BIODIVERSITY AND UTILIZATION STATUS OF GASTROPODS IN THE SEAGRASS BEDS OF PIT-OS FISH CORAL SANCTUARY AND ITS ADJACENT GLEANING GROUNDS IN MURCIELAGOS BAY

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Abstract

Gastropod gleaning is one of the main activities that locals living in coastal areas practice since time immemorial. This study determined the biodiversity, utilization and conservation status of gastropods in the seagrass beds of Pit-os Fish Coral Sanctuary and its adjacent gleaning grounds in Murcielagos Bay. Moreover, it evaluated the health and performance of the said MPA. Two sampling sites were identified, within MPA and its adjacent gleaning ground. In each site, 30 replicates of quadrats with 1 x 1 m² in dimension were randomly laid and the gastropods found were identified and counted. The seagrass and the overall substrate of the area was also assessed. Data showed 14 gastropod species inside and only 12 species outside the sanctuary. These species belong to eight (8) gastropod families namely; Cassidae, Cerithiidae, Conidae, Cypraeidae, Mitridae, Strombidae, Tegulidae and Turbinellidae. Diversity is low in both areas. T-test showed no significant difference with t-value of 1.19 and p-value of 0.24. However, it was clearly shown that protection on gastropods enabled a higher density on every species found inside the MPA. Mann-Whitney U test was used on abundant species and only the Conomurex luhuanus, locally known as "liswi", exhibited the spillover effect. Most of the gastropod species found are under the status of "not evaluated" except the species from family Conidae that are all "least concern" according to the International Union for Conservation of Nature (IUCN). In addition, this study affirms the effectiveness of MPA on some of the gastropod species evaluated but further research is needed on gastropod where initial status before protection is known and the recovery rate of gastropods is identified to understand species-specific requirements so that all species can benefit completely from MPA protection.

Keywords: *gastropods, gleaning, sanctuary, spillover, coastal areas*

Introduction

The ocean is an essential component of life on Earth. It is rich in biodiversity, provides vital food supplies, and serves as a major carbon sink (Sala et al., 2021). Humans have relied on the sea for food since long before recorded history. When civilization came to exist and ways of life came to evolve, their use is no longer limited for source of food consumption but of income like tourism among others as well. Being the largest ecosystem on earth, the role and significance of marine environment remains insurmountable.

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In the Philippines, bays and coastal waterways cover 266,000 km² whereas oceanic waters comprise 1,934,000 km². The coastline stretches over 36,289 kilometers. Around 60% of the entire population lives in these coastal cities and communities. (Philippines: Environment Monitor, 2003) As a result, fisheries play a significant part in the economic and social fabric of the Philippines (Palomares and Pauly, 2014).

Seagrass is a productive ecosystem in the shallow marine environment that plays an important role in marine life. These are a coastal ecosystem of ecological importance and often support a high level of biodiversity (Short T et al., 2007). It provides conditions for the growth and abundance of invertebrates and fish that many local coastal communities collect and catch for their livelihood (Japar Sidik et al., 1999). The presence of seagrass in coastal regions contributes significantly to the nutritional fertility of coastal waters and the marine environment. They serve as primary producers, nutrient recyclers, bottom water stabilizers, sediment traps, and erosion barriers (Tomascik et.al, 1997).

Invertebrate gleaning plays an important role in providing food and income to coastal communities. It is one common but often overlooked category of small-scale fisheries. Invertebrate gleaning is a popular fishing method to collect invertebrates in many intertidal coastal areas and in tropical regions it is usually conducted in reef flats, mangroves and seagrass meadows (Furkon et al., 2019). Gleaning for edible invertebrates in the Philippines on shallow reef flats is a chronic activity mainly for subsistence but also for supplemental family income (De Guzman et al., 2019).

Gastropods, or snails (Class Gastropoda), are asymmetrical molluscs that underwent torsion belonging to phylum Mollusca (Baharuddin et al., 2018). It is one of the most varied and speciose animal families, accounting for more than half of all identified mollusks. Gastropods eat very small organisms. The majorities of them scrape or brush particles off of rocks, seaweeds, stationary animals, and other objects. Gastropods use a radula, a hard plate with teeth, to feed (Leal 2022).

The importance of marine gastropods in the economy has grown over time and cannot be overlooked. The locals used it for food, ornaments, and a source of income (Tabugo et al., 2013). However, regardless of how abundant they are, marine fauna, including gastropods, are vulnerable to a variety of threats such as marine pollution as a result of increasing anthropogenic activities. Literature stated that the human activities have increased the biodiversity extinction rates to 1,000-10,000 times of their natural rates (Lovejoy 1997).

Marine protected areas (MPAs) are conservation tools that have proven to be beneficial in recovering and conserving fisheries inside the MPA (Maypa, 2012). Moreover, Russ et al. (2004) states that marine reserves are thought to contribute to the sustainability of external fisheries by becoming net exporters of adults (the "spillover effect") and propagules (the "recruitment effect"). Marine protected areas (MPAs) have remained one of the most powerful marine management tools used worldwide for conserving species and habitats, maintaining ecosystem functioning, and ensuring sustainable use of marine resources (Agardy et al., 2011).

A study on no-take marine reserves (NTMRs) viability was conducted by numerous researchers throughout the globe to test its effectiveness in restoring and maintaining the biodiversity and ecosystems inside them as well as improving the biodiversity outside its boundaries through spillover and recruitment effect. One of these researches is a study on 2011 by Russ and Alcala wherein two Philippine no-take reserves were investigated and data were collected to test if NTMRs can "enhance species richness and complexity beyond their boundaries" overtime. The study provided us evidences and a positive result on exportation of adults "spillover effect" and on exportation of propagules "recruitment effect" through a time span of 14 and 25 years with a fourfold and 11-fold of increased fishery, respectively. Overtime, the benefits brought by NTMRs no longer remain a theory but has been established and realized.

