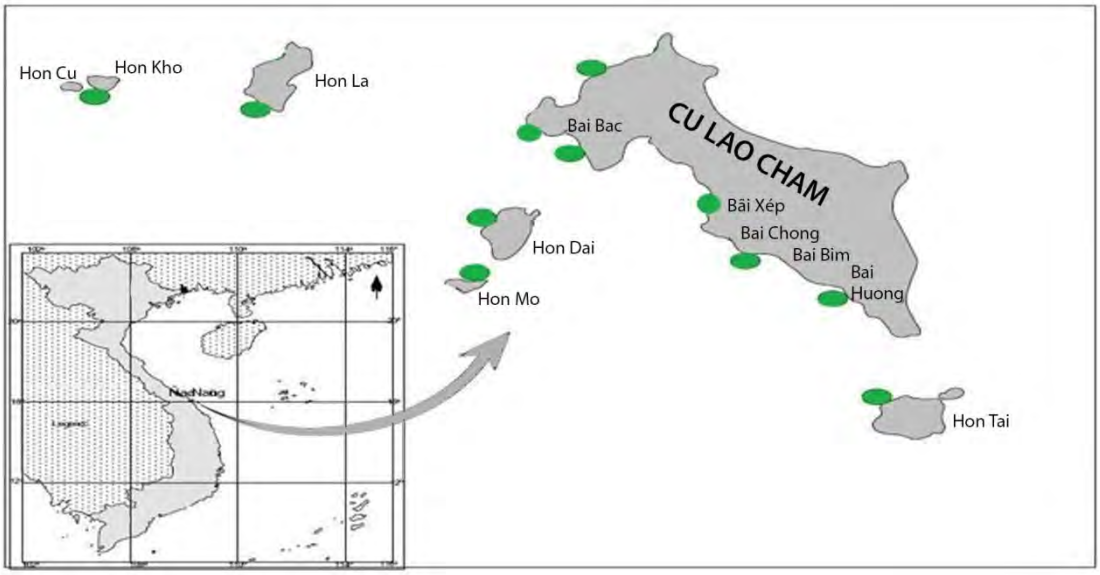

Figure 8. Fishing grounds, Cu Lao Cham

5.3.2 Displacement of fishing grounds

Fishers were asked about the consequences on travel time and fuel consumption of changing fishing grounds due to the creation of the MPA. They were also asked about the factors affecting their decisions about where to fish.

Our survey of 135 fishers revealed that a considerable proportion of fishers (57.04%) fish in a different fishing ground as a result of the establishment of the MPA (Figure 9). When the fishers changed their fishing ground, they fished farther out. The crew size of almost all the vessels remained constant, ranging from two to four fishers. However, the distance and travel time from the home port to the chosen fishing ground increased, so any costs associated with fishing time and location, such as an increase in fuel consumption, also increased. Vessels have to compete for space within this remaining area. Fishers work longer hours to compensate for the loss of their old fishing grounds. Some vessels make two-day fishing trips instead of one-day trips, which was the norm before the creation of the MPA.

Figure 9. Change in fishing grounds

There are different consequences of displacement for fishers using different gear types. Longline and liftnet vessels have to travel farther and take longer trips compared to fishers using gillnets (Table 4); thus, their fuel expenditure increases. Fishers using longlines and liftnets responded that they found new fishing grounds, since their traditional fishing grounds are under increased pressure from displaced gillnet fishers. The larger size of longline and liftnets, compared to gillnets, allows their safer use in more distant areas compared to gillnets.

The factors that impact decisions on where to fish were ranked by fishers. The most important factors were the abundance of the fish, local knowledge of the fishing ground, and locations near the MPA (Figure 10). Fishers choose their fishing location based on their introduction to it by their parents or by other experienced fishers and also from using their own knowledge of the number of fish and the condition of the sea floor habitat. MPA regulations are also an important factor that fishers take into account when choosing a fishing location. This indicates that many fishers are aware of and comply with MPA regulations.

