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Determination of coral reef health status using social indicators

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Abstract. The Lamawan Pony Marine Protected Area (MPA) in San Jose de Buenavista, Antique, Philippines, was created to improve marine conservation and fisheries management. The socio-cultural component of this study deployed primarily Key Informant Interviews (KIIs), Focus Group Discussions (FGDs), and face-to-face surveys in four fishing communities. Findings from the surveys revealed that the MPA status is poor due to anthropogenic impacts. The knowledge of MPA presence is high (86%); however, the local perception of MPA sustainability is low (26%), due to fishing challenges. Despite these conditions, results suggest that increasing the no-take zone area to at least 20% of the total MPA size is necessary to achieve the goals set for an MPA. The data in this study are imperative for improving sustainable fishery management in the future that balances the economic needs of its coastal populace.

Keywords: *Anthropogenic impact, MPA knowledge, MPA perception, and Lamawan MPA.*

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1. Introduction

The primary target of Sustainable Development Goal 2 of the United Nations is to secure food security through sustainable means by 2030. Adhering to this call, the Philippines, being an archipelagic country, strengthened its national laws that provided protection and management to some areas of ecological, social, and economic importance. The institutionalization of Republic Act No. 11038 authorized the local government unit to manage their local fisheries resources against unsustainable human activities through the establishment of a marine protected area (MPA) of different resources such as sea grasses, fish, corals, or both (FAO, 2022). With this, it hopes to increase biological conservation that provides integrity to ecosystem services (Hoyt, 2018), including the productivity of fishing as a livelihood source.

There are 337 MPAs in the country that cover 31,833 km^2 of the total marine waters (MPAtlas, 2022). Of these, 119 are identified as highly protected, and 217 MPAs are less protected. One of these reported protected reefs is Lamawan Pony MPA in San Jose de Buenavista, Antique, Western Panay Island, with a total core zone (no-take zone) area of 0.065 km^2 (Azcuna-Montano & Silapan, 2018). Since it was considered their "last jewel", a number of localized initiatives on coastal fisheries management were sought. Despite these efforts, an average annual decrease in coral cover was observed during reef surveys from 2008 to 2015 (Azcuna-Montano & Silapan, 2018).

The fishers' activities in an MPA-covered community like that of the Lamawan Pony are known to affect the MPA's performance on conservation and management. Although studies investigating knowledge and perception are scarce, assessing the opinions of the resource end users, in particular the fishermen, is vital for successful management. This paper attempted to determine fishermen's understanding of MPA management. The total density of fishermen was estimated to determine the extent of possible fishing pressures. Their opinions about why and how the MPA can improve the status of their marine fisheries were also assessed, including the factors influencing their perceptions over time. In particular, this research aimed to answer some

specific questions: What are their current fishing practices? Do their understandings of MPA management relate to the impact of their fishing activities on the MPA? Are there changes in the resources that the fishermen can identify? Do fishers utilize their reef fish resources sustainably now?

1.1. History of Lamawan Pony MPA

Lamawan Pony MPA is one of the 25 MPAs in the 11 coastal municipalities in the province. From 1998 to 2015, there have been five resource assessments conducted. These assessments were done by the Hayuma Foundation, the Process Foundation, and the US Peace Corps Coastal Resource Management (CRM). Though the sampling sites were different, the majority of the assessments were conducted within the four coastal communities (Barangay) where the coral reef area was situated: Barangay 4 (Pantalan), Barangay 3 (Comon), Barangay Madrangca, and Barangay Funda-Dalipe (Figure 1).

The preliminary rapid coral reef assessment data was performed by the Hayuma Foundation in Barangay Funda-Dalipe towards Barangay San Angel in 1998. The various technical studies that followed thereafter further revealed a significant decrease in hard coral cover. In 2008, hard coral cover was identified as being in fair condition (38.1%), emphasizing the importance of protecting the remaining live corals in four coastal communities. This initial recommendation led to the passage of Municipal Ordinance No. 2001, which declared the 0.672 km^2 area an MPA. The core zone (no take area zone) is located in Barangay Funda-Dalipe, known as Lamawan Pony (6.5 ha or 0.065 km^2), while the remaining area of 60.7 ha (0.607 km^2) is spread across all four communities and is considered the buffer zone that restricts hook and line (*pamunit*) and spearfishing (*pamana*) techniques within the core zone area. However, in the study of Azcuna-Montano & Silapan (2018), it was reported that the estimated total area of the MPA core zone was 0.0586 km^2.