Pit-os Marine Sanctuary in Nasipang, Rizal is a 74.2 ha coral reef area that was established on 2002 pursuant to Municipal Ordinance No. 2002-07. It was originally a seagrass bed (42.85 ha) but was relocated toward the reef edge, stretching approximately 1.4 km running parallel to the reef edge and covering a portion of the channels (Regional Fisheries Livelihoods Programme: Philippines Baseline Study, 2011). In 2007, the said sanctuary has been renamed into Pit-os Fish Coral Sanctuary with an area of 70.24 hectares located at the mouth of Rizal-Murcielagos Bay pursuant to the Municipal Ordinance No.2007-03 (Revised Municipal Fisheries of 2014). It houses a diverse marine life including the marine invertebrate gastropods.

The significance of Pit-os Fish Coral Sanctuary to the community of Nasipang, Rizal is vital especially that it is where gastropods are abundant. These gastropods then serve as their source of livelihood. Therefore, assessment of the biodiversity, utilization and conservation of gastropods in the seagrass beds of the sanctuary and its adjacent gleaning grounds was the objective of this study. Specifically, this study determined the: 1) diversity and abundance of gastropods and seagrass in the Pit-os Fish Coral Sanctuary and the adjacent gleaning grounds, 2) the effects of the protection of gastropods done by the locals through the establishment of marine sanctuary and, 3) how it was utilized by the local gleaners.

Theoretical/ Conceptual Framework

This study is anchored on the scientific evidences by Russ and Alcala (2011) which states that no-take marine reserves can help to reverse the decline of marine ecosystems and biodiversity and that the spillover of species richness and community complexity reveals a significant advantage of biodiversity and ecosystem export from reserves. The said study which focused on reef fishes spillover and recruitment effect was being applied in the case of marine gastropods.

Gastropod gleaning is one of the main activities that locals living in coastal areas practice. Just like fishing, it serves both as a food and income source in coastal communities. The concept of assessing Gastropods species within and ouside MPA where both locations have the same seagrass beds (%) cover is to know the biodiversity, utilization and conservation status of gastropods in the seagrass beds of Pit-os Fish Coral Sanctuary and its adjacent gleaning grounds in Murcielagos Bay. By assessing the diversity and abundance of this mollusc, the health of the MPA was checked in terms of the status of gastropods in the seagrass beds of the bay within and outside the protected area. Moreover, the utilization of gastropods was assessed to know how valuable these mollusks are for the local gleaners. A conservation status for each gastropod species being present in the area was evaluated according to the IUCN conservation status to determine how likely these species exist in the present times as well as in the future.

Ensuring biodiversity is ensuring the longetivity of life for mankind and Earth as a whole. Biodiversity is an essential component to make sure of the survival of every species in a longer run. According to Rawat and Agarwal (2015), "we rely on biodiversity for the air we breathe, the food we eat, and the water we drink... Biodiversity conservation is about preserving life on Earth in all of its forms and keeping natural ecosystems functional and healthy. This includes the protection, maintenance, long-term usage, rehabilitation, and promotion of biological diversity components... To ensure intra and intergenerational equity, it is important to conserve biodiversity."

Baharuddin and Zakaria (2018) tells us that despite the fact that molluscs have one of the widest and most diverse distributions, they have the most seriously affected extinction according to the data in 2016 in the International Union for Conservation Nature (IUCN) Red Lists third issue, where 297 out of 744 species were listed as extinct (Cowie et al 2017). This would make us see the gap that needs to be focused on for research studies amidst their seemingly unregarded significance.

Evaluating the biodiversity status of gastropods in the seagrass beds of Pit-os Fish Coral Sanctuary and its adjacent gleaning grounds in Murcielagos Bay is important since it serves as an equalizer in the marine ecosystem. Aside from its economic importance, Fortunato (2016) states that molluscs play a crucial role in ecosystem engineering, helping to shape aquatic bottom ecosystems while also providing habitat, protection, and food for a variety of other species. Molluscs have traditionally been significant to humans in a variety of ways, and they are now a globally important economic group. They can give valuable information on previous climatic events and oceanic shifts as large calcareous creatures with a substantial fossil record, therefore boosting our understanding of expected future changes.

A comprehensive research study on the diversity and abundance of gastropods in the seagrass beds of Pit-os Fish Coral Sanctuary and its adjacent gleaning grounds in Murcielagos Bay is necessary to provide us biodiversity information status of mollusc in the area as well as the biodiversity status of the MPA and its overall health. An interview on utilization status was also conducted to determine how widely gleaned gastropods are and how useful they are to the locals. This will strengthen resource protection on marine environment and will raise awareness for global conservation in addressing threats of the ocean. Periodic assessment is also encourage to better take into account the judgments of information that was made based on gathered facts for further evaluation.

The result gives us a better reason in making sure that these species will continually thrive considering the fact that residents in coastal communities utilizes them for food consumption and as a source of income. Even though invertebrate gleaning seems like a "forgotten fishery" and data on this activity is scarce (Furkon *et al.,* 2019), the existence of climate change and increasing consumption of fish that continually threatens the wild fisheries will give us a driving force that shall push us to make further efforts in protecting and ensuring the continuity of existence on every marine life. With this same reason, a conservation status using the IUCN was provided on every gastropod species found in the sampling site.