Table 4. Consequences of displacement from fishing grounds

Fishing Gear	Greater Distance (km)	Extra Fuel Expenditure per Trip (liter)
Longline	4.73	3.8
Gillnets	0.69	1.1
Liftnets	5.25	4.2

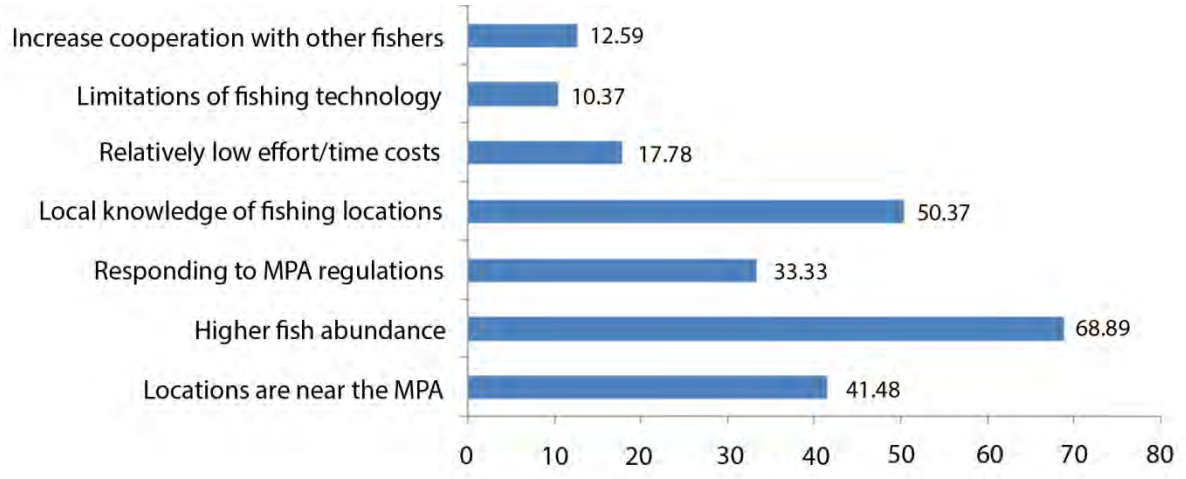

Figure 10. Factors that impact fishers' decision on where to fish (in percent)

5.3.3 Revenue loss from displacement of fishing ground

The loss of access to traditional fishing grounds poses a challenge to local communities as it results in loss of revenue during the initial stages of the establishment of the MPA. In 2006, 40 fishing households were compensated for their individual revenue loss (Figure 11). The average loss of revenue was 19.09%. MPA protection often results in short-term losses for the local community, but empirical literature shows that the economic benefits of reserves can offset the costs of closure in as little as five years (Sala et al. 2013). The distribution of financial aid in the early stages of the establishment of MPAs aims to compensate for short-term losses and exert a shift in resource pressure amongst local fishers.

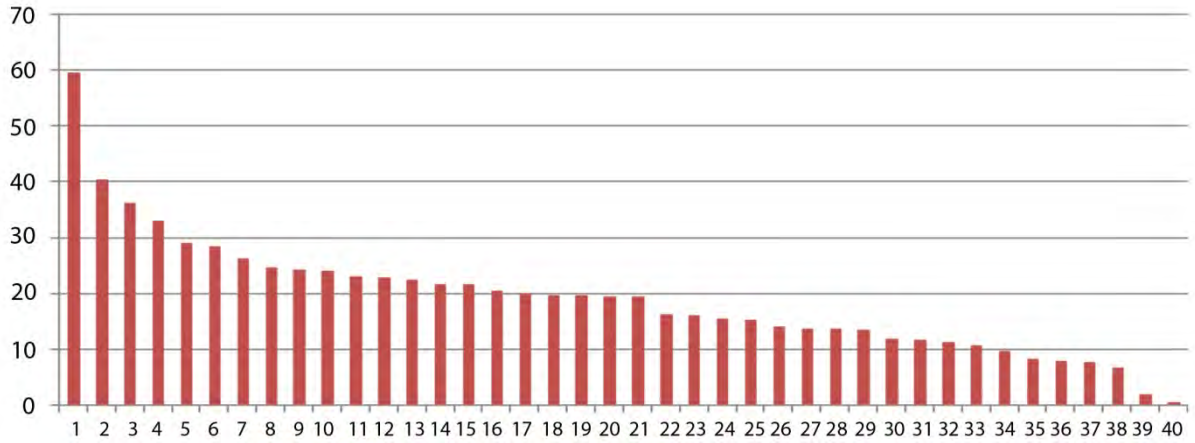

Figure 11. Fishers' revenue loss due to displacement of fishing grounds in 2006 (in percent)

Source: Management board of Cu Lao Cham MPA

5.4 Employment

Fishers initially tend to oppose the creation of MPAs due to the potential loss of access to fishing grounds. Local fishers have to choose to fish in another location or find alternative or supplementary livelihood opportunities. Since 2006, tourism has been promoted in Cu Lao Cham. The development of tourism (Figure 12) has diversified the local economy via new businesses, jobs, and income for the local community. Potential increases in revenue from visitors could offset losses to fishers due to the MPA and help to finance MPA management. The number of vessels and fishers declined at Cu Lao Cham fish landing site following the establishment of the MPA (see Table 5). The main reason for this is because 12 tourism-related livelihood activities were promoted after the MPA was established. When tourism is introduced to communities, it complements and displaces existing fishing activity. Some fishers have gained full or partial employment in other sectors, such as small businesses or tourism.

