

***Economic analysis of Marine Protected Areas:  
Bioeconomic Modeling and Economic Valuation Approaches***

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## List of papers

### **Paper 1.**

Xuan, BB, Armstrong CW. (2016). Marine reserve creation and interactions between fisheries and capture-based aquaculture: A bioeconomic model analysis. *Natural Resource Modeling*, 00, 1–15.

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### **Paper 2.**

Bui Bich Xuan, Erlend Dancke Sandorf and Margrethe Aanesen. Informing Management Strategies for a Reserve: Results from a Discrete Choice Experiment Survey. Manuscript

### **Paper 3.**

Bui Bich Xuan. Extractive and Non-extractive Values of a Marine Protected Area: A Bio-economic Model Application. Manuscript





## Summary

Marine protected areas (MPAs) are often established for conservation objectives. Benefits provided by MPAs exceed pure biodiversity conservation as they may include contributions to social and economic benefits of local communities. And though it is still debated, MPAs may provide a management tool for sustainable fisheries and/or solving conflicts of interests between users of marine resources. It is of value to analyze and understand how implementation of an MPA can give different benefits to the economy and society. This thesis attempts to analyze some of the benefits of MPAs in specific situations. The thesis includes two parts; part 1 presents the general introduction of the thesis and part 2 consists of three papers. There are three main sections in the introduction. The first section presents the basic literature on the use of natural resources and MPAs, as well a description of the Nha Trang Bay marine protected area (NTB MPA) as an empirical case study. The second section presents research objectives and the summary of three topics dealing with these objectives. The first topic describes how an MPA can be used as a management tool to solve economic conflicts between ocean users, more specifically aquaculture and wild commercial fisheries competing for the use of the same species. An integrated bioeconomic model is developed for analyzing the impacts of an MPA on aquaculture-fisheries interactions. In the second topic, benefits from MPA-based tourism activities are derived using the discrete choice experiment method. The empirical analysis is applied to the NTB MPA in Vietnam. The total benefits of the coexistence of multiple activities, i.e. fisheries and tourism, affected by MPAs is analyzed and discussed in the third topic. The combination of a bioeconomic model and non-market valuation techniques (i.e. discrete choice experiment) is the approach for this study. Data from the anchovy purse seine fishery in Khanh Hoa province and tourism activities related

to the NTB MPA are applied for the empirical analysis. The final section presents overall conclusions of the thesis.

## **PART 1. INTRODUCTION**

### **1. Background**

#### *1.1. Literature overview and research motivation*

According to the IUCN (2008), coastal resources and marine ecosystems are in decline worldwide. Many of them have collapsed due to the impacts of overfishing, pollution, habitat degradation, and climate change. More than half of global fish stocks are fully exploited, while more than one fourth are either overexploited or depleted, and about 70% of coral reefs worldwide are threatened or destroyed. Implementation of MPAs is suggested as a key management strategy to address the issues that have impacts on marine ecosystems and resources. As a result, there has been a remarkable growth of MPAs worldwide from 0.9% to 8.4% of areas under national jurisdiction during the period of 1990 – 2014 (Juffe-Bignoli et al. 2014). Despite the increase in the number of MPAs worldwide, and the target of at least 10% of the world's marine and coastal regions by 2012 made at the Convention of Biological Diversity in 2006 (Jentoft et al. 2012), only 3.4% of the global ocean area was protected by 2014 (Juffe-Bignoli et al. 2014). This consists of 10.9% of all coastal waters, but only 0.25% of marine areas beyond national jurisdiction are protected (Juffe-Bignoli et al. 2014).

Together with the growth of global marine protected area coverage, the literature on MPAs has rapidly increased during recent decades. However, economic analysis is only a small share of this literature (Alban et al. 2008). MPAs are known as an effective fisheries management tool to recover over-exploited fish stocks, though the economic benefits in terms of fisheries management are still controversial (Merino et al. 2009). Some studies show that MPAs combined with optimal harvesting outside the reserves is less beneficial to fishers compared to conventional management tools (Hannesson 1998; Conrad 1999). Other research indicates that optimal harvest combined

with a certain size of MPA can under some circumstances generate more resource rents than optimal harvest without an MPA (Sanchirico & Wilen 2001; Grafton et al. 2009; Punt et al. 2010; Punt et al. 2013; Schnier 2005b; Schnier 2005a). Moreover, MPAs have also been considered as a management tool for reducing the economic conflicts between ocean users (Bohnsack 1993).

