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INFLUENCE OF MARINE PROTECTED AREAS ON FISH CATCH PRODUCTIVITY AMONG SELECTED FISHERS IN LEYTE, PHILIPPINES

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Abstract

The study aimed to examine the catch productivity of selected fishers in Leyte, both from fishing grounds nearby Marine Protected Areas (MPAs) and those far from MPAs. Descriptive analysis, nonparametric statistics, and regression analysis were the analytical tools used. Using data from 266 respondents, results showed that the average time spent per fishing day was 6.43 hours while the total travel time from the shoreline to fishing area per fishing trip was 1.41 hours. The average daily fish catch was 2.86 kg with a daily gross economic yield of PHP 476 (USD 9.46). Non-MPA fishers statistically took longer fishing days than MPA fishers. Controlling for several socio-economic variables and fishing characteristics, results of multiple regression analysis showed that fishing grounds near MPA sites have higher catch than fishing sites far from MPAs. Three regression models displayed a consistent positive influence of MPAs on fish catch rates. This outcome supports the fish spill over effect which influence high fish yield in adjacent fishing grounds to MPA sites. The results suggest for the establishment of more properly managed MPA sites to maintain healthy fish stocks and also increase catch among fishers.

Key words**:** *small scale fishers, fish spillover, rural Philippines, marine protected areas*

INTRODUCTION

Fish is a food of excellent nutritional value, providing high-quality protein and a wide variety of vitamins and minerals, including vitamins A and D, phosphorus, magnesium, selenium, and iodine in marine fish [4]. In developing countries, there are an estimated 20 to 30 million small-scale fishers. They play a vital role in contributing directly to food and livelihood security, poverty reduction, wealth creation, foreign exchange earnings and rural development [5].
The Philippines ranked among the top fish producing countries in the world [7]. The fishing industry provided employment to about one million Filipinos or around three percent of the country's labor force in 1998 [17]. There are about 1,614,000 fishers involved in municipal waters extending up to 15 km offshore, while 16,500 fishers are involved in commercial fishing operations in waters beyond 15 km [6]. It was confirmed that due to the domestic increase of pollution, abusive fishing techniques worldwide and illegal, unreported and unregulated fishing, catches have been shrinking and fish stocks are often declining at alarming rates [3]. Coastal fish resources have been overexploited [13] and there have been doubts being raised about the long-term sustainability of certain fisheries [14].
The rising of the environmental threats to the marine and coastal biodiversity had led to the creation and development of the marine protected areas (MPAs). A marine protected area (MPA) is an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources, managed through legal or other effective means [12]. It contributes to the restoration and replenishment of resources for social,

economic, and cultural enrichment [23]. MPA is essentially a space in the ocean where human activities are more strictly regulated than the surrounding waters [18]. The MPAs consist of well-delineated areas that either by decree or legislative action prohibit certain activities [22]. A well-managed MPA will increase the population size, the number of species, and the reproductive output of marine animals and plants [11]. However, there are concerns about how fishers will benefit from MPAs if these areas are off-limits [10].

Fish spillover is defined as the active movement of fish swimming out of MPAs into adjacent areas by the movement of the eggs, larvae and juvenile fishes out of protected areas [16]. To investigate the relevance of fish spill over in locally managed MPAs, this study aims to examine fishing productivity in areas near MPA and compare fish catch in areas or fishing grounds far from MPA. If fish spillover is evident, it is expected that fish catch productivity is higher in fishing grounds adjacent to a designated MPA. Thus, it is imperative to collect empirical evidence that will serve as a support to better fishing in areas adjacent to MPA. The findings of this study will be useful in helping fishers, policymakers and private sectors make informed decisions and rationally organize their resources in order to make fishing more sustainable. In addition, results of the study will add to the literature on investigating the effect of MPAs on human well-being. Rasheed (2020) shows that empirical studies that quantify the contributions of MPAs are scarce [19].