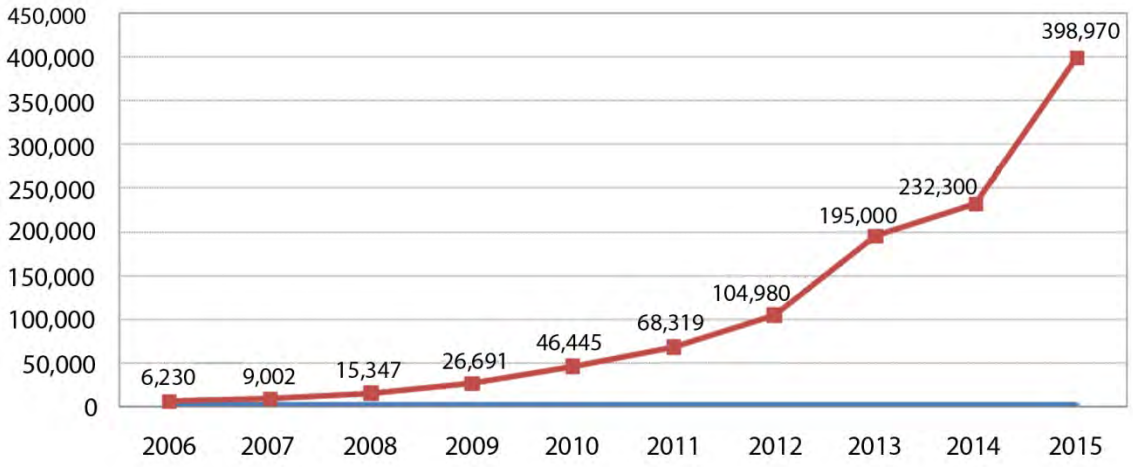

Figure 12. Number of tourists in Cu Lao Cham, 2006–2015

Source: Management board of Cu Lao Cham MPA

Table 5. Occupations of residents in Cu Lao Cham

Pre-MPA (2004)		Post-MPA (2011)	
Occupation	Percentage	Occupation	Percentage
Fisheries	45.74	Fisheries	31.35
Agriculture	8.24	Farming	7.23
Small business	12.78	Small business	17.50
Housekeeping	15.63	Housekeeping	9.27
		Tourism	19.45
Others	17.61	Others	15.20
Total	100.00	Total	100.00

Source: Trinh (2011)

With the simultaneous goals of enhancing people's livelihoods through socioeconomic development and engaging in conservation as part of the MPA, no hotels are permitted on the island. This ensures that tourists have to use homestays as a way of experiencing island culture. Homestays are a good source of income for families, provide opportunities for international exchange, and can help locals develop their English skills. With these new livelihoods, annual income per capita increased from VND 6 million (USD 274) in 2004 to VND 30 million (USD 1,365) in 2014 (Trinh 2014).

5.5 Fishing Revenue

We focus on three main types of fishing gear: longlines, gillnets that target squid, and gillnets that target fish. As the stochastic frontier analysis requires a single-output measure and since the fishing gear catches multispecies, the average annual revenue is used as the output of the function. This is then inflated to the 2015 value through the consumer price index.
The revenue and its determinants related to technical characteristics and fishing effort were investigated by stochastic frontier analysis in Equation (1). The TE of each vessel is estimated based on Equation (2).

In this study, physical inputs—engine power, the length of the vessels, and the number of days at sea—are used as the proxy measure of capital invested and capital utilization in the fisheries (Table 6). For the inefficiency model, a number of variables are used to investigate the determinants of technical efficiency of fishing vessels. The key variables used are skipper experience, crew size, the age of the vessel, and dummy variable for the years 2014 and 2015 to cover the change of efficiency over time (Table 7).