Similar to terrestrial resource use, where there are potential conflicts of interests as regards land use and species conservation (Schulz & Skonhofs 1996; Skonhofs 2007), there are potential conflicts of interests between ocean users related to marine resources. A few studies have discussed issues of economic conflicts related to marine resources use. Ottolenghi (2008) indicated that tuna capture-based aquaculture has negative impacts on wild resources and hence conflicts in interests with other resource users. For example, the activity of tug boats towing tuna cages disturb the traditional longline fisheries and reduce tuna catches in many countries (e.g. Italy, Malta, and Tunisia). Bluefin tuna capture-based aquaculture relying entirely on wild-caught seed is shown to be the main cause of the reduction in the spawning stock, and the rapid increase in fishing mortality is the reason behind conflicts with the fisheries sector. In addition, bluefin tuna farmers in Croatia have serious conflicts with tourism activities in the use of the coastal zone (Ottolenghi 2008). Lee and Iwasa (2011; 2014) demonstrated the potential economic conflicts in natural resource use involving tourists as recreational anglers in competition with fishers as traditional divers. Liu et al. (2014) used a bioeconomic model to analyze the interactions between escaped farmed and wild Atlantic salmon in Norway. They show that both harvests and profits of wild commercial and recreational fisheries may decline after the escape of cultured fish from a marine aquaculture facility, but the total profits from the harvest of both wild and farmed stocks may either increase or decrease, depending on the change in values of parameters in the model. The analysis of the economic conflicts between aquaculture and wild fisheries, that is, the presence of aquaculture

having negative effects on wild fisheries and hence reducing wild stocks, harvest and profits, was also carried out by Hoagland et al. (2003) and Mikkelsen (2007).

Marine resources are abundant and diverse. They provide various goods and services to different users (Cicin-sain & Belfiore 2005). Conflicts over resource use among users are common and expected to increase in extent and severity (Armstrong 2007; Mikkelsen 2007). In this thesis, the conflicts between capture-based aquaculture and wild fisheries is considered as the case study. A question is therefore addressed: how to solve the economic conflicts between ocean users, fishers and farmers?

Via zoning and separating different interest groups, implementation of an MPA is suggested as a solution to reduce the conflicts of interests at sea (Bohnsack 1993; Lee & Iwasa 2011; Ngoc & Flaaten 2010). Some studies, however, indicated that implementation of an MPA may not be an effective solution for reducing the economic conflicts between groups in marine resource use. Holland (2000) used a fleet dynamics model integrated with an age-structured model of a multi-species fishery to explore how an MPA implementation might affect the efficiency and distribution of benefits among different fishing groups. He indicated that introducing an MPA may have little effect in overall revenues but have different impacts on fishing groups from different ports, i.e. there will be winners and losers. Sumaila & Armstrong (2006) used a two-cohort model for a single species harvested by two groups and showed that the economic rents of cooperating fishing groups can be increased with the implementation of an MPA. However if fishers do not cooperate, introducing an MPA may not ensure rents to all the involved fishers. The question asked in this thesis is whether it is possible to achieve a win-win management strategy with an MPA implementation, which allows an increase in economic benefits for both competitors in marine

resource use, fishers and farmers, while at the same time achieving biodiversity conservation objectives.

Besides the benefits of an MPA as a management tool for sustainable fisheries and solving economic conflicts between groups in marine resource use, an MPA may provide resources for tourism development. The recovery of marine biodiversity and degraded habitats due to protecting marine areas rapidly makes the areas become attractive for tourism (Alban et al. 2008). Some studies have underlined the attractiveness of MPAs for tourism, and indicated that tourists are willing to pay a premium price for an increase in the quality of the ecosystems (Can & Alp 2012; Parsons & Thur 2008; Schuhmann et al. 2013). As a result, developing tourism associated with MPAs might be regarded as a way of translating benefits of ecosystem conservation into economic terms (Alban et al. 2008).

In the economic literature on MPAs, the two benefits of MPAs, fisheries management and tourism opportunities, are often evaluated separately. However, as for management of common marine resource use, the economic values associated with different users are important for determining the optimal size of MPAs. A few studies have taken into account the combination of either non-extractive and extractive values or non-use and use values for a maximization of social welfare in connection to natural resources (Alexander 2000; Bulte et al. 1998; Clark et al. 2010; Moyle & Evans 2008; Rondeau 2001). In terms of MPAs, there are very few studies on the multiple benefits provided by MPAs, such as in work by Boncoeur et al. (2002) and Merino et al. (2009), who use bioeconomic models to illustrate the benefits of the coexistence of fishing and tourism activities under circumstances of different area-size distributions and fishing-effort levels. This thesis investigates the question of optimal size of an MPA, while integrating various values in order to maximize total value over all relevant stakeholders, i.e. in fisheries and tourism.



MPAs, although they provide various potential benefits, they also involve costs (Balmford et al. 2004). The issue of management costs of MPAs, especially enforcement costs, is still controversial (Alban et al. 2008). Some authors suggest that costs may be lower with an MPA than with conventional management tools (Armstrong & Reithe 2001), while others have the opposite point of view (Sanchirico et al. 2002; Cullis-Suzuki & Pauly 2010; Parrish et al. 2001). It is shown that about 70% – 80% of MPAs worldwide are protected only in name and are not effectively managed and hence the objectives of conservation and fisheries management of the MPAs are not ensured. The lack of ability to secure funds for running and managing MPAs has been indicated as the main obstacle to the success of MPA implementation (Depondt & Green 2006). It is also indicated that funds for maintaining MPAs often come from very limited public budgets, resulting in problems for the managers of MPAs (Cullis-Suzuki & Pauly 2010).