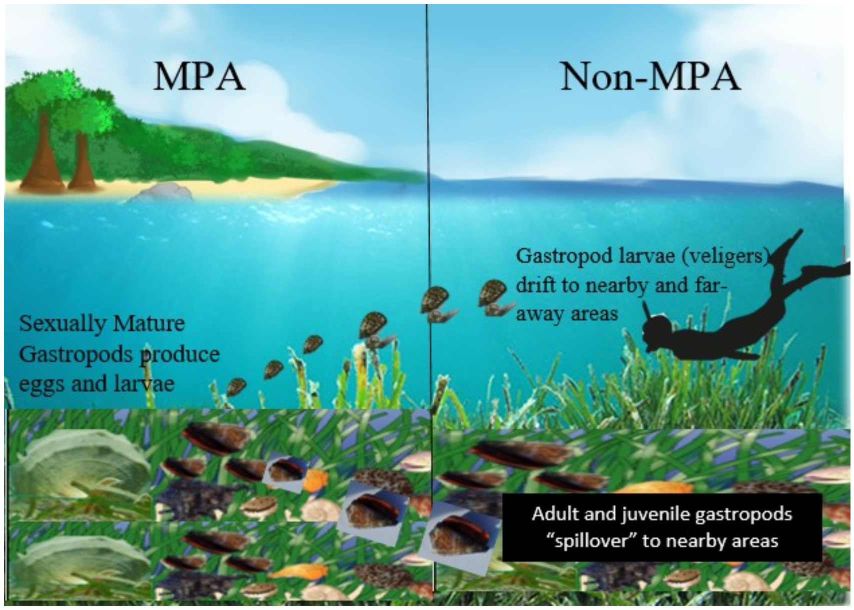


Figure 1. *Conceptual Framework of the Study*

This study evolves around the concept of spillover effect brought by MPAs. A study on 2011 by Russ and Alcala wherein two Philippine no-take reserves were investigated and data were collected to test if NTMRs can "enhance species richness and complexity beyond their boundaries" overtime. The study provided us evidences and a positive result on exportation of adults "spillover effect" and on exportation of propagules "recruitment effect" through a time span of 14 and 25 years with a fourfold and 11-fold of increased fishery, respectively.

Method

This study was conducted in the seagrass beds of Pit-os Fish Coral Sanctuary and its adjacent gleaning grounds in Murcielagos Bay which is situated in the Municipality of Rizal, Zamboanga del Norte. The Pit-os Fish Coral Sanctuary has an approximate geographical coordinate of 8º39'17 N, 123º23'31 E while its adjacent gleaning grounds in Murcielagos Bay where the non-protected area data was collected has an approximate geographical coordinate of 8º35'47" N, 123º35'10" E.

The Municipality of Rizal is at the eastern part of Zamboanga del Norte. With a population density of 168 per km2, it comprises 22 barangays, six of which are coastal. The population density of smaller coastal barangays is often greater. This municipality is a fifth-class municipality that is largely urban. (Regional Fisheries Livelihoods Programme: Philippines Baseline Study, 2011)

Pit-os Marine Sanctuary in Nasipang, Rizal is a 74.2 ha coral reef area that was established on 2002 pursuant to Municipal Ordinance No. 2002-07. Pit-os Sanctuary was originally a seagrass bed (42.85 ha) but was relocated toward the reef edge, stretching approximately 1.4 km running parallel to the reef edge and covering a portion of the channels (Regional Fisheries Livelihoods Programme: Philippines Baseline Study, 2011). In 2007, the Pit-os Marine Sanctuary has been renamed into Pit-os Fish Coral Sanctuary with an area of 70.24 hectares located at the mouth of Rizal-Murcielagos Bay pursuant to the Municipal Ordinance No.2007-03 (Revised Municipal Fisheries of 2014). It houses a diverse marine life including the marine invertebrate gastropods.

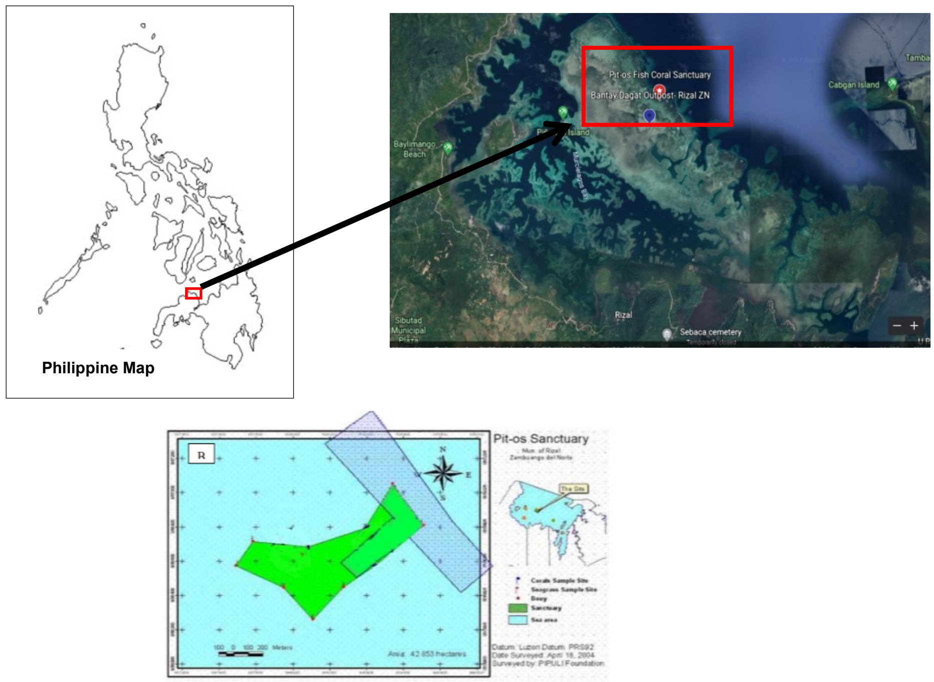


Figure 2. *A. The geographic location of the site map indicating the location of the present Pit-os Fish-Coral Sanctuary and the Bantay Dagat Outpost of Rizal,Zamboanga del Norte (Source: Google Earth). B. The old Pit-os sanctuary (green) and the new Pit-os Fish Coral Sanctuary (blue) (Source: Uy, 2006).*

Shown in the figure is the geographic location of the site map indicating the location of the present Pit-os Fish Coral Sanctuary and the Bantay Dagat Outpost of Rizal, Zamboanga del Norte where the researcher stayed for the whole duration of the study. It is at the mouth of the bay and is only accessible by boats. It is also the part of the bay that directly received waves from the open ocean. In fig. 2b, the change of location of the old sanctuary to the new one was given emphasis. This transition could be seen visibly on the green color representing the old sanctuary that is mostly composed of seagrass and the blue color representing the new sanctuary where it mainly focused in protecting the coral reef present in the area.