Table 6. Variable description

Name	Gillnets (Squid)	Longlines	Gillnets (Fish)
No. of boats in sample	15	14	11
No. of observations	120	112	88
Input			
Engine power (hp)	13.9	18.9	12.3
Vessel length (meters)	10.2	16.7	10.7
Days at sea (days)	107	123	112
Output			
Ave annual revenue (million VND)	94.2	115.7	56.4

Table 7. Production frontier

Variable	Gillnets (Squid)		Longlines		Gillnets (Fish)	
	Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
Intercept	9.12	10.45***	–0.73	–0.78	–2.33	–2.54***
LnHP	2.21	2.12**	1.07	2.65***	0.87	2.23**
LnLength	– 5.07	–7.21***	–2.39	–1.34	0.35	1.45
Lnday	1.12	2.76***	1.48	2.93***	1.37	2.31**
$LnHP^2$	0.08	0.42	0.69	4.12***		
$LnLength^2$	–0.04	–0.05	2.25	3.12***		
$Lnday^2$	–0.05	–0.65	–0.23	–3.17***		
LnHP * LnLength	1.31	1.68	–3.21	–4.65		
LnHP * Lnday	0.82	4.15***	–0.15	–0/78		
LnLength * Lnday	–1.57	–3.09***	0.34	0.57		
Inefficiency Model						
Skipper experience	–1.99	1.97**	0.73	1.23	–1.11	1.98**
Crew size	–0.79	1.84*	0.34	2.14**	0.56	1.23
Vessel age	0.01	2.02**	–0.25	1.01	1.37	–0.96
D2014–2015	–0.24	2.91***	–0.12	1.23	–0.08	1.78**
δ^2	0.06	4.83***	1.24	4.23***	0.39	4.69***
γ	0.63	7.18***	0.79	19.79***	0.68	4.01***
Log-likelihood	10.308		–70.108		–75.732	
Mean technical efficiency	0.64		0.68		0.61	

Notes: (1) * significance at the 10% level, ** significance at the 5% level, *** significance at the 1% level. (2) The tests specify the correct function form of the model and confirm the presence of inefficiency.

From the inefficiency model, three variables were found to have a significant impact on efficiency scores in the longline model, while only two variables were significant in the gillnet (squid) and gillnet (fish) models. The factors affecting technical inefficiency could be explained by the algebraic sign and the significance of the estimated coefficients. The coefficients in the inefficiency model would express the direction of the effects of the corresponding factors on technical efficiency. Note that the positive sign will imply a negative impact. Thus, skipper experience and crew size have a positive impact, and the age of the vessel has a negative impact on efficiency for the longline model.

In the inefficiency model, note that the gillnet vessels were more efficient in 2014 and 2015 than in the previous years (2006–2011). The dummy variable can indirectly account for resource stocks and fishing practices. For mixed-catch fisheries in developing countries, a direct estimate of the abundance of each resource stock is usually not available. In such cases, variation in relative aggregated catch rates may indicate changes in stock abundance, to be studied by use of dummy variables for different months, years, or areas (Pascoe and Mardle 2003). Thus, this dummy variable can also indicate the contribution of coral reef conservation and MPAs in improving the fish condition and in turn enhancing the income of the fishing community.

5.6 Perceptions of Outcomes, Management, and Enforcement of MPAs

Coral reef conservation and MPAs can lead to empowerment; improved governance; alternative livelihoods; improved fisheries; and improved social, educational, and cultural benefits. Understanding stakeholder perceptions of coral reefs and MPA management and the outcomes of these environmental protections is critical in designing socially and politically palatable management. In the study, the fishers were questioned on their perceptions of the condition of the coral reef and on the impact of the MPA on coral reef conservation, fish protection, food security, alternative livelihood options, and enforcement and participation in management planning. A set of statements regarding these issues was investigated using a five-point Likert scale ranging from "strongly disagree" to "strongly agree" (Figure 13).