The resources that were consistently assessed were hard coral cover and fish surveys. The coral cover for the entire Lamawan Pony MPA has decreased from 22.7% in 2010 to 15.99% in 2015 (Azcuna-Montano & Silapan, 2018). The fish densities were low at only 1.15 individuals per square meter in the 2015 assessment. Heavy sedimentation was observed smothering the corals in 2012. A high sedimentation rate of 6.5 mg cm^{-2} per day was determined in 2015 (Azcuna-Montano & Silapan, 2018).

Two coral species and one fish species listed on the IUCN Red List were observed within the MPA. These were: blue coral *Heliopora coerulea* is listed as vulnerable by the IUCN, including commercially threatened black corals observed in deeper areas and a juvenile endangered species, *Cheilinus undulatus* (Erftemeijer et al., 2012; Azcuna-Montano & Silapan, 2018).

2. Materials and Methods

2.1. Study site

This research was carried out adapting the protocol of the National Assessment of Coral Reef Environments: People and the Environment: Assessment of Reef-Fish Resiliency and Associated Livelihoods (NACRE-PEARRL). The respondents from the four MPA-covered communities (Figure 1) are composed of three groups: (1) 152 fishers, accounting for 60% of the total local fishers, were administered with semi-structured survey questionnaires; (2) five key community informants identified by community leaders as pioneer volunteers at the early stage of Lamawan Pony MPA creation; and (3) a total of 49 fishers who have been fishing for at least fifteen years for livelihood.

The interviews employed approaches such as face-to-face survey questionnaires, key informant interviews (KII), and focus group discussions (FGD) with fishermen and local leaders within the study site. The total number of fishermen was obtained from the official records of the Municipal Environment and Natural Resources Office (MENRO). The interviews were conducted by two trained local interviewers experienced in doing local surveys. To minimize biases, the interviewers were trained on delivering the survey questions prior to the interviews. KII and FGD were also conducted to validate the results from the face-to-face interview, including discussions on issues and threats confronting the fisheries. Most of the information and perceptions that were generated were about the status of coastal fisheries and other local fishery practices, which include fishing gear and resources. The size of the municipal MPA was estimated by the ArcGIS shared by the Phil-LIDAR 2 Project 7.

During the 2015 survey, fisheries information like fishing activity, knowledge, and perceptions of management were obtained. Recent updates (2016-2022) were also gathered from MENRO and the Office of the Provincial Agriculture and Fisheries Division to capture related activities, *i.e.*, implementation, monitoring, and evaluation of plans and programs for MPA management.

