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Indicators for Assessing Marine Protected Areas - the Case of the Nha Trang Bay Marine Protected Area in Vietnam

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Abstract

Although marine protected areas have existed in Vietnam for 10 years and there are some separate assessments of biological or social aspects, few comprehensive evaluations of the management effectiveness have been carried out. This paper presents some easily accessible ecological, economic and social indicators for marine protected areas and discusses them for the case of the Nha Trang Bay Marine Protected Area (NTB-MPA) as an example, by putting together data from a number of different sources. The outcome is that the creation of the NTB-MPA provides some social benefits for stakeholders by improving livelihoods for MPA residents, but could not achieve the conservation objectives targeted for 2005.

Introduction

Over the past two decades, thousands of marine protected areas (MPAs) have been established worldwide. Many protected sites are meeting their goals while many others are failing to achieve their expected outcome (Wells and Dahl-Taccon, 2006a). The creation of MPAs requires the evaluation of management effectiveness. According to the IUCN World Commission on Protected Areas Guidelines, *management effectiveness evaluation* is defined as the assessment of how well the protected area is managed, and the extent to which it protects values and achieves goals and objectives (IUCN, 1994). MPAs are established with various objectives, including conserving biodiversity, protecting commercial fish stocks, improving livelihoods, generating tourism, providing opportunities for people to study marine plants and animals as well as resolving conflicts between stakeholders. Evaluation must therefore be conducted to examine whether these objectives are being or can in the future be achieved.

Vietnam's coastline is about 3,260 km with an exclusive economic zone (EEZ) encompassing more than 1,000,000 km^{-2}. The first MPA established in Vietnam was the Nha Trang Bay Marine Protected Area (NTB-MPA) in 2001. Currently, Vietnam has six MPAs in total, including NTB-MPA, Cu Lao Cham MPA, Phu Quoc MPA, Nui Chua Nature Park, Con Co MPA and Hon Cau MPA. The major objectives of these MPAs are to conserve biodiversity and improve livelihoods. Almost all MPAs aim to conserve coral reef and sea grass.

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Some MPAs also protect some other specific species such as turtle, dugong, dolphin and giant clam. Generating alternative incomes outside of fishing is focused upon as a way to achieve these objectives. Despite the ten-year history of MPAs in Vietnam, there are a limited number of separate assessments of biological or social perspectives, and no comprehensive evaluation of the management effectiveness is carried out. The reason for this is the lack of local expertise and an official system of criteria to base such assessments upon.

Several methods have been developed and can be applied to evaluate MPA management effectiveness: World Heritage Management Effectiveness Workbook (Hockings et al. 2004)**;** Workbook for the Western Indian Ocean (Wells and Mangubhai, 2005); How Is Your MPA Doing (Pomeroy et al. 2004); The five-S framework for site conservation (The Nature Conservancy, 2003)**;** World Bank Scorecard to Assess Progress (Staub and Hatziolos, 2004); and MPA Report Guide and Rating System (Wells and Dahl-Taccon, 2006b). The main concern is how to choose an evaluation method. This choice depends on the reason and the scope of the evaluation, the level of resources available for evaluation, the depth of the available data and what will be possible to collect (MPA News, 2006).

The aim of this paper is to provide information about the basic data requirements for this kind of evaluation, with special focus on Vietnamese MPA creation. The methodology is based on the approach to evaluate management effectiveness of MPAs as suggested by Pomeroy et al (2004). We choose to focus on this approach as it contains numerous indicators and suggests simple techniques to measure them. We also provide examples from the NTB-MPA to support and illustrate these techniques.

Materials and Methods

For the evaluation process, it is necessary to have clear management objectives so that the evaluation indicators and relevant data can be selected based on them. The evaluation is important since it determines whether management action can help to reach the objectives for the establishment of the MPA. Data collection prior to the implementation of the MPA is highly valuable, to have a benchmark for which to compare. However, lacking this prior data, data inside and outside the MPA is also an option, but differences in natural environments inside and outside can make comparisons somewhat spurious. Time series data after the implementation is however also of interest, as it may indicate changes over time. On the whole, some data are better than none, and data collection is always a trade-off between costs and benefits of obtaining data.