MATERIALS AND METHODS

Study site

MPAs are increasingly used to protect threatened habitats [1]. In the Philippines, there are over 1800 MPAs. To evaluate the influence of MPAs on the fish catch productivity of small scale fishers, this study covered both fishing grounds adjacent to MPAs and those which are far from MPAs (Fig.1). The municipalities with fishing grounds far to the MPAs are the municipalities of Hilongos and Albuera. On the other hand, the municipalities with fishing grounds that are near from MPAs include the municipalities of Matalom, Inopacan, and Baybay. We are using the case of Leyte to investigate the influence of marine protected areas on fish catch productivity.

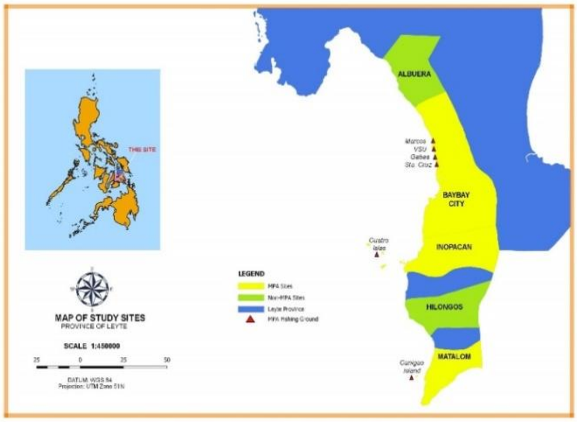

Fig. 1. Map of study sites in Leyte Island, Philippines
Source: [15].

Sample Size Determination

The sample size was estimated using a 95% confidence interval with a Z-value of 1.96. The population variance was estimated using proportions. It was assumed that the proportion is 0.5 since there is limited information available. For the margin of error, a modest 6% assumption was used. The bigger the margin of error, the lower is the sample size. The estimated sample size for the study areas was computed using Eq.1:

$$n_o = \frac{Z_{\alpha/2}^2 (p) * (1-p)}{e^2} \qquad \text{(Eq. 1)}$$

The computed number of respondents was 266.

Nonparametric Test

The Mann-Whitney U test is a nonparametric alternative to the t-test for independent samples**.** This nonparametric test does not require the population's distribution to be denoted by specific parameters. The test is mainly based on the differences in medians [21]. To determine the influence of MPA establishment using the selected fishing variables, the following hypotheses were tested:

Null hypothesis: There is no significant difference between fishing grounds distant and nearby MPAs.

Alternative Hypothesis: Fishing grounds distant from and near to MPAs vary significantly.

Empirical Model

Regression analysis was used to investigate the influence of MPAs on fish catch productivity. The dependent variable was fish catch, measured in kilograms, while the independent variables were fishing variables, a dummy variable for MPAs and other socio-economic characteristics. Three different models were postulated to examine the effect of MPA establishment on fish catch productivity. Model 1 captures the socio-economic variables. Model 2 displays the fishing variables while Model 3 is a combination of both socio-economic and fishing variables (Eq. 2). After conducting regression analysis, appropriate diagnostic tests were conducted to further evaluate the empirical results.

$$Yi = \beta_0 + \beta_1 age_i + \beta_2 married_i + \beta_3 hh\_size_i + \beta_4 heduc_i + \beta_5 spouse\_work_i + \beta_6 fishing\_hrs_i + \beta_7 boat\_own_i + \beta_8 motor\_boat_i + \beta_9 org\_member_i + \beta_{10} num\_comp_i + \beta_{11} fishing\_costs_i + \beta_{12} traveltime_i + \beta_{13} MPA_i + e_i \quad \text{(Eq. 2)}$$

where:

Y_i = captures the average daily fish catch in kilograms;

age_i = age of a fisher respondent;

$married_i$ = a dummy variable, 1 if married, 0 if non-married;

hh_size_i = number of family members in a household;

$heduc_i$ = a dummy variable that represents educational attainment, 1 if at least high school education and 0 if primary level of education;

$spouse\_work_i$ = a dummy variable that captures the employment of spouse, 1 if spouse is working and 0 otherwise;

$fishing\_hrs_i$ = total number of fishing hours;

$boat\_own_i$ = a dummy variable for the ownership of fishing boat, 1 if owned and 0 otherwise;