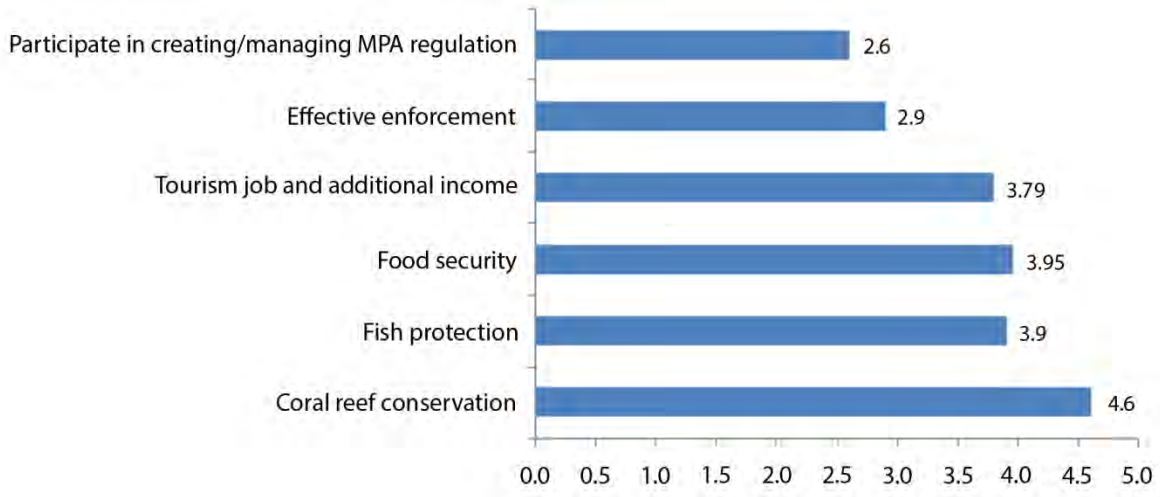

Figure 13. Perceived impact of the MPA from different perspectives

Note: 1 = Completely Disagree, 2 = Somewhat disagree, 3 = Neither agree nor disagree, 4 = Somewhat agree, 5 = Completely agree

The coral reef ecosystems of Cu Lao Cham are in better condition than prior to the establishment of the MPA due to the conservation efforts of both MPA staff and local people. In general, fishers perceived the improvement in coral reef ecosystems. Fishers strongly believed that the MPA can help to conserve the coral reef and enhance fish abundance. The majority of fishers in the survey believed that the MPA is necessary and acknowledged that fishing resources are the primary source of their income.

Fisheries resources are also an important component of human diet. Fisheries may contribute to food security in two ways: (1) directly, as a source of essential nutrients, and (2) indirectly, as a source of income to buy other foods. In Cu Lao Cham, 203 households out of 567 households depend on fisheries and the coral reef ecosystem for their food, income, and livelihoods. Fish from small-scale fisheries are an important source of household food consumption. About 20% of the total catch is kept for home consumption (Trinh 2011). Prior to the establishment of the MPA, the fishers often sold their catch to local sellers or to middlemen, who then sold the fish to seafood processing companies. Since the creation of the MPA, alongside the development of tourism, fish is now also sold to restaurants on the island, thereby improving the income of the fishers. Coral reef conservation activities and MPA implementation have been accepted by fishers as beneficial tools for the improvement of their food security. Our survey also found that food security is achieved by fisheries not only as a source of food for fisher families, but also as a source of livelihoods for other local people because fisheries provide employment and income through vessel maintenance, fish trading, etc.

The promotion of alternative livelihoods for fishers displaced by MPA regulation is a priority. Alternative livelihood programs are often applied as incentives or as compensation for the loss of fishing activity, and also as strategies for poverty alleviation. The impact of alternative livelihood programs on biodiversity conservation and the well-being of fishing communities are the main focus of the management process. Alternatives to fishing livelihoods in Cu Lao Cham are mainly related to the tourism industry. There is a general feeling among the fishers that the MPA can result in improving prospects of tourism jobs, thus increasing household income.

Regarding perspectives of governance, perceptions of the effectiveness of enforcement are quite critical. One of the greatest constraints on the performance of an MPA is illegal fishing due to lack of effective enforcement. Illegal fishing in Cu Lao Cham emerges both from inside the local community and from outsiders fishing in the area. However, most of the violators come from nearby provinces such as Quang Ngai and Da Nang.

Community participation is a key ingredient of good governance. Failure to involve stakeholders in the decision-making process is one of the main causes of ineffective management of marine resources (Jentoft 1989). In Cu Lao Cham, comanagement has been put in place since 2008 in order to enhance stakeholder participation in the management and decision-making process; however, fishers perceived their participation in the management and decision-making processes as deficient. Fishers expect further empowerment that would allow them to participate adequately and effectively in the management process.

6.0 DISCUSSION AND CONCLUSIONS

Marine protected areas have been widely applied as a tool for coral reef conservation (McClanahan et al. 2006). It is also increasingly being recognized as an ecosystem-based management approach to fisheries management (Bohnsack 1993; Roberts and Polunin 1993). Most MPAs have ecological, socioeconomic, and governance goals and objectives. From an ecological perspective, effective coral reef conservation can be viewed as increasing or maintaining key ecosystem parameters such as fish biomass or coral cover and maintaining ecosystem processes and function (Hughes et al. 2003).

From a socioeconomic perspective, consideration of local socioeconomic factors; fostering food security, livelihoods, and equitable distribution of benefits from the MPA; and enhancing environmental awareness and knowledge are essential (Pomeroy, Parks, and Watson 2004). From a governance perspective, the focus should be on maintaining effective management strategies, ensuring effective stakeholder participation, enhancing management plan compliance by resource users, and managing and reducing resource use conflicts.