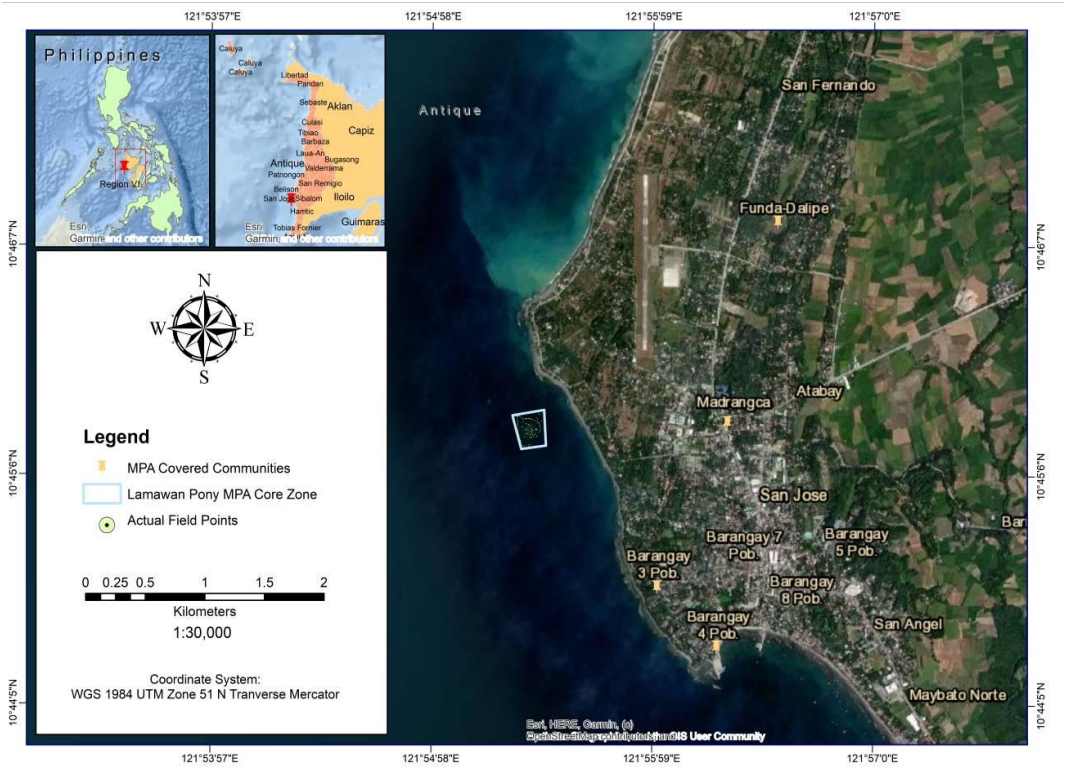

Figure 1. Site of the Lamawan Pony MPA showing the core zone boundary and the MPA-covered communities

2.2. Statistical analysis

The approach of this research is descriptive narrative, exploring the opinions of the fishermen about MPA management anchored in grounded theory. All statistical analyses like frequencies, mean, and standard deviation were processed using SPSS Windows 24.0.

3. Results and Discussion

3.1. Density of fishers

A total of 152 fishermen participated in the face-to-face interviews as respondents. All respondents identified fishing as their families' main source of food (98.7%) and livelihood (100%). The socio-demographic data of the respondents is shown in Table 1. Full-time fishermen accounted for the highest share at 60.5% and were above 40 years old (45.4%). Of the total fishers interviewed, 71.7% were married and supported an average of three children, which explains the fishers' primary need to augment income was to meet family exigencies. The survey revealed low educational attainment (71.1% elementary), suggesting the fishers' limitations in acquiring better livelihood sources. Most have been local residents in the communities since birth (84.2%) and started fishing at the age of 10-15 years old (42.1%). The migrants accounted for were 15.8% from the neighboring provinces and have been in the area for more than 10 years (86.4%) after marriage to a local (77.3%) and after considering fishing in the area as a main livelihood source (18.2%).

During the focus group discussion with long-time fishermen, the estimated total number of fishers in the four coastal communities was 279 (9.11% of the total household), where full-time and part-time fishers were 153 and 126, respectively. Among the four coastal communities, Funda-dalipe has the highest population (39% of fishers), while Barangay 3 has the smallest fisher population (14%). Considering Lamawan Pony MPA as the only fishing ground, the total density of fishers (number of fishers per km^2 of the fishing ground) was estimated to be 415.18 fishers per km^2, suggesting a dense fisher population. This further implied that there might be competition among fishermen in both fishing grounds and target fisheries. The human population is considered low fishing pressure if it is sparse at 23 individuals per km^2 of reef habitat and populous at 65 individuals per km^2 of reef habitat at a 3% growth rate (Aswani, 2006). This finding is consistent with that of Newton et al.

(2007), where the Philippines' reef fisheries were assessed to be overexploited due to a high coastal fishing population and high fishing pressure. As reported by Teh et al. (2013), the fisher density levels in the Philippines are above 21.8 fishers per km^2 of fishing ground, thus indicating high fishing pressure.