The main objectives of MPAs in Vietnam as mentioned above are to conserve the biodiversity and improve livelihoods. From these objectives, to evaluate the MPA management effectiveness in Vietnam, both natural and social science aspects should be studied. Here in this paper, we suggest some of these indicators.

Table 1. Suggested indicators for evaluating MPA management effectiveness in Vietnam.

Natural science knowledge	Social science knowledge
The abundance of species	Perception of availability of fish
Composition and structure of communities	Household income
Fishing effort and catch per unit effort	Household occupational structure
	Conflicts between resource users
	Costs and earnings of the vessels affected by MPAs

These indicators were adapted from Pomeroy et al (2004). The indicator "costs and earnings of the vessels affected by MPAs" was added by the authors since in our opinion this indicator will provide input on the effect the MPA has on fishermen who are often the most affected by the creation of an MPA. These indicators are chosen because they are useful for managers to assess management improvement, and they may be applied to different locations and different conditions. Also, it is both easy and relatively cheap to collect the data.

Natural science knowledge

Following the creation of MPAs, a range of biological and environmental indicators may be affected. This section only describes some key indicators and data requirements to investigate whether the biological conditions are improved by the creation of MPAs.

The abundance of species

Species abundance is a commonly used proxy for population size. This indicator should be studied for two main reasons. First, it may reflect how the target species are protected and maintained. Second, improvement and sustainability of target species in the MPA may indicate the effectiveness of the MPA management (Pomeroy et al. 2004). Observing the abundance of several species helps to explore a divergence between fished and un-fished locations. The difference in abundance of species between protected area and fishing area may demonstrate the spillover effect from the closed area to the fished area. This is important evidence of effectiveness of MPAs from a fishery management perspective.

Composition and structure of community

A community is defined as a collection of different and interacting populations of organisms that are found living together in a defined geographic area (Pomeroy et al. 2004). The structure of a community can be described as the relative abundance of all species in the community. The data collection should include: a record of each organism (species) observed, the number and size of each individual and the position in the water column where the individual is observed.

The composition of the community should be recorded in a careful way to examine whether new species occur inside and outside the MPAs. Examining this indicator helps managers to understand the environment in the area and effectiveness of management. Managers are then able to set up appropriate management plan corresponding to changing conditions.

Fishing effort and catch per unit effort

The effort and catch data may help to explain or support the magnitude of difference arising between protected and fished areas and their connection to the magnitude of fishing pressure before, and during protection. It is highly likely that the extent of fishing before, and during the period of protection will have great influence on the degree of recovery observed, and it may account for much of the variability recorded. The types of data collected include (Pomeroy et al. 2004): (1) The type of fishing gear, engine capacity, length of the vessel and crew size; (2) Total time needed to move to the fishing ground and harvest; (3) Composition of the catch; (4) Total weight and money value of the catch; and (5) Fishermen's income.

The catch per unit effort (CPUE) then can be computed. An increase in CPUE may indirectly show the spillover effect from the protected area. However, it is worth noting that a unit effort will over time increase its catching capacity due to technological improvements. It is therefore important to adjust effort to this change over time. This information also indicates how well the MPA management achieves its objectives.

Social science knowledge

Socio-economic considerations may provide insight into how protecting certain areas in the ocean might socially and financially impact local communities. In the same way that natural science data should be collected both inside and outside the MPA area, social science data connected to the MPA can beneficially be compared to data outside. This is to correct for any general changes not necessarily resulting from the MPA creation.