Eleven years after its establishment, the Cu Lao Cham MPA has provided ecological and economic benefits for the local people, especially for the fishing community. The conservation value of the MPA has been recognized by stakeholders. The coral reefs are currently being conserved owing to the MPA, which also provides alternative livelihood opportunities, increased catch and income, and food security for the local fishing community, albeit coral reef conservation and the MPA have also led to loss of access to traditional fishing grounds. The new alternative fishing grounds can sustain the fisheries. This is good evidence of how coral reef conservation can transfer the flow of benefits from an ecosystem to local people. This also highlights the opportunities that create win-win solutions where conservation and development objectives can be achieved together.

Despite the fact that coral reef conservation supports critical ecosystem services for people, discussions regarding trade-offs are necessary to maintain human well-being and to improve ecosystem management because gains for one ecosystem service or group of people may result in losses for others (McClanahan et al. 2006). Evidence of a decline in the density of some reef fish species and of the disappearance of some fish species have been reported by fishers. These changes in catch composition have been linked to tourists' increased demand for seafood, implying that a trade-off has occurred. Fisheries resources have declined in exchange for increased human well-being. This is also the case for ecosystem services around the world. The MEA indicated that human well-being has grown steadily over the past 50 years, in part due to the rapid conversion of ecosystems to meet human demand for food, fiber, and fuel. Incorporating trade-off thinking into ecosystem management should also be considered in order to investigate both the positive and negative aspects of conservation and development objectives.

Tourism is the main economic driver in Cu Lao Cham, contributing 30% to its total income (Trinh 2011). However, the development of tourism has had significant social and environmental costs for the local community. Approximately 3,000 tourists visit Cu Lao Cham every day—the daily influx of tourists is higher than the population of the island, which is 2600 people. The level of visitor use seems greater than the island's capacity for tourism. The increased stream of visitors, with their accompanying inadequate environmental awareness, has imposed negative impacts on nearby coral reefs from diving, snorkeling, and the anchoring of boats. Tourism has also caused other forms of environmental degradation and has added to the consumption of seafood in the area, which in turn has led to the overexploitation of fisheries resources.

Illegal fishing is a problem in the Cu Lao Cham MPA. Violators are usually people from neighboring provinces engaged in activities that damage the coral reef, such as diving in the coral reef area or using trawling that is prohibited in the MPA. With the establishment of the MPA, fishers are often concerned about equity issues and the distribution of benefits and costs resulting from MPA management regulations. In the case of Cu Lao Cham, resource-use conflict has emerged. Local fishers perceive that there seems to be an inequitable distribution of benefits from the MPA. Although local fishers have had to count the cost of the loss of their traditional fishing grounds and of sustaining the benefits of the reserve, the conserved resources are then exploited by outsiders. Interviews with local fishers show that illegal fishing emerges mostly as a result of perceptions of MPAs and due to a lack of will on the part of management. Without effective enforcement, illegal fishing can have negative environmental effects and can lead to a domino effect—if local fishers believe that others are fishing illegally, they are less likely to comply themselves, so compliance levels could continually decline.

It is thus important for MPA managers to tackle the issue of which management measures can ensure that the well-being of fishing communities continues to improve in the future without negatively affecting the coral reef ecosystem. Failure to account for all the benefits for all the stakeholders, combined with failed management, could lead to further degradation in both ecosystem services and human well-being. Bennett and Dearden (2014) demonstrated that the success of a conservation area is strongly affected by the involvement of the local people and the management of the MPA.

Comanagement is considered an effective and acceptable approach that can involve communities through sharing power and responsibility between MPA managers and local people (Clifton 2003; Jones 2002). Comanagement has been applied for the Cu Lao Cham MPA; however, it also faces challenges related to funding uncertainty, time commitments, conflicts between user groups, and local willingness to participate (Trinh 2011). Therefore, comanagement should be implemented based on the social-political context. Different zones have been created for different user groups; however, more effective regulation may also be required.

Local fishers accept that more and better enforcement is needed to manage ocean resources, and it should be noted that MPA compliance is not associated solely with enforcement efforts (Arias et al. 2015). Levels of compliance are related to socioeconomic and institutional conditions. In the case of Cu Lao Cham, compliance is related to livelihood. Those people who are solely dependent on fishing have a negative relationship with compliance. The alternative livelihood program should be implemented more effectively. Fishers in Cu Lao Cham tend to keep their occupation, despite the risks, and few would change to another occupation with a similar income. The alternative livelihoods provided for fishers should have some of the same characteristics as those considered desirable in fishing, such as the ease of obtaining food and income, appropriation of knowledge and capacity by fishers, and the independence of being self-employed. Alternative livelihoods should also aim to relieve the pressure and stress on natural resources and should support conservation objectives while decreasing local poverty and vulnerabilities.