Tourist payments in the form of user fees for entering and using protected areas is a way to ensure the sustainable financial source funding for management of MPAs. It is well known that the use of terrestrial protected areas (e.g. national parks) for non-extractive commercial activities, such as eco-tourism, yields a price-premium (Bandara 2004; Baral et al. 2008; Birol et al. 2006; Wang & Jia 2012). Corresponding effects of MPAs are less explored (Jacobsen & Thorsen, 2010). A few studies underline the attractiveness of MPAs for tourists through recreational activities such as diving (Parsons & Thur, 2008; Sorice, Oh, & Ditton, 2007) and whale watching (Wilson & Tisdell, 2003), and attractive sea scenery as well as other tourist activities (Can & Alp, 2012, Hall & Hall, 2002). They show that tourists are willing to pay more than the current fees for improved biodiversity and environmental quality within the MPA. The increased income may be a sustainable financial source supporting the management costs of MPAs.

In this thesis, Nha Trang Bay MPA (NTB MPA) is used as an empirical case study to investigate the preferences of tourists visiting the MPA as regards the improvements of biodiversity and environmental quality within the MPA. The results of this study give relevant information for MPA managers in relation to potential sustainable source funding of ongoing MPA management costs as well as additional costs associated with environmental improvements. This study therefore contributes to the existing literature on assessing the potential use of tourism fees as a solution for sustainable financial sources of MPAs. Furthermore, the NTB MPA is used for the empirical analysis of multiple services provided by MPAs in this study.

### *1.2. Nha Trang Bay MPA and its total economic value*

An international definition of MPAs is “a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values” (IUCN, 2008, page 3). MPAs are therefore acknowledged to be the cornerstone for promoting biodiversity, ecosystem services, and human well-being (Kemsey et al. 2012). If well-managed, MPAs may provide various benefits such as conserving biodiversity and ecosystems, protecting important habitats for fish, providing opportunities for nature-based recreation and tourism, and providing focal points for education, training, heritage and culture, etc. (Toropova et al. 2010).

In this thesis, the Nha Trang Bay (NTB) MPA is used as an empirical case study to investigate a part of the various quantifiable values which can be generated by an MPA. The NTB MPA was established in 2002, with two main purposes: to conserve marine biodiversity and to provide sustainable uses of natural resources, of which the former is considered to be the most important goal (Vo et al. 2002). The biodiversity in NTB was well known as the highest in Vietnamese

coastal waters and relatively high for the overall Pacific Ocean, with 350 species of hard coral (accounting for over 40% of all reef-building coral species in the world), 220 species of demersal fish, 160 species of mollusks, 18 species of echinoderms, and 62 species of algae and seagrass (Vo et al. 2002; Nguyen & Phan 2008). This marine area therefore does not only support a variety of important habitats and ecosystems (i.e. coral reefs, mangrove forests, seagrass beds, sandy-muddy bottom areas, and rocky shores), but it is also considered a major nursery ground supplying fish larvae to other Vietnamese ocean areas and possibly also to Cambodian waters (Dung, 2009).

For management purposes, a zoning scheme for the NTB MPA was applied. The total protected area is 160 km<sup>2</sup>, consisting of nine islands and their surrounding waters, and regulated into three zones with different levels of use and protection (see Figure 1). The core zone included four islands, i.e. Hon Mun, Hon Noc, Hon Cau, and Hon Vung, and the areas from the water's edge out to 300 meters around these islands, where only tourism is allowed. The buffer zone included the remaining islands and waters within 300 meters of these islands, and additional waters of 300 meters surrounding the core zones. Tourism, fishing, and marine farming were allowed in this zone, but no trawling. The transition zone opens to all activities, though limiting bottom trawl with regards to mesh size and engine power (Vo et al. 2002). In 2014, the names of the three zones, their boundaries, and the regulations related to the use and the protection were changed. The three regulated zones are currently renamed as the strictly protected area; the ecological rehabilitation zone; and the development zone, respectively. The strictly protected zone is now extended northward from Hon Mun and the whole area east and the southeast of Hon Tre. Fishing is not allowed in both the strictly protected area and the ecological rehabilitation zone.<sup>1</sup>

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<sup>1</sup> Nha Trang Bay regulations. <http://thuvienphapluat.vn/van-ban/Tai-nguyen-Moi-truong/Quyiet-dinh-3363-QD-UBND-2014-Quy-che-quan-ly-vinh-Nha-Trang-Khanh-Hoa-263937.aspx>.