Perception on availability of the fish

This information should be collected from the fishermen to study fishermen's perceptions of the availability of target species and other species around the MPA. Data collected can help to examine the following questions: (1) Whether the MPA management achieves its objective of increasing harvest? (2) How the abundance and the structure of the population have changed? Information that could be collected includes (Pomeroy et al. 2004): How the catch/harvest and composition of the catch has changed compared to earlier, which species are often found in the catch, and whether there are any new species found in the catch recently.

Household income

By investigating household income, managers understand how the creation of MPAs affects the income of the household, how to generate appropriate livelihoods for the community and to what extent the community depends on resources. Following the creation of MPAs, an alternative livelihood generation programme is often implemented. Comparing the data of household income before and after the creation of MPAs also helps to examine the success of the alternative livelihood generation programme. It is also relevant to check the sustainability of the alternative livelihoods, and whether they are able to continue without programme funding or support.

The shifting of income from fishing activity to other activities is important information to examine whether the zoning from the creation of the MPA affects the income of fishermen, and whether the local fisher community is tapping into the alternative livelihoods that the MPA may be creating. Experience from many developing countries shows that local fishing communities often lose out on the implementation of MPAs, and that people from outside obtain the new jobs created in tourism and other sectors.

Household occupational structure

Information about the occupations of household members can help the manager understand how the occupational structure changes due to the creation of an MPA; e.g. identifying any change in the percentage of the households that depend on the marine resources for their livelihoods. To examine this, the income and the occupational structure of all members of the household should be collected. It is important to record the primary and the secondary income of each household so that managers can determine the range of household income.

Conflicts between resource users

Establishment of MPAs may create associated conflicts. Such conflict can exist between fishermen using mobile gear (trawls, purse seine) and static gear (longline, gillnet), between fishermen and aqua-culturists or between fisheries and tourism development. It is difficult to quantify the level of resource conflicts within the MPA. To examine the conflicts, the following information should be collected (Pomeroy et al. 2004): the stakeholders concerned; the main conflicts and the problems that can cause conflicts, who obtains the advantages and who bears the costs of MPA implementation; and whether and how conflicts are resolved, how this is done and by whom. This information can help to understand how the conflicts change over time and how MPA management can tackle those conflicts.

Costs and earnings of the vessels affected by MPAs

This data should include the costs and earnings of the vessels before and after creation of the MPA. Does the creation of an MPA increase income for fishermen? Or does it just impose an

increase in operation costs since the fishermen may have to travel further away for fishing or spend more time seeking the fish.

The choice of the fishermen with regards to the fishing ground is also valuable information. Are the preferred fishing grounds the same or different compared to before the creation of the MPA? Is there increased use of some grounds? And how have revenues and costs of vessels changed due to change in fishing areas? Answers to these questions may help to explain whether the MPA positively or negatively affects the fishing activity. Another question is whether and how often fishermen fish the line, i.e skirt the edges of the MPA. If they do, it may indicate the presence of the spillover effect. It must however be noted that the MPA may be a very productive area even prior to closure, i.e. a coral reef or seagrass meadow, hence the fishermen skirting the MPA are just trying to get as close as possible to this productive area.

The above indicators for MPA assessment were applied for the case of NTB-MPA. The assessment process in this paper includes collecting information from published and other reports of NTB-MPA and evaluating the information against selected biophysical and socio-economic indicators. Two main objectives were identified for NTB-MPA, to conserve a representative sample of internationally significant and threatened marine biodiversity; and to enable local communities to improve their livelihoods. The assessment is also focused on these objectives.

Results

Background on Nha Trang Bay MPA

NTB-MPA, established in 2001, has the highest biodiversity in Vietnam covering nine islands and their waters in Nha Trang Bay (Tuan et al. 2005). According to initial survey of the area, there were 350 species of corals, 250 species of fish, 122 species of crustaceans, 112 species of molluscs and 69 species of seaweed (Tuan et al. 2005). The regulation and zoning scheme encompass three zones: the core zone, the buffer zone and the transition zone.