Table 1. Socio-demographic data of respondents in Lamawan Pony MPA communities

MPA Barangays/	**Funda-Dalipe** (n=84)		**Madrangca** (n=35)		**Barangay 3** (n=17)		**Barangay 4** (n=16)		**Total (n=152)**	
	Freq	%	Freq	%	Freq	%	Freq	%	**Mean**	**%**
Type of fisher										
Full-time	43	51.2	26	74.3	15	88.2	8	50.0	**92**	**60.5**
Part-time	41	48.8	9	25.7	2	11.8	8	50.0	**60**	**39.5**
Age										
15-20	0	0.0	2	5.7	0	0.0	0.0	0.0	**2**	**1.3**
21-25	8	9.5	6	17.1	4	23.5	0.0	0.0	**18**	**11.8**
26-30	12	14.3	4	11.4	0	0.0	0.0	0.0	**16**	**10.5**
31-35	14	16.7	5	14.3	5	29.4	1	6.3	**25**	**16.4**
35-40	15	17.9	2	5.7	0	0.0	4	25.0	**21**	**13.8**
40+	35	41.7	16	45.7	8	47.1	10	62.5	**69**	**45.4**
Marital status										
Single	9	10.7	19	54.3	7	41.2	4	25.0	**39**	**25.7**
Married	72	85.7	16	45.7	10	58.8	11	68.8	**109**	**71.7**
Separated/widow	3	3.6	0	0.0	0	0.0	2	12.5	**5**	**3.3**
Number of children										
0	4	4.8	13	37.1	2	11.8	5	31.3	**24**	**15.8**
1 to 3	46	54.8	10	28.6	9	52.9	6	37.5	**71**	**46.7**
4 to 6	29	34.5	11	31.4	6	35.3	3	18.8	**49**	**32.2**
7 above	11	13.1	1	2.9	0	0.0	2	12.5	**14**	**9.2**
Education										
None	3	3.6	6	17.1	0	0.0	0.0	**9**	**5.9**	
Under high school	70	83.3	14	40.0	14	82.4	10	62.5	**108**	**71.1**
High school graduate	10	11.9	12	34.3	2	11.8	5	31.3	**29**	**19.1**
Vocational	0	0.0	2	5.7	1	5.9	0	0.0	**3**	**2.0**
College level	1	1.2	1	2.9	0	0.0	1	6.3	**3**	**2.0**
College graduate	0	0.0	0	0.0	0	0.0	0	0.0	**0**	**0.0**
Resident since birth										
Yes	70	83.3	29	82.9	17	100.0	12	75.0	**128**	**84.2**
No	14	16.7	6	17.1	0	0.0	4	25.0	**24**	**15.8**
Age started fishing										
Below 10	0	0.0	1	2.9	1	5.9	0	0.0	**2**	**1.3**
10 to 15	29	34.5	20	57.1	8	47.1	7	43.8	**64**	**42.1**
16 to 20	35	41.7	7	20.0	6	35.3	6	37.5	**54**	**35.5**
21 to 25	10	11.9	4	11.4	1	5.9	1	6.3	**16**	**10.5**
26 to 30	6	7.1	2	5.7	1	5.9	1	6.3	**10**	**6.6**
30+	4	4.8	1	2.9	0	0.0	1	6.3	**6**	**3.9**
Has other source of income										
Yes	43	51.2	7	20.0	2	11.8	13	81.3	**65**	**42.8**
No	41	48.8	18	51.4	15	88.2	3	18.8	**77**	**50.7**

3.2. What are the current fishing practices in Lamawan Pony MPA?

There are twelve fishing practices that fishermen have identified in Lamawan Pony. These are *pangtaga* (hook fishing), *pangdilis* (net for anchovy fishing), *pamukot* (surface gill net), *pamimilya* (fry gathering), *pamunit* (simple hook and line), *balidawan* (shark oil fishing), *pamana* (manual spear fishing/harpoon), *padamag* (use of light, raft and coconut fronds to attract fish), *panginhas* (gleaning), *pamintol* (use of baskets, traps or pots), *pamalaran* (fishers go fishing from four o'clock in the afternoon to five o'clock in the morning using of hooks, nylon and nets), *biray* (fluvial parade in honor of patron) and *kutsitsa* (people helping fishers to remove fish catch from nets and be given fish in return due to catch abundance). Natural factors that determine fishing activities are the *amihan* (northeast monsoon), *habagat* (southwest monsoon), and *bagyo* (typhoon).

Overall, there are twelve different gear types that fishermen use in the four coastal Lamawan Pony communities in their fishing activities. These are manual spears or harpoons *(pana),* spears with lights *(sulo),* bottomset gill nets *(pukot), screen/rison* (fine nets used to catch anchovies and squids), hooks *(taga),* hooks and lines *(kawil),* multiple hooks and lines *(kristalet),* long lines *(labay),* cast nets *(laya),* skimming nets (motorized *buldos*), crab lift nets (*bintol*), and moored rafts (*balsa/payaw*). The five most common fishing gears used are *pana*, *sulo*, *pukot*, screen, and *taga*. Among the communities, fishers in Funda-dalipe have the highest number of fishing gears used (11) for food and livelihood, while Barangay 3 has the least number of fishing gear types used (4).