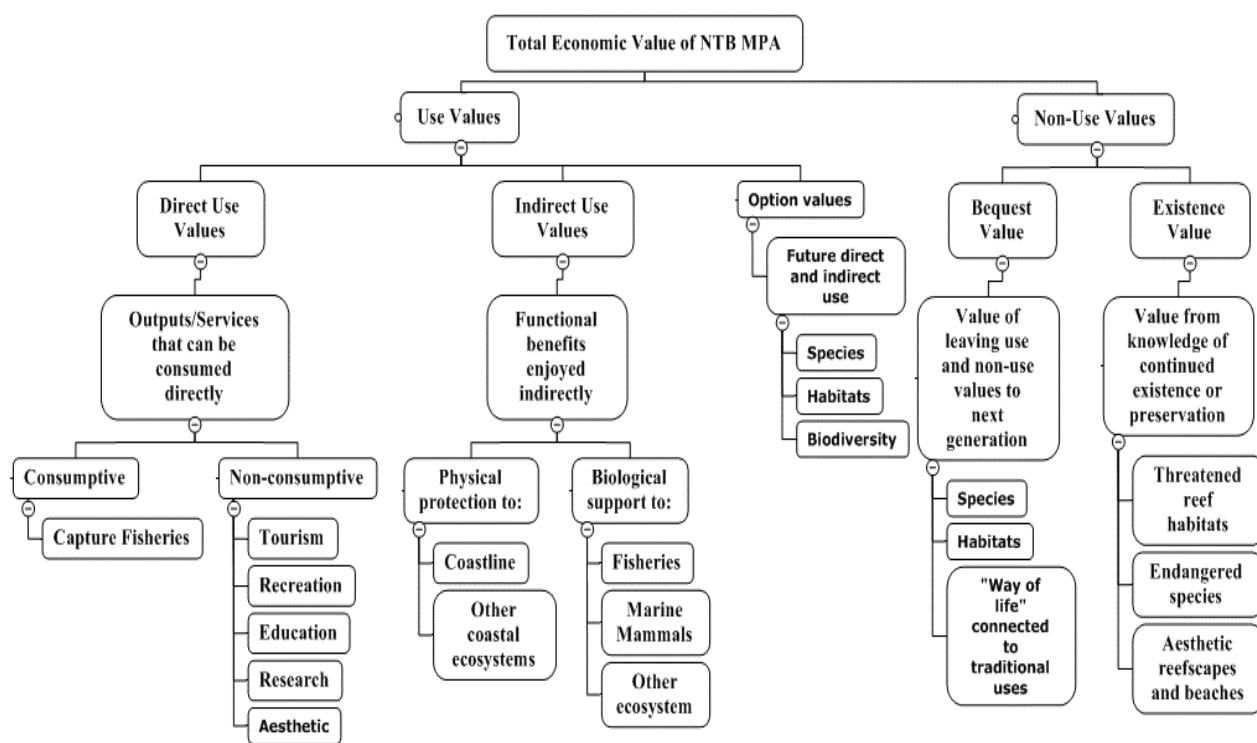


**Figure 1.** Map of the NTB MPA.

*Source:* Van (2013)

Figure 2 presents a summary of potential total economic value (TEV) of the NTB MPA, constructed based on both the general framework of the TEV of MPAs presented by Grafton et al. (2011) and the particular objectives of the NTB MPA project as indicated in Vo et al. (2002). The TEV of the NTB MPA includes the two components, use and non-use values. The use values consist of direct, indirect, and option values. The direct use values include consumptive use (e.g. fishing) and non-consumptive use. Non-consumptive use values are obtained from direct uses of natural resources for recreational purposes, i.e. diving/snorkeling or sea mammal-watching, and an increase in knowledge of marine system (i.e. education and research). Indirect use values are the values of ecosystem services with regards to biodiversity conservation and habitat protection. Option values are the current values of potential future direct and indirect uses of marine ecosystem.

Another important contribution of MPAs is non-use value, being the benefits obtained from conserving threatened, endangered and rare marine species. It consists of two components, i.e. existence value and bequest value. The former is the benefit of the knowledge about the species protected by an existing MPA, and the latter refers to benefits from ensuring the availability of the ecosystem services of MPAs to the coming generations (Grafton et al. 2011).



**Figure 2.** Total Economic Value of the NTB MPA.

Based on the potential values provided by NTB MPA, these can be grouped into two main economic topics. One is the valuation of ecosystem services provided by MPAs, the other is the analysis of the economic impact of an MPA as a management tool on these services. The former is conducted with the help of some assessment methods such as revealed preference (i.e. travel

cost and hedonic pricing) and stated preference techniques (i.e. contingent valuation and discrete choice experiments), while the latter is often performed using bioeconomic modelling (Alban et al. 2008).

In this thesis, I focus on both economic topics of MPAs, one is the use of MPAs as a management tool to reduce the economic conflicts between ocean users, using an integrated bioeconomic model. This topic is presented in the first paper. Another topic is the valuation of the direct use values of the NTB MPA, i.e. from fisheries and tourism. A discrete choice experiment (DCE) method is used to evaluate the tourism value provided by the NTB MPA, which is presented in the second paper. A combination of both approaches, bioeconomic modelling and DCE, is used to analyze the multiple benefits provided by MPAs (e.g. fisheries and tourism). This is presented in paper three. Although other values of the NTB MPA such as option values and non-use values are not included here, the approach used in this thesis to evaluate non-consumptive value can be applied for the valuation of the remaining values of the NTB MPA.

## **2. Research objectives**

The overall theme of this thesis is the economic benefits provided by MPAs. Three main topics have been analyzed and discussed:

- (1) Can an MPA be considered to reduce the potential economic conflicts among ocean users, i.e. fishers and farmers?
- (2) May the willingness to pay of national tourists for an improvement of biodiversity and environmental quality within an MPA be sufficient to cover the costs connected to this improvement?
- (3) What is the optimal management for the multiple use provided by MPAs, i.e. fisheries and tourism?



Each topic is studied in a separate paper, presented below.