The two sites were established as sampling sites. The first site is within the seagrass beds of Pit-os Fish-Coral Sanctuary where protection of the marine environment is uphold and the second site is 50 meters away outside the sanctuary where the seagrass % cover and the benthic habitat as whole is as similar as possible to the reserve itself. In each site, 30 replicates of quadrats with 1 x 1 m^2 in dimension with 16 inner quadrats of 0.25 x 0.25 m^2 were randomly laid and the gastropods found were identified and counted. The seagrass and the substrate of the area were also surveyed.

Data Collection Procedure

A request of endorsement and approval was initially sought upon by the researcher from the research adviser to conduct the study. Right after the approval, the researcher then went about obtaining information. Formal letters were sent by the researcher to the Mayor of the Municipality of Rizal and a Bantay Dagat was then made available to accompany the researcher in the study site.

A reconnaissance assessment was conducted in Murcielagos Bay to determine if the location is suitable for the study. During this phase, preliminary data such as the physical environment and the history of the marine protected areas present in the bay was obtained. After that, a pilot research was undertaken in chosen regions within and outside the sanctuary where seagrass beds could be discovered to eliminate the marine environment factor that may affect the variation of gastropod diversity and abundance. This allowed the researcher to have a better picture of the situation and chose the Pit-os Fish-Coral Sanctuary as the final study site because it best suit to achieve the goal of the study.

Seagrass Cover Survey

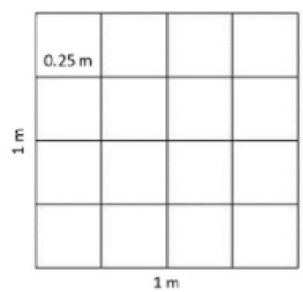


Figure 3. *A 1 x 1 m² in dimension quadrat with 16 inner quadrats of 0.25 x 0.25 m²*

A 1 x 1 m² quadrat with 16 inner quadrats of 0.25 x 0.25 m² was randomly laid within Pit-os Fish Coral Sanctuary and its adjacent ground in Murcielagos Bay. There were 30 quadrat replicates on each site and coordinates were obtained to mark the location. Seagrasses present were identified and captured using an underwater camera for verification and documentation purposes. Subquadrats with seagrass were then counted as well as the other substrate like sand and rubbles were taken into account. Percent cover on seagrass and the whole substrate were calculated.

Gastropod Survey

In obtaining the biodiversity status of gastropods, sampling was carried during the lowest tide possible on the sampling dates on the two sampling sites, namely; the Pit-os Fish Coral Sanctuary (protected area) and its adjacent gleaning grounds in Murcielagos Bay (non-protected area). Areas where seagrass beds and the substrate as a whole for the two sites were made sure to exhibit similar marine environment or seagrass percent cover to eliminate gastropod variability due to the differences of seagrass beds.

After that, 30 quadrats were randomly laid on both areas with 1 x 1 m² in dimension and with 16 inner quadrats of 0.25 x 0.25 m². In every quadrat the gastropods were identified, counted and recorded. Every species found was captured using an underwater camera for verification and documentation purposes. Collection of organisms was avoided to reduce disturbance and to not put stress on the biodiversity of gastropods in the area.

Interview

Right after the field sampling was conducted, an interview to the local gleaners took place using the Gleaning Catch Survey developed by De Guzman *et al* (2016) to evaluate the utilization status of gastropods in the area. Gleaners from Barangay Nangcaan, Barangay Nasipang and Barangay Sebaca in the Municipality of Rizal were interviewed with a number of 1, 2 and 13 individuals respectively. Information like gleaner's age group, number of years gleaning, amount of income from the activity and most gleaned gastropods were gathered.

Conservation Status of Gastropods

When the gastropods found were identified, counted and recorded, an online research was conducted to determine the conservation status of these gastropods using the International Union for Conservation for Nature (IUCN). The activity was done for the evaluation of extinction rate of the gastropod species found. The information gathered served as a reminder that gastropods are not only economically important, as indicated in its utility status, but also ecologically valuable following the fact that every organism that exists has its own role to play in the ecosystem.

Data Analysis

Seagrass Cover

Seagrass species composition and (%) cover were estimated using a systematic sampling method according to English et al. (1997).

Gastropod Biodiversity

Species identification

Captured gastropods were reviewed and identified to the lowest possible taxonomic level using taxonomic identification keys of Baharuddin & Marshall (2014).

Data analysis

Ecology indices included density, species diversity, and dominance index was applied in this study. Data was analyzed according to formulas as follows (Odum 1993):

a. Density (Di) = ni/A, where:
   A = Density species i;
   ni = Total number of individual species i;
   L = Total area of plot

b. Simpson Dominance Index C = ∑ (ni/ N)2, where:
   ni = Number of individual species – i
   N = Total number of individual species

   Criteria :
   $0 < C \leq 0.5$ = Low
   $0.5 < C \leq 0.75$ = Moderate
   $0.75 < C \leq 1.00$ = High

c. Shanon- Wiener Diversity Index H = -∑ (ni/N) In (ni/N), where:
   ni = Number of species – i
   N = Total number of species
   H' = Diversity Index
   Criteria :
   $0 < H' \leq 2.0$ = Low
   $2.0 < H' \leq 3.0$ = Moderate
   $3.0 < H' \leq 4.0$ = High

In measuring the significant difference of gastropods and seagrass (%) cover between the Pit-os Fish Coral Sanctuary (protected area) and its adjacent gleaning grounds in Murcielagos Bay (non-protected area) a T-test: two sample assuming equal variances was chosen using the Excel Microsoft

where:

if $p \leq 0.05$ = significant difference

if $p > 0.05$ = no significant difference

Species that possibly exhibited spillover were further tested using Mann-Whitney U test to compare differences between two independent groups where the dependent variable is ordinal or continuous but not normally distributed

where:

if $p \leq 0.05$ = statistically significant

if $p > 0.05$ = not statistically significant

Interview

The result of the interview using the Gleaning Catch Survey developed by De Guzman *et al* (2016) was analyzed to know how people use, understand and interact with the marine resources, especially gastropods, in the area.