LITERATURE CITED

Agardy, T. 1995. The science of conservation in the coastal zone: New insights on how to design, implement, and monitor marine protected areas. Paper presented at the 4th World Congress on National Parks and Protected Areas, 10–21 February 1992, Caracas, VE.

Arias, A.; J.E. Cinner; R.E. Jones; and R.L. Pressey. 2015. Levels and drivers of fishers' compliance with marine protected areas. Ecology and Society. 20(4): 19.

Beaumont, N.J.; M.C. Austen; J.P. Atkins; D. Burdon; S. Degraer; and T.P. Dentinho. 2007. Identification, definition, and quantification of goods and services provided by marine biodiversity: Implications for ecosystem approach. Marine Pollution Bulletin. 54(3): 253–265.

Bennett, N.J. and P. Dearden. 2014. From measuring outcomes to providing inputs: Governance, management, and local development for more effective marine protected areas. Marine Policy. 50: 96–110.

Bohnsack, J.A. 1993. Marine reserves: They enhance fisheries, reduce conflicts, and protect resources. Oceanus. 36(3): 63–71.

Boyce, J.K. 1994. Inequality as a cause of environmental degradation. Ecological Economics. 11(3): 169–178.

Bruun, O. and T. Casse. 2013. On the frontiers of climate and environmental change vulnerabilities and adaptations in Central Vietnam. Springer-Verlag, Berlin/Heidelberg, Germany.

Chou L.M.; Low J.K.Y.; Loo M.G.K., 1994. The state of coral reefs and coral reef research in Singapore. C.R. Wilkinson (ed.) *In* Living coastal resources of Southeast Asia: Status and management. Report of the Consultative Forum, Third ASEAN-Australia Symposium on Living Coastal Resources, Chulalongkorn University, Bangkok, Thailand, May 1994. Australian Institute of Marine Science, Townsville, Australia. 77–87.

Cleaver, K.M. and G.A. Schreiber. 1994. Reversing the spiral: The population, agriculture, and environment nexus in Sub-Saharan African. The World Bank, Washington, D.C., VA.

Clifton, J. 2003. Prospects for comanagement in Indonesia's marine protected areas. Marine Policy. 27(5): 389–395.

Coelli, T.J.; D.S.P Rao; C.J O'Donnell; and G.E. Battese. 2005. An introduction to efficiency and productivity analysis. 2nd ed. Springer, New York.

Coulthard, S.; D. Johnson; and A. McGregor. 2011. Poverty, sustainability, and human wellbeing: a social well-being approach to the global fisheries crisis. Global Environmental Change. 21(2): 453–463.

Díaz, S.; J. Fargione; F.S. Chapin; and D. Tilman. 2006. Biodiversity loss threatens human well-being. Plos Biology. 4(8): e277.

FAO (Food and Agriculture Organization). 2003. The ecosystem approach to fisheries: Issues, terminology, principles, institutional foundations, implementation, and outlook. FAO Fisheries Technical Paper No. 443. FAO, Rome, Italy.

Forcada, A.; C. Valle; J.L. Sánchez-Lizaso; J.T. Bayle-Sempere; and F. Corsi. 2010. Structure and spatio-temporal dynamics of artisanal fisheries around a Mediterranean marine protected area. ICES Journal of Marine Science. 67(2): 191–203.

Garcia, S.M. and K.L. Cochrane. 2005. Ecosystem approach to fisheries: A review of implementation guidelines. ICES Journal of Marine Science. 62(3): 311–318.

Garcia, S.; E.H. Allison; N. Andrew ; C. Béné, G. Bianchi, G.D. Graaf, D. Kalikoski, R. Mahon; L. Orensanz. 2008. Towards integrated assessment and advice in small-scale fisheries: Principles and processes. FAO Fisheries and Aquaculture Technical Paper No. 515. Food and Agriculture Organization, Rome, Italy.

Halpern, B.S. 2003. The impact of marine reserves: Do reserves work and does reserve size matter? Ecological Applications. 13(1): 117–137.

Hastings, A. and L.W. Botsford. 1999. Equivalence in yield from marine reserves and traditional fisheries management. Science. 284(5419): 1537–1538.

Hien L.T. 2006. Cu Lao Cham socio-economic baseline survey. Hoi An – Quang Nam: Cu Lao Cham MPA report.

Hughes, T.P.; A.H. Baird; D.R. Bellwood; M. Card; S.R. Connolly; C. Folke; R. Grosberg; and O. Hoegh-Guldberg. 2003. Climate change, human impacts, and the resilience of coral reefs. Science. 301(5635): 929–933.