Of the total respondents, 46.7% (71 fishers) are reef fishers, and 53.3% are pelagic fishers. Out of the 71 coral reef fishers, 27.6% used manual spears or harpoons as their main fishing gear, while the remaining 72.4% used other fishing gear, such as hooks and simple hook and line (Table 2). Among the four communities, results showed that the highest number of reef fishers was from Barangay Funda-Dalipe and the fewest were from Barangay 3.

Table 2. Summary of common fishing gear used in all communities

Type of Gear	Percentage (%)
Hook and line	84.2
Drift gill net	27.6
Manual spears	27.6
Bottom-set gill net	19.1
Basnig (bag net)	20.4
Jig (squid/octopus)	11.2
Others	5.4

The fishing gears commonly used by fishermen are categorized as active and passive gears based on their movement or absence when capturing target species. Two (drift gill nets and manual spears) are classified as active gears, while the rest of the gears identified are passive ones since the target species are the ones moving towards the gear (Balisco et al., 2019). The variability of the use of the fishing gear as well as that of the fishing practices to capture target species could be due to different monsoon seasons (Padios et al., 2017) in the locality.

There are several studies that document the damage that fishing activities using fishing gear cause to vulnerable habitats, including MPAs. Based on conservationists distinctions of fishing gear with negative environmental impact on a coral reef, trawling nets, harpoons or manual spears, gill nets, and small and fine mesh nets are considered destructive (Raycraft, 2019). Inside the MPA, trawling nets and manual spears are restricted, while gill nets and small and fine mesh nets are regulated based on mesh size, usage, geographic location, and licensing (Silva, 2006). While many fishers in Lamawan Pony MPA are compliant with gear restrictions, illegal fishing activities such as the use of bottom-set gill nets within the MPA core zone (Figure 2) still exist.

3.3. How is the fishers' understanding and perception of MPA fishing activities linked to MPA management?

The sustainability of fishery development is primarily determined by social dimensions. This includes the understanding of fishers about the management of the MPA and the possible effect of their fishing practices on the MPA. The outcomes of the survey on knowledge about the existence of Lamawan Pony MPA are presented in Table 3.

The fishermen in Lamawan Pony MPA communities reported being familiar with the MPA's presence. Of the total respondents, a high proportion (86%) said that their knowledge of its existence was due to the installed flags and buoys as

markers and through the information of community and local officials, while 14% said they had no idea. Respondent fishers were well aware of the restricted zones in the area. Most of them said that despite the restrictions, they continued doing otherwise due to slack implementation of the marine fishery laws and ordinances. Despite the communities' high awareness of its presence, not a single respondent knew exactly the name, location, or even the total number of MPAs present in their areas. These responses revealed poor MPA knowledge on the part of the respondent fishers in the communities. The local support for MPA sustainability is also not evident. Other than the lack of government assistance to the fishers, the primary reason for the fishers' seemingly conditional support (42%) is their insufficient knowledge of the importance of MPA and its encompassing benefits to the ecosystem. Time is acknowledged as a need to obtain improved knowledge on the MPA's management plan, rules, and zoning (Pita et al., 2020). Since the MPA's establishment in 2001, poor MPA knowledge on the part of the fishermen may have led to MPA deactivation, whose causes include a lack of sustainable financial systems, mismanagement, and a lack of political and community support (Maypa et al., 2012).

Table 3. Knowledge of fisher-respondents about Lamawan Pony MPA (n=152).

Barangay	No of MPA	Name of MPA	MPA Location	Year known	Are there still fishers inside the core zone?
Funda-Dalipe	1 (89%)		Dalipe	2003	Yes
	4 (1%)	MPA/Sanctuary	Dalipe, Barangay 3, Barangay 4, Madrangca	No idea	Yes
	No idea (5%)	No idea	No idea	No idea	Yes
Madrangca	1 (100%)	MPA	Funda-Dalipe	2004	Yes
Barangay 3	0 (18%)	No idea	No idea	No idea	Yes
	1 (41%)	Lamawan	Funda-Dalipe	2005	Yes
	Uncertain (18%)	No idea	Between Dalipe Madrangca	No idea	Yes
Barangay 4	1 (31%)	MPA/Lamawan Pony	Dalipe Madrangca	2002	Yes
	2 (13%)	MPA	Maybato	No idea	Yes
	3 (12%)	MPA	Barangay 3	No idea	Yes
	Uncertain (44%)	No idea	San Fernando	No idea	Yes

The survey further showed that human impacts are the main causes of the decline in marine fisheries (Table 4). A considerable proportion of the fishers being interviewed said that, so far, the income from fishing was able to sustain the family's daily needs (75.7%), although changes were evident in terms of the amount of fish caught (94.7%) and the kinds of fish caught (94.7%). It was also perceived that the high competition brought by commercial fishing boats ranks highest (81.6%) for its negative consequences. Also, other perceived causes of change were the increasing population of fishermen (74.3%), the ineffective implementation of fishery laws and ordinances (41.4%), and the illegal entry of fishermen from other municipalities (40.1%).