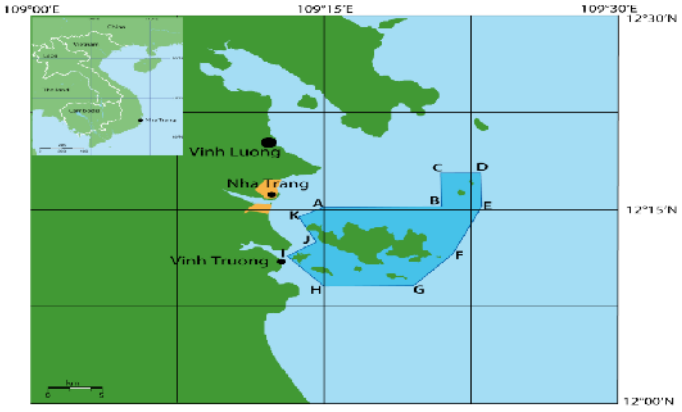

Fig. 1: The location and boundaries of the NTB-MPA, Vietnam.

Fish abundance in NTB-MPA from 2002-2005

The abundance and size of all fish were investigated annually in NTB-MPA (Tuan et al. 2005) starting from 1 year after the establishment, in 2002 to 2005. These investigations allowed statistical detection of changes that might occur over time (see Fig. 2). To collect the data, four replicate 100 m^2 belt-transects were surveyed in each depth range, centered on the 4 x 20 m line transects, of 2.5 m width on either side of the line. Following placement of the transects, the observer waited to allow the fishes to resume their normal behaviour. The observer then swam slowly down each transect recording all fishes that were distributed within the borders of the transect. This method can be applied for different sites and different MPAs in Vietnam.

The abundance of fish increased immediately 2 years after the MPA was created. However, the abundance began to decrease in the two following years. The abundance of all species was also measured to make comparisons between the core zone and non- core zone. The difference in abundance between these two zones was not statistically significant (Tuan et al. 2005). By 2005, there was no evidence of a spillover effect in the NTB-MPA.

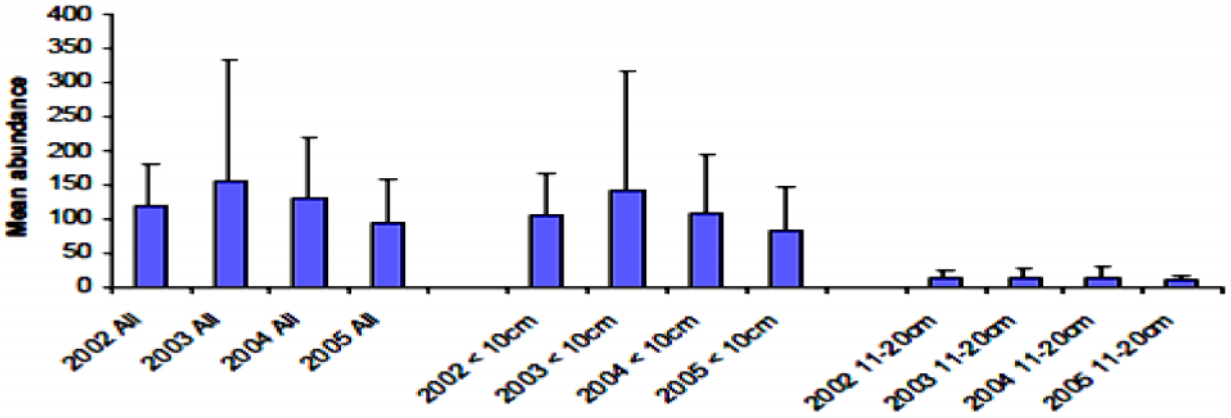

Fig. 2: Temporal trends in mean abundance (±s.d.) per 100 m^2 *(*Tuan et al., 2005).