Data gathered from the interview include gleaner's gender, age distribution, number of years gleaning, utility of gleaned catch, amount of income from the activity and the most gleaned gastropods among others.

Conservation status of Gastropods

The International Union for Conservation for Nature (IUCN) was consulted to gather information on the conservation status of gastropod species found in the seagrass beds of Pit-os Fish Coral Sanctuary and its adjacent gleaning grounds in Murcielagos Bay which is situated in the Municipality of Rizal, Zamboanga del Norte.

Results and Discussion

Seagrass Composition and Percent Cover

There were two seagrass species mainly found in the seagrass beds of Pit-os Fish Coral Sanctuary and the adjacent gleaning grounds in Murcielagos Bay. Both of the sampling sites constitute the seagrass species of *Enhalus acoroides* and *Thalassia hemprichii.* Considering that the marine sanctuary is largely composed of coral reefs due to the change of target ecosystem protection from seagrass beds to coral reefs, the researcher surveyed the substrate composition on both sites to rule out the substrate factor that may affect the diversity and abundance of gastropods in the two sampling sites. MPA has an account of 73% seagrass, 24% sand and 3% rubbles substrate cover while the non-MPA has an account of 75% seagrass, 21% sand and 3% rubbles substrate cover. The t-test that shows the value of $n > 0.05$ points out the lack of significant difference between the two substrate. With this data, the substrate factor was being ruled out to cater a reasonable result in comparing the gastropod species on the two sites. It allows the researcher to better evaluate the effectivity of protection between two sites.

Table 1. *Diversity and Concentration of Seagrass in the Seagrass Beds of Pit-os Fish Coral Sanctuary and its Adjacent Gleaning Grounds in Murcielagos Bay*

Seagrass Species	Sampling Sites	
	Seagrass Bed of Pit-os Fish Coral Sanctuary (MPA)	**Adjacent Gleaning Grounds in Murcielagos Bay (Non- MPA)**
Enhalus acoroides	47%	50%
Thalassia hemprichii	26%	25%
Total (%) Cover	**73%**	**75%**

Table 1 shows the species composition and mean percentage of seagrass species *Enhalus acoroides* and *Thalassia hemprichii* in two environmental conditions, undisturbed (Seagrass Bed of Pit-os Fish Coral Sanctuary) and disturbed (Adjacent Gleaning Grounds in Murcielagos Bay). In the marine sanctuary, *E. acoroides* comprise *47%* and *T. Hemprichii* comprise *26%* cover while 50% and 25% cover in the outside, respectively. The greater % cover outside the marine sanctuary is because the adjacent gleaning ground used to be part of the old sanctuary that had an aim to protect the seagrass beds in Murcielagos bay. Also, the area sampled by the researcher is far from the mainland where only those who have boats could access the area thus it is not that disturbed just like the seagrass bed inside. However, two sampling sites show no significant difference on seagrass % cover using the t-test on comparison across sites.

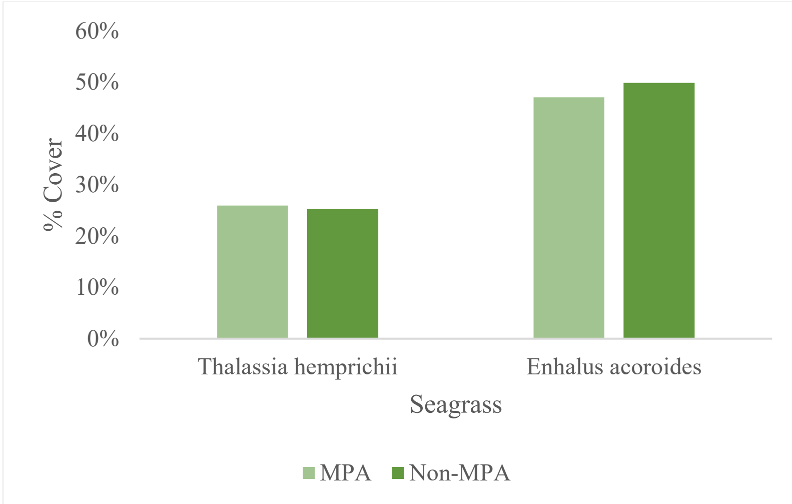


Figure 4. *Shows the overall seagrass % cover between Seagrass Beds of Pit-os Fish Coral Sanctuary and its Adjacent Gleaning Grounds in Murcielagos Bay*

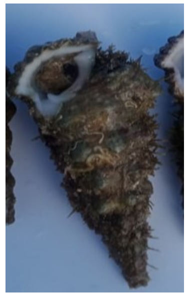
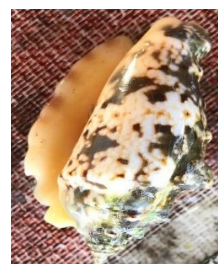
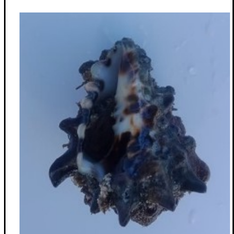
The figure 4 shown above is the total percent cover of both *Enhalus acoroides* and *Thalassia hemprichii* in the two locations compared. The 49% - 51% cover inside and outside the marine sanctuary respectively shows the insignificant 2% cover that differs between sites.

Gastropods Diversity and Abundance

Figure 5 presents the different species found in the seagrass beds of Pit-os Fish Coral Sanctuary and its adjacent gleaning grounds in Murcielagos Bay. The 14 species found in the sampling sites were *Cassis cornuta, Cerithium nodulosum, Conus leopardus, Conus litteratus, Conus marmoreus, Cypraea tigris, Mitra mitra, Conomurex luhuanus, Lambis lambis, Lambis millepeda, Harpago chiragra, Lentigo lentiginosus, Tectus niloticus,* and *Vasum turbinellus.* These species belong to eight (8) gastropod families namely; Cassidae, Cerithiidae, Conidae, Cypraeidae, Mitridae, Strombidae, Tegulidae and Turbinellidae.