*Topic 1: MPAs – a potential solution for solving the conflicts of interests between fishers and marine farmers.*

In the economic literature, there are many studies on the interactions between wild fisheries and marine aquaculture (Anderson 1985; Hannesson 2003; Naylor et al. 2000; Valderrama & Anderson 2010; Ye & Beddington 1996). These studies present the two main classes of interactions, one being the market interaction which may indirectly provide positive effects of aquaculture on wild fisheries by increasing total supply to the market and thereby reducing fish prices which may result in reduced fishing effort and hence a potential increase in wild fish stocks and harvest in open access fisheries. The other is the interaction related to environmental issues and wild resource uses (e.g. wild seeds and feeds), which may show the opposite effects, that is, the growth of aquaculture may reduce wild fish stocks and hence wild catch. The latter is considered to be one of the reasons for the conflict of interests between fishers and marine farmers. These conflicts have been analyzed and discussed in the literature by Hoagland et al. (2003), Mikkelsen (2007) and Liu et al. (2014), though the authors do not include a solution to reduce these conflicts.

Hoagland et al. (2003) present a bioeconomic model to analyze the external negative impacts of aquaculture on fish population dynamics and hence wild fisheries production. By letting carrying capacity of fish stock be a linear function of aquaculture area, they investigate the impacts of aquaculture on wild fisheries via different management scenarios, i.e. under an open access fishery, an optimally managed fishery with individual quotas, and an optimal management of both industries competing in the market of fish production. In the first two scenarios, they show that the presence of aquaculture reduces fishing effort or the equilibrium value of quota. This may induce the fishers to oppose the introduction or expansion of marine aquaculture. In the last scenario, they

look for the optimal solution of the coexistence of aquaculture and wild fisheries in an ocean area. They show that economic optimum is often related to a corner solution, i.e. either wild fishery or aquaculture should be carried out exclusively in the region, and the coexistence of the two users is sub-optimal. A counter-intuitive optimal outcome is also indicated; that higher unit cost of aquaculture results in a larger area allocated to aquaculture (and with a contraction of wild fishing effort), implying a tradeoff between aquaculture and wild fisheries.

In a similar vein, Mikkelsen (2007) analyzes the potential impacts of aquaculture on wild fisheries by modelling negative effects of aquaculture on aspects of wild fish: 1) carrying capacity, 2) intrinsic growth rate, and 3) catchability, depending on aquaculture production volume. These effects are investigated under both open access and sole ownership regimes. The author shows that the steady state fish stocks, fishing effort, and fishing yield, both under open access and sole-owner fisheries, vary depending on whether the impact of aquaculture on fisheries is via carrying capacity, intrinsic growth rate or the catchability coefficient. Despite the varying values in optimal variables, the equilibrium fishing rents decline for all three types of negative effects of aquaculture on fisheries, inducing the potential economic conflicts between fisher and marine farmers.

Similarly, Liu et al. (2014) present a bioeconomic model to analyze the impacts of escaped farmed fish (i.e. a type of biological invasion) on wild fish stock and harvest. Escapees have negative ecological effects, but positive economic effects on wild fisheries because escaped fishes increase the stock available for harvest. The authors suggest that stock, growth, and harvest of wild fish may decline after an invasion, and hence also the profitability of the wild fishery, but the total profits from fishing both wild and escapee stocks decrease only slightly. In some cases, the total profits can be improved compared to solely catching wild fish. This is due to the assumption that there is no difference between wild and farmed fish to fishers, the escaped farmed fish therefore

contribute to the available stock for harvest. However, this may not always be the case as indicated by Olaussen & Liu (2011), that is, anglers are willing to pay substantially more for wild than escaped farmed salmon.

In this thesis, the external effect of aquaculture requiring wild juveniles, on the commercial wild fisheries of the same species, has been applied particularly in model analysis. Aquaculture that relies on the collection of live material from the wild is of concern, as it is one reason for the reduction in juvenile availability with resulting impacts on capture fisheries, potentially creating economic conflicts between users (Sadovy de Mitcheson and Liu [2008]). When wild seed fisheries are poorly managed, growth of aquaculture may contribute to the threat of overfishing for some species (FAO 2011) or even cause fishery collapse, of which the lobster fishery in Vietnam is an example (Thuy & Ngoc 2004). Implementing an MPA is not only expected to mitigate these negative effects of aquaculture on wild fisheries, but may increase the harvests and hence profits for both fishers and farmers as well, and thereby reduce the conflict of interests between them. This topic is analyzed and discussed in paper 1.

With regards to the role of MPAs in fisheries management in general, and in relation to solving the conflicts of interests between users in particular, the benefits of MPAs include both biological (i.e. increase in fish abundance) and economic (i.e. positive spillovers to adjacent fisheries) perspectives (Kompas & Schneider 2005; Lee & Iwasa 2011; Ngoc & Flaaten 2010; Sumaila & Armstrong 2006). Bioeconomic models are the major approach, used to capture the economic impacts of MPAs. Bioeconomic models of MPAs are built upon the basic bioeconomic fisheries models and usually based on the key assumption of density-dependent dispersal. The models can be categorized into three major types: the logistic Schaefer model (see Conrad 1999; Hannesson 1998; Flaaten & Mjølhus 2010), the age- and size-structured population model (see Holland &

Brazee 1996; Holland 2000; U.R. Sumaila 2002), and spatially explicit bioeconomic models (see Sanchirico & Wilen 1999; Sanchirico 2004). In paper 1, we apply the first type of bioeconomic MPA model in order to analyze the impacts of an MPA on the interaction between wild fisheries and aquaculture.