Composition of the fish in general

For the 10 fish families in Table 1, it is not clear whether the management of the NTB- MPA up until 2005 has secured any increase in abundance. Basing on the work by Tuan et al. 2005, and shown in Table 1, it is however clear that Pomacentridae, a family of perciform fish, is a major contributor to abundance at the NTB-MPA.

Table 1: Abundance of some fish families in the Nha Trang Bay MPA, 2002-2005.

Family	2002	2003	2004	2005
Pomacentridae	4301	5125	4950	3607
Labridae	565	1054	1128	765
Scaridae	682	705	493	435
Acanthuridae	559	545	459	169
Chaetodontidae	319	262	213	142
Siganidae	173	38	22	0
Pomacanthidae	29	46	59	110
Serranidae	24	58	23	24
Haemulidae	14	0	7	1
Lutjianidae	0	3	1	0
Total	**6,666**	**7,836**	**7,355**	**5,253**

Source: Tuan et al. (2005)

The NTB-MPA covers nine islands, but focuses on a few, so the enforcement activities varied throughout the area (Tuan et al. 2005). In some areas, fishermen still regularly fish despite the illegality of their activity (Dinh et al. 2005). The declining trend of some fish families from 2002 to 2005 implied that to achieve effective management for NTB-MPA, fisheries surveillance and enforcement need to be directed towards minimising potential effects from exploiters.

Fishing effort and catch per unit of effort

Most of the vessels operating around the NTB-MPA are small-scale vessels. The data collected in 2005 is based on the same survey sample as 2002. The same households interviewed in 2002 were also interviewed in 2005 (Thu et al. 2005). From Fig. 4, the engine capacity tended to increase after the creation of the MPA, while surprisingly the proportion of vessels with length longer than 10 m has decreased. If the same households were interviewed in 2005 as in 2002, this data set implies that fishermen chose to scale down after the creation of the MPA.

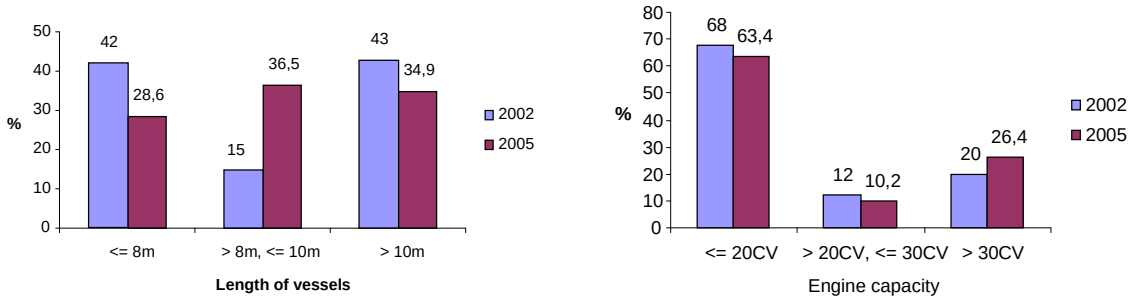

Fig. 4. Percentage distribution of vessels operating around the NTB-MPA according to vessel length and average engine capacity (Thu et al., 2005).

For the CPUE indicator, the CPUE data in Table 2 give no clear indication of MPA effects. For some fishing gears (stick-held dip net and anchovies purse seine), the CPUE was increased during the period 2002-2004. However, for others the CPUE tended to decrease. It is necessary to have more time series data to investigate accurately the CPUE in this area.

Table 2. The CPUE of some fishing gears around NTB-MPA.

Fishing gears	CPUE ($kg \cdot hr^{-1}$)	
	2002 – 2003	2004 - 2005
Stick-held dip net	12.19	16.93
Trammel net	1.08	0.75
Anchovies purse seine	5.15	39.26
Lift net (fish)	3.59	2.88
Lift net (Lobster)	2.34	0.58
Longline fishing	0.58	0.49
Hookah diving	0.52	0.43 $kg \cdot hr^{-1}$ and 0.15 $ind \cdot hr^{-1}$

Source: Dinh et al. (2005)

Evaluation NTB-MPA applying social science knowledge

Perception on the fish catch trend

There is no information on perception of the availability of fish, so perception of the fish catch trend prior to and after the creation of NTB-MPA is presented here (Lan, 2009). Data were collected using a survey of fishermen's responses on perceptions regarding fish catch trends. The information collected thus can reflect the state of fish stocks or the availability of fish as perceived by the fishermen.