$motor\_boat_i$ = type of boat being used, 1 if motorized boat, 0 if non-motorized boat;

org_member_i = 1 if member in fisher's organization and 0 for non-member;

num_comp_i = number of companions in fishing activity;

$fishing\_cost_i$ = daily variable costs measured in Philippine peso (PHP);

$travel\_time_i$ = travel hours from shoreline to the fishing area;

MPA_i = a dummy variable that represents location, 1 if fishing grounds nearby MPA and 0 otherwise; and

e_i = remaining error term

RESULTS AND DISCUSSIONS

Socio-Economic Characteristics of Respondents

Table 1 shows the socio-demographic characteristics of the respondents. Results show that the youngest respondent is 15 years old and the oldest is 89 years old, with an average age of 45 years old. The majority of fishers are married (80%), with an average household size of five (5) members. More than half (52%) have attended at least a high school level of education. Thirty percent (30%) of the respondents reported that their spouse is working. The average monthly income in fishing is PHP 475.10 (USD 9.44) but their incomes were supplemented by other sources, which averagely reached up to PHP 10,477.77 (USD 208.23) in a month.

In terms of fishing related characteristics, on average, they spend 6.43 hours fishing. Half of the respondents (50%) owned the boats they used in fishing and a third of the respondents (36%) used motorized boats in fishing. About 37% of fisher-respondents were members in any organization for fishers. For fishing companions, there were eight (8) fishers, on the average, but it varies depending on fishing methods employed. Furthermore, the total daily fishing costs reached up to PHP 279.80 (USD 5.56), while the total amount of time it takes to reach the fishing area from the shoreline was 1.41 hours.

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Table 4. Descriptive statistics of the characteristics of the fishers

Variables	Mean	Min	Max
Age	45.378	15	89
Married fishers	0.8	0	1
Household size	5.03	1	13
At least high school level of education	.52	0	1
Spouse working	.3	0	1
Monthly income in fishing (in PHP)	475.10	25	1,800
Monthly income in other sources (in PHP)	10,477.77	240	84,050
Fishing hours	6.43	1	16
Boat ownership	0.5	0	1
Use of motorized boats	0.36	0	1
Membership to fishing organization	0.37	0	1
Fishing companion	8.34	0	60
Daily fishing cost	279.8	5	1,690
Time hours to fishing area	1.41	0	6
Fishing grounds nearby MPA	0.51	0	1

Source: Authors' own calculation and analysis (2020).

Comparison of Fishing Grounds Near (MPAs) and Distant from MPA (non-MPA)

The respondents adjacent to MPAs and far from MPAs were compared based on selected fishing variables using the Mann Whitney U test. Mann Whitney U test is a nonparametric alternative in comparing two independent groups when the normality of data cannot be confidently assumed. Table 2 shows the comparison of means between MPA and non-MPA using selected fishing indicators. Results show that there was no statistically significant evidence showing that non-MPA fishers allotted longer hours in fishing activity than MPA fishers. On the number of companions, it depends on the method of fishing used by fishers. There were methods that would require the involvement of several fishers, specifically haul seine (fishing method that uses long net for commercial fishing) which was mostly used in non-MPA fishing grounds. Method like hand line fishing (a technique in which a line with a hook, usually baited, is lowered into the water from a drifting, anchored or moving boat while waiting for a fish to take the bait), which was dominant in MPA fishing sites requires only a few individuals or none. In terms of net income, there is no statistical evidence showing a significant difference in net income per fishing between MPA fishers and non-MPA fishers. The fishers' income is largely dependent on the kind of fish species caught and this makes sense because different species have their corresponding prices. However, in terms of average daily catch, results show that fishing grounds in the nearby MPA had a statistically greater catch than fishing grounds distant from MPA (MPA= 3.02, non-MPA= 2.69).