In this paper, the presence of aquaculture that relies on wild caught juveniles is assumed to reduce the intrinsic growth rate of wild fish stock, and hence wild stock and harvest. The results of this study show that introducing an MPA of a certain size improves the results from both a biological and an economic perspective, compared to without an MPA under both open access and optimal management regimes.

Particularly, under open access, the equilibrium wild stock size increases with increasing MPA size and is larger than without an MPA, given aquaculture production. For a certain size of MPA, the equilibrium wild harvest is larger than without an MPA. These results are somewhat similar to existing studies, i.e. Hannesson 1998; Sanchirico & Wilen 2001, despite the fact that the underlying model in the first paper includes an aquaculture effect on wild fisheries outside the MPA. The combination of a certain size of MPA and optimal harvesting outside the MPA gives better results compared to conventional management tools. The optimal wild stock size increases with an increasing MPA size and is larger than without an MPA. The total profit of both industries as well as the profit of each with an MPA is larger than without an MPA. The results of this study are different to those indicated by Holland (2000) and Sumaila & Armstrong (2006), that is in the competitive environment of resource use there may be losers and winners when introducing an MPA.

## *Topic 2: Informing Management Strategies for a Reserve: Results from a Discrete Choice Experiment Survey*

The second topic in this thesis is to examine whether information from a study of MPA valuation can help to design management strategies adequate to conserve and improve the poor state of biodiversity and environment within the MPA. For this topic, the NTB MPA in Vietnam is used as the empirical case study. This topic is presented in the second paper of the thesis.

The purpose of an MPA creation is often to conserve marine biodiversity and ecosystems, and hence ensure social and economic development (IUCN 2008). Many studies have focused on the effectiveness of MPAs and indicate that insufficient funding is one of the main obstacles to successful MPA implementation (Depondt & Green 2006). A few studies show that revenue from MPA-based tourism can be a sustainable financial source to cover the costs of managing an MPA (Grafeld et al. 2016; Depondt & Green 2006; Gelcich et al. 2013; Emang et al. 2016; Terk & Knowlton 2010; Thur 2010).

To assess the economic values of ecosystem goods and services which cannot be directly observed in markets, one often uses non-market valuation techniques (Grafton et al. 2011). Non-market valuation techniques can be divided into two main types: revealed and stated preference. Revealed preference methods (i.e. travel cost and hedonic pricing method) are often used to assess non-consumptive use values of marine resources, based on observations of actual choices or travel behavior of the visitors. Stated preference methods (i.e. contingent valuation, discrete choice experiment, and best-worst scaling) are often used to estimate monetary values of ecosystem goods and services, based on public surveys asking respondents about their willingness to pay to protect or improve the quality of the ecosystem, which is often constructed in a hypothetical referendum.

In evaluating ecosystem quality, the stated preference techniques are more commonly used (Grafeld et al. 2016). Of these, discrete choice experiments (DCEs) have been shown to have some distinct advantages, of which the ability to disaggregate policies/resources into appropriate characteristic sets and levels is the key feature (Adamowicz et al. 1998; Hanley et al. 1998). The second paper in this thesis therefore applies the DCE method to elicit national tourists' willingness to pay (WTP) an additional premium for boat trips within the NTB MPA, in relation to improvements in the environmental quality and increased biodiversity within the MPA.

As mentioned in the previous section, one of the most important objectives of establishing the NTB MPA is to conserve marine biodiversity. However, after more than 10 years of protection from 2002 to 2015, it is indicated that overall the status of biodiversity in Nha Trang Bay has not changed, though it does include areas with improvement as well as deterioration (Ben et al. 2015). The increases in live coral cover as well as diversity and abundance of fish were recorded mostly in the core zones of the MPA, i.e. Hon Mun, while declines were observed in the buffer zones, i.e. Hon Mieu and Hon Tam. Coral reefs at some sites are shown to be in such a degraded condition that they will not recover naturally (Ben et al. 2015).

Two main reasons have been suggested for why the MPA has failed to achieve the desired increase in biodiversity. One is the unplanned and unregulated human activities existing within the MPA, i.e. overfishing, aquaculture, tourism and urban run-off. These human activities have negative effects on the recovery of coral reefs and reef fish abundance which were heavily degraded prior to 2002 (Tuan 2011). Another reason is the core zone of the NTB MPA is believed to be too narrow to ensure biodiversity restoration and prevent marine environmental pollution (Dung 2009; Tuan 2011). Particularly, most protection has been focused on Hon Mun which is a small area, so the



potentially positive dispersal effects of the MPA core zone may not be really effectively promoted (Tuan 2011).

Expanding the core zone of the NTB MPA and changing management policies may improve marine biodiversity, coral reef cover and coastal environmental quality. However, the funding for sustaining and running the NTB MPA at present is indicated to be one of the greatest challenges (Dung, 2009) and expanding the core zone of the MPA is expected to incur even more management costs. The second paper therefore focuses on the assessment of whether MPA-based tourism development can generate a sustainable source funding for managing the NTB MPA. The results of the second paper show that Vietnamese tourists are willing to pay a price premium for boat trips visiting the NTB MPA and confirms there is a potential sustainable financial source to fund the improvements in biodiversity and environmental quality within the MPA.