All 14 species were found inside the sanctuary and only 12 were also found on the adjacent gleaning grounds. During the data gathering, two spider conch species were absent outside the sanctuary. These two are the species of *Lambis millepeda* and *Harpago chiragra.* The existence of gastropod species were consistent as they were found in every quadrat randomly laid in both areas.

Types of Gastropod Species

 *Cassis cornuta* Family : *Cassidae* Size : *228.60mm* Substrate when found : seagrass and sand	 *Cerithium nodulosum* Family : *Cerithiidae* Size : *58.42mm* Substrate when found: seagrass and sand	 *Conus leopardus* Family : *Conidae* Size : *60.96mm* Substrate when found: seagrass and sand	 *Conus litteratus* Family : *Conidae* Size : 63.50mm Substrate when found: rubbles	 *Conus marmoreus* Family : *Conidae* Size : 66.04mm Substrate when found: rubbles	 *Cypraea tigris* Family : *Cypraeidae* Size : 63.50mm Substrate when found: rubbles	 *Mitra mitra* Family : *Mitridae* Size : *55.88mm* Substrate when found: seagrass
 *Conomurex luhuanus* Family : *Strombidae* Size : *50.80mm*	 *Harpago chiragra* Family : *Strombidae* Size : *203.20mm*	 *Lambis lambis* Family : *Strombidae* Size : *137.16mm*	 *Lambis millepeda* Family : *Strombidae* Size : *127mm*	 *Lentigo lentiginosus* Family : *Strombidae* Size : *50.80mm*	 *Tectus niloticus* Family : *Tegulidae* Size : *66.04mm*	 *Vasum turbinellus* Family : Conidae Size : *40.64mm*

Substrate when found: seagrass	Substrate when found: seagrass	Substrate when found: seagrass	Substrate when found: seagrass	Substrate when found: seagrass	Substrate when found: seagrass and sand (Photo by Dolorosa, Picardal and Conales 2015)	Substrate when found: seagrass and sand

Figure 5. *Images taken on sample species during the survey*

Table 2. *Gastropod species diversity and density within and outside the sanctuary.*

Gastropod Species/m²	Sampling Sites	
	Pit-os Fish Coral Sanctuary (MPA)	Adjacent Gleaning Grounds in Murcielagos Bay (Non- MPA)
Cassis cornuta	0.67 ± 0.25	0.03 ± 0.18
Cerithium nodulosum	0.70 ± 0.84	0.27 ± 0.45
Conus leopardus	0.20 ± 0.48	0.17 ± 0.46
Conus litteratus	0.17 ± 0.38	0.10 ± 0.31
Conus marmoreus	0.10 ± 0.31	0.07 ± 0.25
Cypraea tigris	0.23 ± 0.50	0.17 ± 0.38
Mitra mitra	0.30 ± 0.70	0.07 ± 0.25
Conomurex luhuanus	4.7 ± 3.23	1.13 ± 0.86
Lambis lambis	0.20 ± 0.48	0.03 ± 0.18
Lambis millepeda	0.20 ± 0.48	0 ± 0
Harpago chiragra	0.17 ± 0.38	0 ± 0
Lentigo lentiginosus	0.47 ± 0.73	0.23 ± 0.50
Tectus niloticus	0.23 ± 0.43	0.03 ± 0.18
Vasum turbinellus	0.23 ± 0.43	0.13 ± 0.35

In table 2, the density of gastropods within and outside the MPA was compared using mean ± SD /m^2. As reflected in the table, the density of all gastropod species are higher inside the sanctuary compared to that of the outside with 17.07 ± 9.62/m^2 and 5.21 ± 2.31/m^2 within and outside MPA, respectively. This number of gastropod is more than three (3) times higher within the seagrass beds of Pit-os Fish Coral Sanctuary compared to its adjacent gleaning grounds in Murcielagos Bay.

Table 3. *Diversity indices on gastropods within and outside the marine sanctuary.*

	MPA	Non-MPA
Taxa_S	14	12
Individuals	239	73
Simpson_1-D	0.63	0.75
Shannon_H	1.66	1.85

For the ecological indices, the data presented was applied in this study to show comparison between sites in Table 3. Simpson dominance index is 0.63 and 0.75 inside and outside the marine sanctuary, respectively. This indicate that both sampling sites have moderate dominance as shown in the index but data also shows that inside the sanctuary is more diverse compared to the outside. For diversity index, the Shanon-Wiener Diversity Index was used. It exhibits a low diversity status on both locations with 1.66 inside and 1.85 outside the marine sanctuary. Using the Shanon-Wiener Diversity Index, we could say that outside the sanctuary is more diverse as this test combines evenness and richness and less weighted on dominant species. The low diversity index on Shanon-Wiener Diversity Index shows that the gastropod species are not highly diverse.

To further show comparison between sites, the data was analyzed with T-test: two sample assuming equal variances using the Excel Microsoft where $p \leq 0.05$ to show that it has significant difference. The study shows no significant difference between areas. Reasons might include the fact that the outside marine sanctuary used to be a seagrass marine sanctuary but with the changed location of the marine sanctuary was being allowed to be gleaned. Another reason is the location of the study site where it is located far from the mainland. Since the area is only gleaned to individuals with boats, the area outside marine sanctuary being sampled is less gleaned compared to those near the land area where the locals live. Next is that the gastropod species inside the sanctuary might have not yet recovered yet considering that the sanctuary existed on 2002 and a change of location happened on 2007 making the whole protection to be less than 20 years. Lastly, spillover and recruitment effect takes long years to happen.

However, looking upon the data there were seven (7) species that possibly exhibited an individual spillover. These are *Conomurex luhuanus, Cerithium nodulosum, Lentigo lentiginosus, Mitra mitra, Tectus niloticus, Lambis lambis* and *Lambis Millepeda.* They were further tested using Mann-Whitney U test to compare differences between two independent groups where the dependent variable is ordinal or continuous but not normally distributed. If ≤ 0.05, then the data has a significant difference.