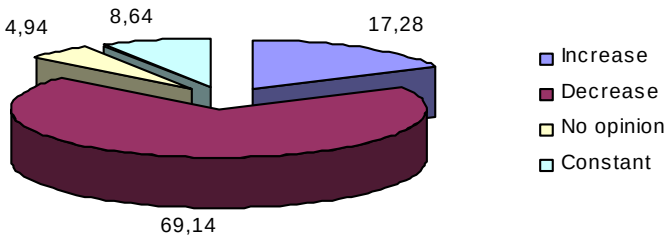

Fig. 5. Perception of fishermen regarding fish catch trends compared to prior to the NTB-MPA establishment (Lan, 2009).

About 69% of the respondents believed that the catch in 2009 has decreased compared to prior to MPA creation while 17.3% of respondents perceived that the catch in NTB-MPA had increased in this time period. The perceived decrease in fish catch was also investigated. It was shown that the main reason for this decrease is believed to be that more fishermen with modern fishing vessels were now operating in the area. The prohibition of the fishing vessels in the core zone and the change in marine environment also explained the decrease in catch (Lan, 2009).

Occupational change

Data on the occupational structure of the husband and wife in a family for 2 years, 2002 and 2005, were collected in household surveys (Thu et al. 2005). Figs. 6 and 7 showed changes in occupational structure for both husbands and wives in Nha Trang Bay. The percentage of the husbands fishing has decreased from 79.8% to 76%. The percentage of housewives also decreased from 79% down to 67.5%. This implies that alternative income generation programmes might have changed the occupation structure of households. This, in turn, may support the management effectiveness of the MPA.

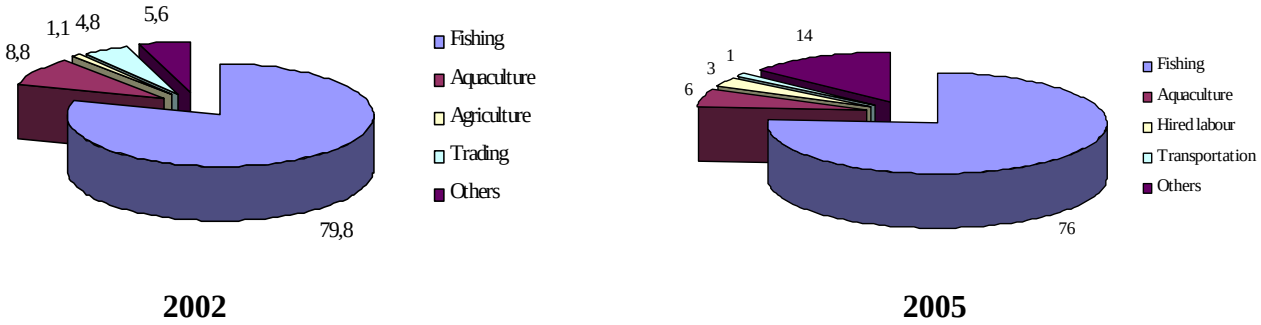

Fig. 6. The change in occupational structure of husbands (Thu et al., 2005).