The majority of studies on tourism values of MPAs using stated preference methods focus on the attractiveness of MPAs for tourists, such as ecological characteristics (i.e. biodiversity and environment) (Grafeld et al. 2016; Emang et al. 2016; Wang & Jia 2012). However, implementing an MPA may have employment effects on the local fishers, as some may lose their jobs due to unavailable fishing grounds. Tourists visiting the MPA may be concerned about the potential job losses of the local fishers when they make choices regarding the alternatives of the MPA management plan. There are apparently no studies on MPA-based tourism valuation taking into account an employment effect of the MPA creation, though it is included as an attribute for tradeoffs in several studies of wetland valuation (see Birol & Cox 2007; Morrison 2002; Morrison et al. 1999; Othman et al. 2004 for more discussion).

In the second paper, an employment effect of an expansion of the NTB MPA on the local fishers is included together with the ecological aspects (i.e. coral cover and environmental quality) in the

DCE design to capture the benefits preferred by tourists. The results show that the tourism values of an MPA can be provided by both the social attributes (i.e. employment opportunities or losses) and the ecological attributes. The latter is normally presented in the literature of MPA valuation, while the former is not.

### *Topic 3: Extractive and non-extractive values of a marine protected area*

The creation of an MPA can be considered an investment in natural capital. Natural assets in general, however, are often providers of multiple services, and hence multiple benefits (Alban et al. 2008). In the literature, the economic values of these services are often evaluated separately and by applying different methods. A few studies combine extractive and non-extractive value or use and non-use value to capture multiple benefits accrued from wildlife both in terrestrial and marine resources. For instance, Alexander (2000) presents a bioeconomic model, using the African elephant as an example, in order to estimate the use and non-use value of endangered species. He shows that non-consumptive value (i.e. tourism revenue) and non-use value (i.e. existence value) can be used to support elephant conservation, and hence play an important role in slowing the population decline. Skonhøft (2007) uses a bioeconomic model taking into account both consumptive and non-consumptive tourism value to analyze the conflict of interests between a park agency and local people related to terrestrial wildlife conservation. Bulte et al. (1998) and Horan & Shortle (1999) integrated non-use values of Minke whale stocks in a fisheries bioeconomic model in order to study the optimal management of whale resources. The results of the two studies show that the Minke whale moratorium was inefficient when only market values (i.e. whale hunting) were considered. However when there existed a significant non-use value, a moratorium could be optimal. Moyle & Evans (2008) included non-extractive or tourism values of whale watching in a model to inform policy and discuss issues related to the economic benefits

of switching from whale hunting to watching. They show that there exists a steady state equilibrium for maximizing the total returns from both consumptive and non-consumptive values of whale populations. Armstrong et al. (2015) use an expanded bioeconomic model to show how non-use value of natural habitats impacts on the optimal fishing activities, using cold water corals in Norway as an example. Hence a combination of multiple benefits accruing from natural resources use may give different economic implications than predicted in the studies solely focusing on commercial harvest.

Nonetheless, very few studies have been carried out in order to investigate multiple benefits provided by MPAs (Boncoeur et al. 2002; Lee & Iwasa 2011), especially using empirical data for model application (see one exception in Merino et al. (2009)). Boncoeur et al. (2002) and Merino et al. (2009) use a bioeconomic model of MPAs to analyze the impacts of an MPA creation on both fishing and ecotourism. Their results show that implementing an MPA does not only increase the benefits for the fisheries, but it also generates additional income through tourism activities. Lee & Iwasa (2011) also use bioeconomic models to analyze and discuss the conflicts of interests between tourists and local fishers in marine resource use, as well as how to reduce these conflicts. The third topic and also the third paper of this thesis, therefore, is about multi-service benefits (i.e. fisheries and tourism) generated by MPAs. A bioeconomic model of MPAs combined with an estimation of tourism values as regards to the MPA is used for an investigation of the optimal management of the two activities; fisheries and tourism. Differing from earlier studies on multi-benefit provided by natural resources, where non-consumptive values and non-use values are modelled as a function depending on either the size of the stocks or the size of harvest (Alexander 2000; Boncoeur et al. 2002; Bulte et al. 1998; Merino et al. 2009), tourism value in this paper is formulated as depending on the size of the MPA. In this paper, implementation of an MPA does

not only address the potential positive effects on fisheries (i.e. spillover effect) and tourism activities, but it is also considered as a controlling factor for a maximization of total values of the two activities.

Empirical data from both the anchovy purse seine fishery and tourism activities related to the Nha Trang Bay marine protected area (NTB MPA), located in the south-central of Vietnam, is applied into the model. It is assumed that the managers want to maximize the total welfare from fisheries and tourism. The tourism value function for the NTB MPA is estimated based on the primary data which is used for estimating tourists' willingness to pay for a hypothetical management policy of the NTB MPA in the second paper. Fishery data are secondary data, the biological and economic parameter values of the anchovy purse seine fishery are borrowed and developed from results of studies carried out by Thi et al. (2007) and Thuy & Flaaten (2013).