Among the seven (7) species that were tested using Mann-Whitney U test, only one gastropod species only shows a significant result and this could be clearly seen in figure 6. This species is the *Conomurex luhuanus* which is locally called as "liswi" in the area. From the test, it has a p value of 0.0001, a value that exhibited a higly significant difference.

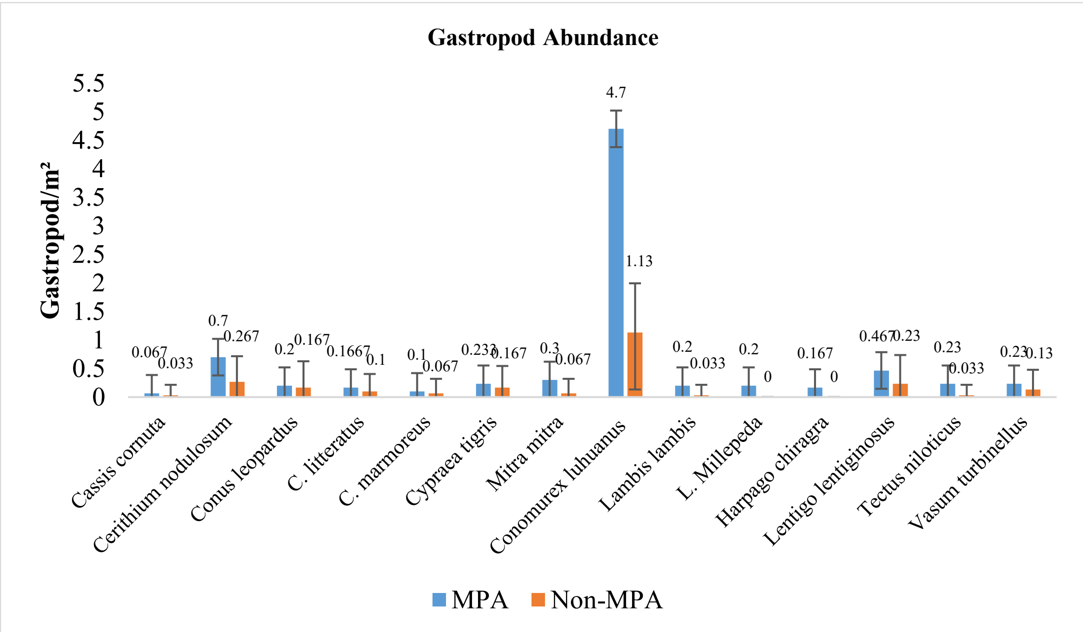


Figure 6. *Gastropods/m² within and outisde MPA.*

The current research shows how the spillover effect develops overtime. Eventhough the study conveys the lack of spillover effect when all gastropod species were sampled and tested as a whole, the individual test made on potentially abundant species inside the sanctuary compared to that of the outside reveals that MPA truly "provides hope that reserves can help to reverse the decline of marine ecosystems and biodiversity"(Russ and Alcala, 2011). With the *Conomurex luhuanus* exhibiting the spillover effect among all other present species, it shows still that spillover "is of vital significance to the successful establishment of reserves" (Russ et al., 2003).

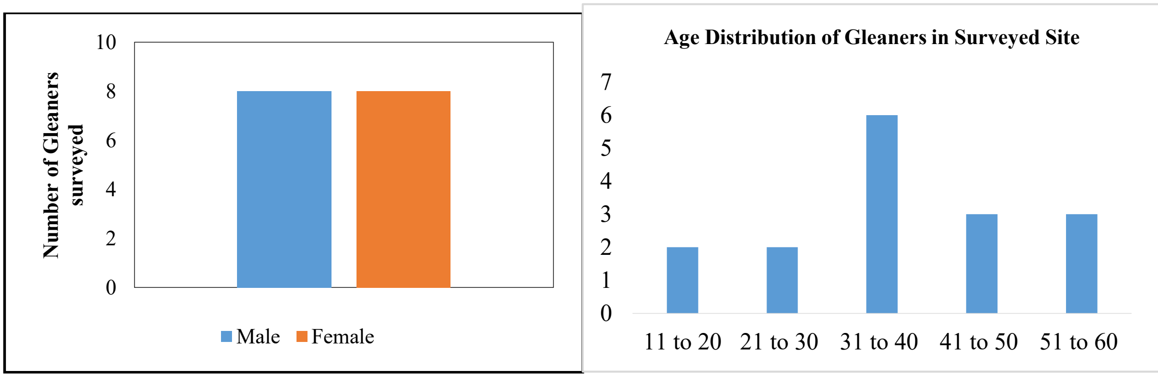
A study by Bednar (2015) affirm that MPAs are successful for some of the gastropod species evaluated, but further research is needed to understand species-specific requirements so that all species can benefit completely from MPA protection. This conclusion and suggestion on species-specific further study and comparison is also being applied in this current study considering that the initial status before protection and recovery rate of gastropods were not identified.

This study attests that a no-take marine reserve (NTMRs) is a potential tool to protect gastropod biodiversity and it can help its adjacent gleaning area through spillover effect.

Utility Status of Gastropods

Invertebrate gleaning plays an important role in providing food and income to coastal communities. In the Philippines, gleaning for edible invertebrates on shallow reef flats is a chronic activity mainly for subsistence but also for supplemental family income (De Guzman et al., 2019). Gastropods are one of the gleaned mollusks that serve as food, ornaments, and a source of income for the locals. It is widely harvested in the gleaning grounds of Murcielagos Bay, making the place known for its economically important gastropods like spider conchs and Strawberry conch or Tiger conch among others.

There were 16 present gleaners interviewed in Barangay Sebaca, and representative gleaners from Barangay Nangcaan and Barangay Nasipang, Municipality of Rizal was interviewed using the Gleaning Catch Survey developed by De Guzman *et al* (2016) to find out how the gleaned gastropods was utilized by the locals. As seen in fig. 7a, eight (8) of them are male and eight (8) of them are female, having an equal representative from sexes. They spent mostly two to three hours on days favorable for gleaning like low tide. On average, these gleaners gleaned three to four days a week.