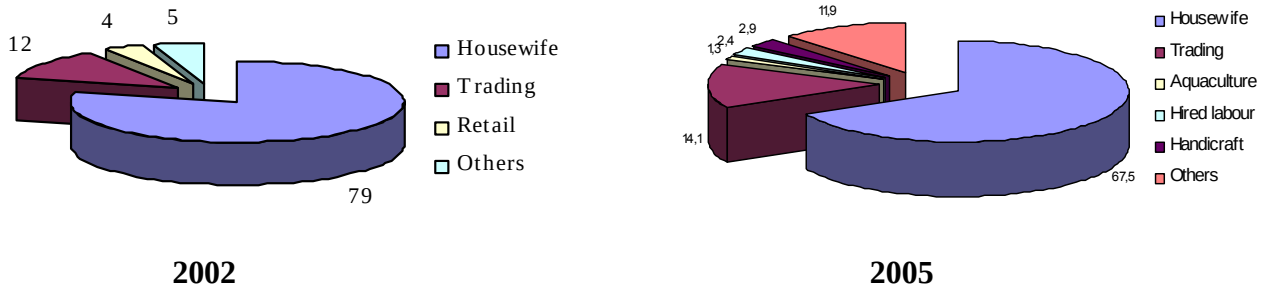

Fig. 7. The change in occupation structure of fishermen's wives (Thu et al., 2005).

Conflicts between resource users

To determine characteristics of conflicts, questions should be posed to key informants. For the case of NTB-MPA, conflicts associated to MPA creation had occurred according to the perceptions of fishermen. The fishermen said that there were conflicts between fishermen living within the MPA and fishermen coming from outside (Lan, 2009). These conflicts occurred as large vessels with modern equipment competed for fishing grounds with small vessels from the MPA area. In addition, the fishermen interviewed also stated that there were conflicts with aqua culturists over the utilisation of water areas for aquaculture.

Costs and earnings of vessels affected by NTB- MPA

The evaluation of costs and earnings of vessels affected by the MPA will provide managers with an understanding of the influence of MPA management on fishermen. Due to lack of data on costs and earnings, we used here the data on gross income per fishing day.

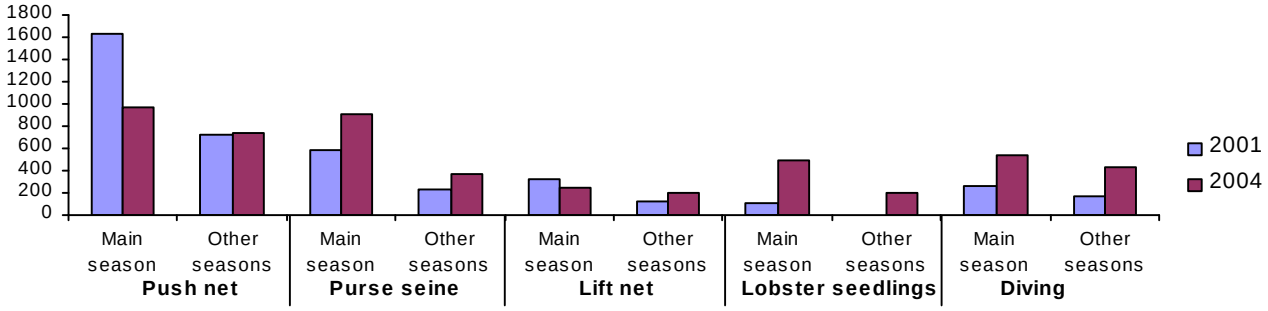

Fig. 8. Gross income per fishing day of different kinds of fishing gears (Thu et al., 2005).

Some gears such as purse seine, lobster seedlings and diving gear provided higher gross income in both peak and low seasons in 2004. Meanwhile, gross income per day from push nets and lift nets were improved in the low season, but were worse off during the main season. Even though the gross income per fishing day for some fishing gear tended to increase from 2001 to 2004, it is hard to conclude about the effect of the MPA on the earnings from vessels. The main reason for this

is that the data set here did not take into account inflation. Therefore the gross income per fishing day may increase due to the increase in price rather than the increase in catch.