Jentoft, S. 1989. Fisheries co-management: Delegating government responsibility to fishermen's organizations. Marine Policy. 13(2): 137–154.

Jones, P.J.S. 2002. Marine protected area strategies: Issues, divergences and the search for middle ground. Review in Fish Biology and Fisheries. 11(3): 197–216.

Lee, D.R. and C.B. Barret. 2001. Trade-offs or synergies? Agricultural intensification, economic development, and the environment in developing countries. CAB International, Wallingford, UK.

Mascial, M.B. and C.A. Claus. 2009. A property rights approach to understanding human displacement from protected areas: The case of marine protected areas. Conservation Biology. 23(1): 16–23.

Mascial, M.B.; C.A. Claus; and N. Robin. 2010. Impacts of marine protected areas on fishing communities. Conservation Biology. 24(5): 1424–1429.

McClanahan, T.R.; M.J. Marnane; J.E. Cinner; and W.E. Kiene. 2006. A comparison of marine protected areas and alternative approaches to coral-reef management. Current Biology. 16(14): 1408–1413.

McEwin, A. 2006. Livelihoods analysis of Cu Lao Cham. Hoi An, Quang Nam, Vietnam. Cu Lao Cham MPA Report.

McGregor, A. 2009. Human well-being in fisheries communities. *In* Building capacity for sustainable governance in south asian fisheries: Poverty, well-being, and deliberative policy networks. Institute for Ocean Management, Chennai, India.

MEA (Millennium Ecosystem Assessment). 2005. Ecosystem and human well-being: Synthesis. Island Press, Washington, D.C., VA.

NCEAS (National Center for Ecological Analysis and Synthesis). 2001. Scientific consensus statement on marine reserves and marine protected areas. NCEAS, Santa Barbara, CA.

NRC (National Research Council). 2001. Marine protected areas: Tools for sustaining ocean ecosystems. National Research Council, Washington, D.C., VA.

Ngoc Q.T.K.; W.C. Armstrong; and Anh N.T.K. 2012. Indicators for assessing marine protected areas: The case of the Nha Trang Bay Marine Protected Area in Vietnam. Asian Fisheries Science. 25: 52–65.

Pascoe, S. and S. Mardle. 2003. Efficiency analysis in EU fisheries: Stochastic production frontiers and data envelopment analysis. CEMARE Report No. 60. Centre for the Economics and Management of Aquatic Resources, University of Portsmouth, Portsmouth, England.

Pomeroy, R.S.; J.E. Parks; and L.M. Watson. 2004. How is your MPA doing? A guidebook of natural and social indicators for evaluating marine protected area management effectiveness. International Union for Conservation of Nature, Gland, Switzerland.

Quan N.V.; Hien N.T.; and Hien T.T. 2008. Coastal and marine ecosystem services and poverty alleviation: A case study of Vietnam. Report for Rufford Foundation. Unpublished document.

Raudsepp-Hearne, C.; G.D. Peterson; M. Tengö; E.M. Bennett; and T. Holland. 2010. Untangling the environmentalist's paradox: Why is human well-being increasing as ecosystem services degrade? Bioscience. 60(8): 576–589.

Roberts, C.M. and N.V.C. Polunin. 1993. Marine reserves: Simple solutions to managing complex fisheries. Ambio. 22: 363–368.

Sala, E.; C. Costello; D. Dougherty; G. Heal; K. Kelleher; and J.H. Murray. 2013. A general business model for marine reserves. Plos One. 8(4): 587–599.

Samonte, G.; L. Karrer; and M. Orbach. 2010. People and oceans: Managing marine areas for human well-being. Conservation International, Arlington, VA.

Trinh C.M. 2011. Building comanagement for enviromental and resource management in Cu Lao Cham MPA, Quang Nam. Vietnam National University, Ho Chi Minh City, Vietnam. PhD dissertation. [in Vietnamese]

———. 2014. Cham Island ecotourism. Report for Cu Lao Cham MPA management board. Unpublished document. [in Vietnamese]

Tuan V.S.; Long N.V.; Tuyen H.T.; Hoang P.K.; Hoa N.X.; Thom P.V.; Tam P.H.; H. Dilev; and R. Linberg. 2004. Marine habitat and resource surveys of Cu Lao Cham marine protected area, Quang Nam province, Vietnam. Cu Lao Cham MPA Report, Hoi An, Quang Nam, Vietnam.

Worm, B.; E.B. Barbier; N. Beaumont; J.E. Duffy; C. Folke; and B.S. Halpern. 2006. Impacts of biodiversity loss on ocean ecosystem services. Science. 314(5800): 787–790.

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