Table 2. Comparison of means between MPA and non-MPA by selected fishing indicators

Variables	Non-MPA	MPA	Difference
Daily catch (kg)	2.69	3.02	0.33***
Revenue (PHP)	428.8	521.03	92.23***
Daily fishing cost (PHP)	214.84	341.90	127.06***
Travel hours from shoreline to fishing area	1.11	1.72	0.61***
Fishing days in a week	6	5	1**
Daily fishing hours	7	6	1
Companions in fishing	9	7	2
Daily net income	214.04	179.13	34.91
No of respondents	130	136	

Note: *** significant at 1%, ** significant at 5% and * significant at 10%
Source: Authors' own calculation and analysis (2020).

This result supports the claim on fish spill over effect by Friedlander (2013), Forcada et al., (2009), Di Lorenzo et al., (2020) which reflects higher fishing catch or yield in fishing grounds adjacent to marine protected areas (MPAs) compared to fishing grounds far from MPAs [9] [8] [3].

Influence of MPA establishment on fish catch productivity

To evaluate the influence of MPA on fish catch productivity, regression analysis was performed controlling for several socio-demographic variables (Table 3). With catch rates as the dependent variable and a dummy variable for MPA coded as 1 for fishing grounds adjacent to MPA and 0 otherwise as the main explanatory variables. The impact of fishing grounds adjacent to MPA was captured across the several regression models to test the consistency and robustness of estimates. Socio-economic factors were the control variables in model 1, fishing characteristics for model 2 and a combination of both socio-economic factors and fishing characteristics for model.

In model 1, a high level of education and fishing grounds nearby MPA showed to have a positive influence on catch rates, which were both significant at 5% and 10% levels, respectively. Fishers with a high level of education or at least with high school educational attainment have 48.8% higher catch than those who are not. On the other hand, fishing grounds nearby MPA have 32% higher catch than those that were far from MPAs. Other socio-economic variables such as age in years, married as civil status, household size and spouse working are not statistically significant.

For model 2, fishing hours showed a significant positive influence on the catch at a 1% level. Longer hours in fishing activity result in increasing catch rates. This result suggests that an additional hour spent fishing per day increases fish catch by 0.0828 kg. Results also indicate that the usage of motorized boats showed a positive and significant influence on catch productivity at a 10% level. This suggests that fishers who are using motorized boats have 45.5% higher fish catch compared to non-motorized boat users. The main variable, which is fishing grounds nearby MPA, is not statistically significant. However, the coefficient is positive, indicating that it correlated to increasing fish catch.

The results of model 3 combine the socio-economic characteristics with fishing variables. Of the variables included, the significant predictors of fish catch are high level of education, amount of time per fishing trip, use of motorized boats, and fishing grounds nearby MPA. Results have consistently shown that having an advanced level of education is associated with higher catch among fishers. It can be inferred that fishers with at least a high school level of education have 48.2% higher fish catch than others. This implies that possessing knowledge and information increases catch productivity. A positive relationship with fish catch was evident because people with a higher level of education are usually more aware and exposed to employing appropriate practices. Increasing hours per fishing trip posted a positive relationship with fish catch. Results showed that every additional hour per fishing trip would increase the catch by 0.0833 kg. This happens because as more time was allotted in fishing activity, there would be greater chances of obtaining abundant fish catch with a variety of species. In addition, the use of motorized boats requires the operator to possess skills specific to the type of boats they are using. Motorized boats were fishing vessels that were powered by engines. Stroke mechanics, vessel maneuvers, reading water conditions, and self-rescue were some examples of skill areas that fishers must be competent when fishing.

Table 3 shows that the use of motorized boats among fishers showed positive and significant influence to fish catch.

The fishers who were using boats powered by engines had 43.7 % higher catch than those who were using non-motorized boats.

This is because motorized boats can go beyond the reef and allow taking heavier load compared non-motorized.