In conclusion, creation of the NTB-MPA provides some socio benefits for stakeholders; however, it does not seem to have achieved conservation objectives targeted for 2005. This implies that to achieve overall goals in terms of both biological and socioeconomic perspectives, it is necessary to have better management policy and enforcement. The creation of the MPA must be put in a long-term context and there is need for an assessment of costs and benefits related to the MPA.

Discussion

The MPAs in Vietnam are often established with major objectives to conserve the biodiversity and improve livelihoods. This sounds a reasonable strategy but it is unclear whether it is viable in the short term at least for MPAs where there are a large number of local people that still depend on fishing activity. Fishing itself is also a livelihood, and often the most important one around the MPA. How to obtain sustainable fishing activity is also a concern that MPA managers should focus on. This is the reason why we add the indicator “costs and earnings of the vessels affected by MPAs” into the list of indicators that should be applied for MPA assessment in Vietnam.

Though the most important goals of MPA creation are often biologically founded, the relevant data to assess success may be expensive to gather, or require expertise that is difficult to come by in Vietnam. Social science data of fisher perceptions can, in such situations, replace or complement natural science assessments. With regards to the NTB-MPA, we see that social science indicators support the somewhat incomplete results from the natural science indicators.

The indicators applied to the NTB-MPA have provided useful information for evaluation of management effectiveness of MPAs. The decline in abundance of the fish inside the MPA and the decrease in CPUE of some fishing gears fishing around the MPA have raised the need for an appropriate management regulation and strict enforcement. However it should be also noted that benefits of MPAs take a long time to appear, from 10 to 15 years (Pomeroy et al. 2004). Four years are probably not long enough to observe the potential success of the MPA. Hence long term assessment and more comprehensive management, within the financial limitations, should be part of the plans for other MPAs in Vietnam. To have a complete picture of socioeconomic consequences of MPA implementation, one needs to compare with indicators measured outside the MPA area (which act as controls), for more overall changes not resulting from the MPA.

Evaluation works best when we understand management objectives. With each objective there will be corresponding indicators and relevant data that can be collected. The methods for collecting data and analysing indicators can also vary depending on specific situations and requirements for the evaluation process. Indicators chosen need to be cost-effective and specific enough to provide necessary information to improve management performance. The nature of the

relevant information collected may thus differ. For the biodiversity conservation objective, the abundance of (target) species should be investigated. If the objective is to improve livelihoods, the structure of income of households is important information to study. The objective of increasing fisheries benefits may be observed based on the CPUE indicator, but also from the elicitation of fisher perceptions or economic situation. Hence, ecological, economic and social indicators can provide information on the same objective.

Advice for management practice based on evaluation needs to be clear to address key issues and to provide appropriate solutions that may impact and enhance management. Both data before and after creation of MPAs thus need to be collected and recorded to explain changes over time. It should be noted that the change in the biological conditions and the socio-economic conditions may differ. While the biological condition can be directly observed from the protected area, the socio-economic conditions may require more time and effort to track. Furthermore, one needs to identify external changes that may have effects upon the MPA, such as population migrations and economic changes.

Data and information collection are important parts of good management practices. Large datasets ensure statistical significance of results and broad data sets may help to address a wider range of related issues. The output of the evaluation may thereby be more robust. From the cases presented here, it is clear that unambiguous results require data over long periods of time. Finally, it is important to adequately record the sources of the data, data strengths and weaknesses, and to ensure that source data is archived and can be referred to in subsequent evaluations.

Conclusion

A good data set will benefit the MPA effectiveness evaluation. Results of the evaluation can be used not only to highlight the progress of an MPA, but also to identify and set new priorities for future management plans. This paper suggests some indicators for MPA assessment in Vietnam that could help MPA managers evaluate their MPA in a simple way, yet still provide enough information about management effectiveness. Evaluation of management effectiveness is an important part of the management process. The results from the evaluation process provide lessons about successes and failures of management strategies and information for adaptive management as well. The success of MPAs thus depends on both the management plan and the information from the evaluation process.

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