Three suggested solutions that they believe can increase or maintain a high fish catch with the highest percentage were: (a) the creation of ordinances that limit the size of fish catch and kinds that are of good market value; (b) the prohibition of commercial fishing, especially purse seines; and (c) the appropriate implementation of fishery laws. It is worth noting that during the survey period; fishermen were caught fishing inside the MPA core zone. These observations are relevant, especially since MPAs are anticipated to have a positive impact on fishing more so than on conservation or area management (Pita et al., 2020). Since local people are one of the key drivers of MPA success, participatory approaches to co-managing the marine conservation sites (Trinh & Brown, 2008) can be one of the interventions.

Table 4. Perception of fisheries status in the communities within Lamawan Pony MPA

	Funda-Dalipe n=84	Madrangca n=35	Barangay 3 n=17	Barangay 4 n=16	Total n=152
	Freq (%)	Freq (%)	Freq (%)	Freq (%)	Freq (%)
Income of fishing					
Good (able to send children to college)	0.0	0.0	5.9	0.0	0.7
Enough to sustain daily needs	83.8	94.3	70.6	6.3	75.7
Not enough for daily needs (needs other income source)	17.9	8.6	23.5	87.5	23.7
Was there change/s on fishery status since first fishing activity?					
Yes	95.2	97.1	94.1	81.3	94.1
None	4.8	2.9	5.9	12.5	5.3
If yes, are there changes in the amount of fish catch?					
Lower catch	95.2	100.0	94.1	81.3	94.7
Higher catch	0.0	0.0	5.9	0.0	0.7
Was there a change in the kinds of fish catch?					
Decreasing catch	95.2	97.1	100.0	81.3	94.7
Increasing catch	0.0	2.9	0.0	0.0	0.7
Why do you think the changes occurred?					
High competition due to commercial fishing boats	89.3	88.6	29.4	81.3	81.6
Illegal entry of illegal fishers	39.3	57.1	41.2	6.3	40.1
Ineffective implementation of fishery laws/ordinances	65.5	22.9	0.0	0.0	41.4
Too many fishers (overfishing)	91.7	71.4	29.4	37.5	74.3
Others (illegal means of fishing)	1.2	0.0	0.0	0.0	0.7