On the contrary, fishers with non-motorized boats might find it harder to fish offshore, particularly in bad weather

Table 3. Influence of MPA on fish catch productivity

Variables	Model 1: Socio-economic factors	Model 2: Fishing variables	Model 3: Socio-economic and fishing variables
Age	0.00203		0.00252
	(0.00775)		(0.00763)
Married fishers	-0.0138		0.274
	(0.264)		(0.271)
Household size	0.0237		0.0207
	(0.0455)		(0.0451)
High level of education	0.488**		0.482**
	(0.199)		(0.200)
Having a working spouse	0.124		0.107
	(0.218)		(0.215)
Time spent on fishing (hours)		0.0828***	0.0833***
		(0.0277)	(0.0280)
Boat ownership		-0.108	-0.287
		(0.246)	(0.256)
Membership in a fishers' organization		0.114	0.106
		(0.210)	(0.212)
Number of companions during fishing		0.00798	0.00865
		(0.00709)	(0.00710)
Daily fishing cost		0.000316	0.000394
		(0.000352)	(0.000354)
Time travel from shoreline to fishing area		0.180*	0.171
		(0.105)	(0.105)
motorized boats		0.455*	0.437*
		(0.258)	(0.258)
Fishing grounds nearby MPA	0.320*	0.320	0.389*
	(0.199)	(0.211)	(0.217)
Constant	2.208***	1.616***	0.941*
	(0.460)	(0.331)	(0.562)
Observations	266	263	263
R-squared	0.036	0.087	0.116

Note: ***, **, * indicates significance at the 1%, 5%, and 10% levels, respectively.
Robust standard errors in parentheses. The regression models are significant at a 99% confidence level because the value of significance F was less than 0.01. Diagnostic tests further suggest that multicollinearity within predictors is not problematic and further tests showed no existing model specification problem.
Source: Authors' own calculation and analysis (2020).

The main variable of interest is the fishing grounds near marine protected areas. Results consistently show that there is a significant difference of catch between fishing grounds near MPAs and those that were far from MPAs (Table 3). Fishing grounds nearby MPA sites tend to be more abundant in terms of the fish catch than those sites that were distant from non-MPA fishing grounds. Fishers near MPAs more likely have higher catch by 38.9% than those fishing far from the MPAs. This is reasonable because fishing grounds nearby MPA sites benefited through the fish spillover effect, as hypothesized in the study. Our results are similar to what Forcada et al. (2009) reported that fish catch where significantly higher near the borders of MPAs [8]. In no-take MPAs, fishing activities were restricted/prohibited and fishes were able to mature to larger sizes and improve their reproductive output since they were left undisturbed. With this, fishes left due to overcrowding and the high competition of food and shelter. This will result in fish abundance to fishing grounds surrounding protected areas, making them available to fishers. This is an evidence of "fish spillover" where fishers benefit when fish become mature and abundant inside an MPA that some move out of the MPA where they become available to recreational and commercial fishers. The sustainability of MPAs will be beneficial to the livelihood of coastal communities who have been threatened by various adversities including climate change [20].

CONCLUSIONS

The determinants that significantly influence fisher's catch include a high level of education, amount of time per fishing trip, use of motorized boats, and fishing grounds nearby MPA. Across the three models, the fishing grounds near MPA displayed a positive influence on fish catch productivity. This provides empirical evidence of fish spillover effect, which appears to play a significant role in increased fisheries yield in adjacent unprotected areas. This outcome is in parallel to the study of Friedlander (2013), Forcada et al., (2009), Di Lorenzo et al., (2020) as empirical evidence of fish spillover where fishers benefit when mature fish move out of the protected areas where they become available to local fishers [9] [8] [3]. Thus, higher catch rates near the protected areas were more likely to occur due to this spillover effect. With these robust results, we suggest that there should be enabling policies and support from the local government units and other organizations for the establishment of more MPA sites in order to improve the overall fisheries productivity in Leyte, Philippines. Additionally, management policies to safeguard newly established MPA sites should also be implemented for sustainability. There must be institutional coordination in support of MPA establishment since the design, implementation, and monitoring of MPAs require effective institutional structures at the local level of management. According to Di Franco et al. (2020), employing good governance processes involving stakeholders may rapidly generate local support for conservation and maximize the effectiveness and enhance support towards the sustainability of marine protected areas [2]. The potential benefits of marine reserves and protected areas will not be realized without a sufficient commitment to enforcement and monitoring. It is necessary that sufficient regulatory authority and funds for enforcement, research, and monitoring be provided to implement management plans in maintaining public support for protected areas.

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