The results of this paper suggest that implementing an MPA is not only a good policy for biodiversity conservation but it also is a good economic policy. Although the fishery bioeconomic model of MPAs in this paper is based on the Conrad (1999) model, which is indicated as giving less benefit to fishers compared to conventional management tools, the inclusion of a tourism value of the MPA in the model highlights a broader picture of the actual reasons for MPA implementation. In this study, optimal management requires an expansion of the MPA and a reduction in fishing effort. This secures the fish population from overexploitation but may have short-term negative effects on local fishers. However, the additional income through MPA-based tourism activities may be used partially or totally to compensate the loss of fishery rent due to the MPA expansion.

The use of MPAs as a fishery management tool is of interest from a bioeconomic modelling point of view. The inclusion of tourism value related to the MPA in the basic fisheries bioeconomic

model strengthens the model's illustration of the multiple benefits of MPAs. Moreover, for management of common marine resources that support various goods and services to different users, the economic values associated with different users are important for determining the optimal size of MPAs. This in turn allows for maximizing the total value over the stakeholders of natural resources. This study, therefore, contributes to the important literature of MPAs as a multi-service provider of common natural resources.

### **3. Conclusions**

The main subject of this thesis is the benefit provided by MPAs. The thesis, therefore, focuses on analyzing the economic values of MPAs, specifically fisheries and tourism, as well as the role of MPAs as a management tool for solving economic conflicts among natural resource users, i.e. fishers and marine farmers. Both the approaches of bioeconomic modeling and economic valuation of non-market goods (e.g. a discrete choice experiment), are used in this thesis. Data from the anchovy purse seine fishery and tourism related to the NTB MPA in Khanh Hoa province in Vietnam are used in the model applications.

Though still hotly debated, MPAs are argued to supply a management tool for sustainable fisheries and to solve the conflicts of interests between oceans users. This thesis adds to the literature a positive effect of an MPA creation in terms of mitigating the economic conflicts between ocean resource users. In this thesis, an integrated bioeconomic model is presented to show that the implementation of an MPA of a certain size may increase both biological (i.e. wild fish stock size) and economic benefits (i.e. harvest and profit) for both fishers and marine farmers who are competing in the use of the same species. Hence the economic conflicts may be resolved. This result implies that implementation of an MPA can be considered to be a win-win management strategy, where both conservation and economic objectives are ensured.

Implementation of an MPA is not only considered as a management tool, but it is also regarded as an investment in natural assets which provide multiple service benefits for people. The literature on MPAs to date however mostly considers the biological significance and increase in fish yields. There is a shortage of the social perceptions of MPAs and economic valuations of activities in MPAs, for example, recreational fishing, diving, ecotourism, and research (Christie 2004) which may contribute to higher values of MPAs. Moreover, in developing countries, with overexploited fisheries and limited funding for monitoring and enforcement, community awareness and their support towards MPAs are crucial for the success of an MPA (Kompas & Schneider 2005). In this thesis, the tourism service benefit is evaluated as an alternative benefit of MPAs. The information derived from this study is relevant for the NTB MPA managers in terms of both management strategies for biodiversity conservation and environmental protection, as well as sustainable financial source funding for maintaining and running the MPA.

MPAs are often established for multiple goals (Kompas & Schneider 2005), and involving different stakeholders. It is necessary to incorporate the benefits of relevant stakeholders for an optimal management of natural resources. The inclusion of multiple benefits provided by MPAs in the model may give more complex economic implications than predicted in studies that solely focus on one benefit of an MPA. However, there are relatively few studies that combine multiple benefits for a better use of MPAs. To fill this knowledge gap regarding MPAs, this thesis presents a bioeconomic model that allows for the incorporation of the benefits from fisheries, aquaculture and tourism activities related to an MPA in order to determine the optimal MPA size for a maximization of total welfare of the two activities. Although the model and its' application are represented by the two activities, fisheries and tourism, the approaches used in this thesis allow

for the inclusion of alternative values of MPAs in the model for a broader illustration of multiple benefits generated by MPAs.

Multiple goals of MPA establishment, which involves different stakeholders, are often connected to conflicts of interests (Jentoft et al. 2012). Potential economic conflicts can occur among conservationists and fishers (Francis et al. 2002), tourists and fishers (Lee & Iwasa 2011; Milazzo et al. 2002), or different fisher groups (Ngoc & Flaaten 2010). Though the conflicts of interest in relation to MPA implementation is discussed in the third paper of this thesis, it is not included in the model as clearly as the interaction effects among groups. Therefore, it is of interest to future research to further take into account these interaction effects for an optimization of common resource use.

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## PART 2. PAPERS

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## PAPER I

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Xuan, BB, Armstrong CW. (2016). Marine reserve creation and interactions between fisheries and capture-based aquaculture: A bioeconomic model analysis. *Natural Resource Modeling*, 00, 1–15.

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## **PAPER II**

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Bui Bich Xuan, Erlend Dancke Sandorf and Margrethe Aanesen. Informing Management Strategies for a Reserve: Results from a Discrete Choice Experiment Survey.

### **PAPER III**

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Bui Bich Xuan. Extractive and Non-extractive Values of a Marine Protected Area: A Bio-economic Model Application.