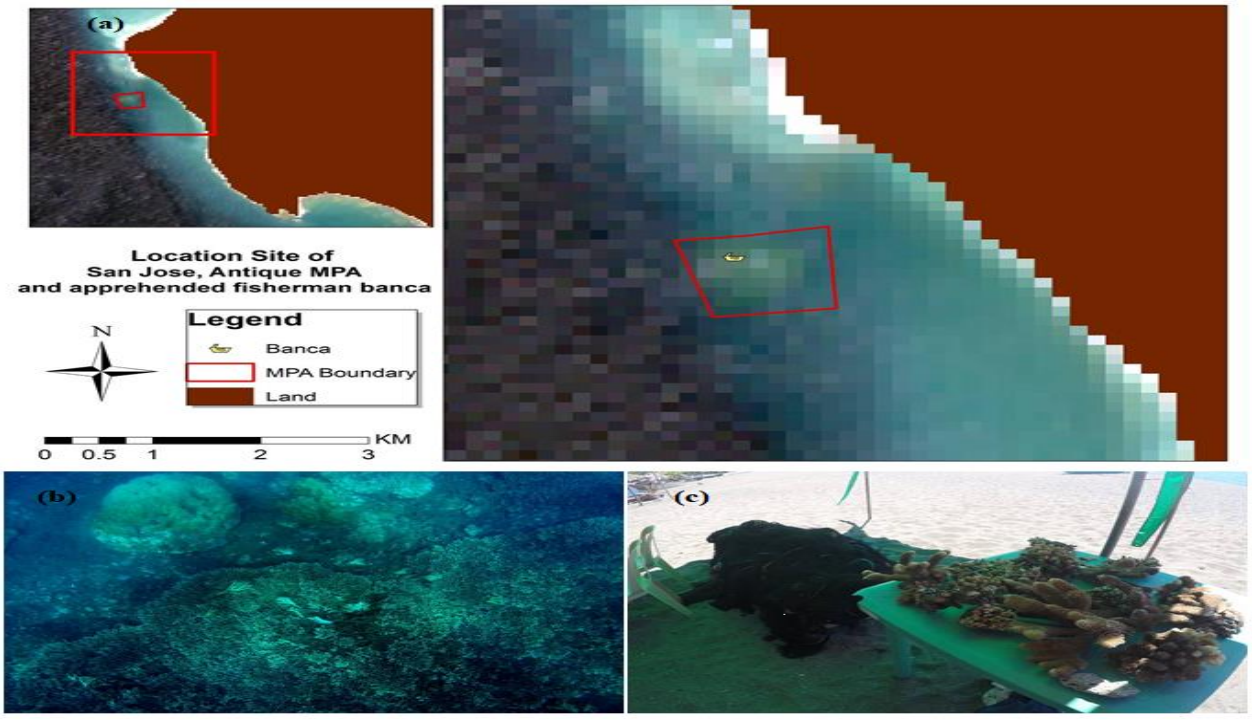

Figure 2. Illegal activities apprehended within the Lamawan Pony MPA core zone: (a) the location site of the boat; (b) underwater photos of the alleged accidental dredging that occurred; and (c) the confiscated fishing nets by the representatives of the Municipal Environment and Natural Office of San Jose de Buenavista.

3.4. Do fishers utilize their reef fish resources sustainably now?

The core zone, or no-take zone, of every MPA plays a vital role in promoting the health of the coral reef. The delineation of the Lamawan Pony MPA core zone was estimated at 0.0586 km^2 (Azcuna-Montano & Silapan, 2018). This showed a difference of 0.004 km^2 as compared to the municipality's previous estimate, which was 0.062 km^2. This might be attributed to the movement of the markers due to wave action, which was the basis for reassessing the delineation.

More than the core zone area; the determination of the size of the core zone should also consider the condition of fisheries management in the area (Dalby & Sorensen, 2002). The declared 0.062 km^2 Lamawan Pony core zone is 9.25% of the total MPA area, revealing the challenges in resource management both inside and outside the MPA as the impact on the communities in the reef is size-dependent (Dalby & Sorensen, 2002). The 2023 monitoring of local fisheries in the province reported that San Jose de Buenavista created a project called fisherfolk settlement site development in 2017. A fish port was also constructed along the coastal zones of the municipality in 2020. While there was a reef assessment done in 2021, no recent survey was conducted with regards to the fishers' knowledge, practices, and perceptions about the MPA. If resource management is poor outside the MPA, the core zone should be increased to a minimum of 20% of the total MPA area to ensure effective conservation of fish stocks (Dalby & Sorensen, 2002). Similarly, other studies of MPAs in the Philippines suggested large MPA size requirements, e.g., 20% in Calauag Bay, 55% in Tayabas Bay (Licuanan et al., 2008), 77% in Lingayen Gulf, 38% in Sogod Bay, 23% in Ormoc Bay, 80% in Sapian Bay, 41% in Sapian Bay, 41% in Davao Gulf (SuPFA, 2006), and 56% of the municipal waters (Muallil et al., 2012).

4. Conclusions

The fishermen's density of reef habitat likely has an effect on the poor MPA condition. The poor local perception of MPA sustainability could be due to the fishers' experiences with challenges such as overfishing, destructive fishing practices, poor law enforcement, and weak government support for fishers. The communities' limited knowledge of the MPA's functionality, their limited opportunities for supplemental and alternative livelihoods, and the need to augment family income beyond subsistence level became compelling reasons to support poorly the protection and conservation endeavors of the government. There are several strategies reported that can improve the fishery conditions in an established MPA. This includes reducing the overall number of fishermen by expanding fishing options outside of fisheries, stepping up enforcement of laws prohibiting destructive and unsustainable fishing methods, including gear-based management, and communicating the results of local knowledge, perception, and practices to the stakeholders in Lamawan Pony MPA.

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