(a) *(b)*

Figure 7. *(a) Number of Gleaners surveyed in the coastal Barangay of Rizal and (b) The age distribution of Gleaners Surveyed*

The gleaners interviewed mostly belong to the age bracket of 31-50 years old. Fig. 7b shows that 38% belongs to an age bracket of 31-40 years old, followed by individuals belonging to 41-50 years old and the least age bracket belongs to 11-20 and 21-30 years old with both having 12% from the population of all gleaners interviewed.

These gleaners have spent 21.5 years gleaning on average. The gleaners in the age bracket of 11-20 years old are those children who accompany their parents during the gleaning activity. They help their parents both for leisure and as they understood also that gastropods or gleaning activity as a whole contributes to the household economy.

Contribution to Household Economy

Local gleaners interviewed in the coastal barangays utilized mostly the gleaned gastropods both for food consumption and as a means of income. Utility of gleaned catch is reflected in Fig.8.

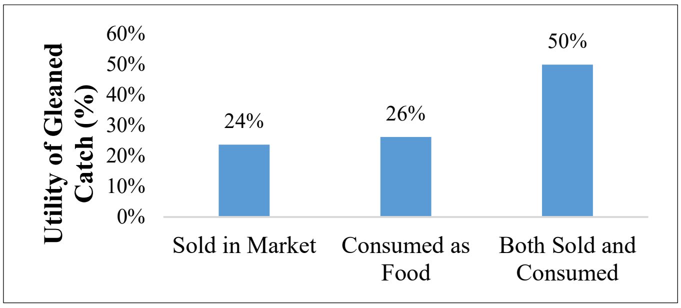


Figure 8. *Utility of gleaning harvest.*

Eventhough the health benefits of these mollusks are equivocal to the local gleaners, all of them perceived it as essential for diet. This is why most of them utilized it mainly for food. However aside from food consumption, gastropods were also sold in the local market and gleaners also confirmed that there is a great demand of it leading to the point where middleman or "*compradors*" have gone to their place. They sold these gastropods using a bucket or "balde" that cost Php 1,000 to Php 1,500 when fully filled. Their estimated monthly revenues from gleaning activities by men and women in surveyed site are Php 6, 200 and Php 15, 300, respectively. The greater amount of income from women is due to the fact that most men only gleaned when conditions for fishing are unfavorable.

Figure 9. *Most Gleaned Gastropods in Murcielagos Bay*

The most gleaned gastropods in the gleaning grounds of Murcielagos Bay includes the "liswi" or *Conomurex luhuanus,* species of spider conchs like *Lambis lambis* and *Harpago chiragra* and the silver conch or "tagmanok"--- *Lentigo lentiginosus.* These gastropods are widely harvested as they are high in value and considered to be the sought-after seashells in the area.

Conservation Status of Gastropods

Table 4. *Conservation status of gastropod species found in Murcielagos Bay.*

FAMILY	English Name	Local Name	Conservation status (IUCN)
Cassidae			
Cassis cornuta	Horned helmet	Budyong	Not Evaluated
Cerithiidae			
Cerithium nodulosum	Giant knobbed cerith	Sungkod-sungkod	Not Evaluated
Conidae			
Conus leopardus	Leopard cone	Baluso	Least Concern
Conus litteratus	Lettered cone	Baluso	Least Concern
Conus marmoreus	Marbled Cone	Baluso	Least Concern
Cypraeidae			
Cypraea tigris	Tiger cowrie	Puki	Not Evaluated
Mitridae			
Mitra mitra	Episcopal miter		Not Evaluated
Strombidae			
Conomurex luhuanus	Strawberry conch or Tiger conch	Liswi	Not Evaluated
Lambis lambis	Spider conch	Saang	Not Evaluated
Lambis millepeda	Millipede spider conch	Saang	Not Evaluated
Harpago chiragra	Chiragra spider conch	Saang	Not Evaluated
Lentigo lentiginosus	Silver conch	Tagmanok	Not Evaluated
Tegulidae			
Tectus niloticus	Commercial top shell	Sundalay	Not Evaluated
Turbinellidae			
Vasum turbinellus	Common Pacific Vase		Not Evaluated

As shown in table 4, all of the gastropods found in Murcielagos Bay are not evaluated except those from family Conidae. This shows that data on marine gastropods are insufficient and the need for further studies is a must. The International Union for Conservation of Nature (IUCN) was consulted to determine how likely the gastropod species will thrive today and to generations to come.

Conclusion

The study accepts the null hypothesis. It shows no significant difference between the protected and non-protected area and the researcher induced some reasons based on facts presented. This includes the reality that the outside marine sanctuary used to be a seagrass marine sanctuary but with the changed location of the marine sanctuary was being allowed to be gleaned. Another reason is the location of the study site where it is located far from the mainland. Since the area is only gleaned to individuals with boats, the area outside marine sanctuary being sampled is less gleaned compared to those near the land area where the locals live. Next is that the gastropod species inside the sanctuary might have not yet recovered yet considering that the sanctuary existed on 2002 and a change of location happened on 2007 making the whole protection to be less than 20 years. Lastly, spillover and recruitment effect take long years to happen.

This study further shows how the spillover effect develops overtime. Eventhough the study conveys the lack of significant difference and spillover effect when all gastropod species were sampled and tested as a whole, the individual test made on potentially abundant species inside the sanctuary compared to that of the outside reveals that MPA is effective in protecting some species of gastropods. Using the Mann-Whitney U test on abundant species, only the *Conomurex luhuanus,* locally known as *"liswi",* exhibited the spillover effect.

A stronger monitoring and protection shall be exerted by the local government for a more effective implementation of the no-take marine reserve.

The local government unit may conduct futher information, education and communication (IEC) drive for a wider distribution of awareness to the local residents on no-take marine reserve benefits and importance in the community.

A further study can be conducted to explore other gastropod species and determine spillover effect on every species found in Pit-os Fish Coral Sanctuary across different substrates and its surrounding areas along Murcielagos Bay.

References

Agardy, T., G. N. di Sciara, and P. Christie. 2011. Mind the gap: addressing the shortcomings of marine protected areas through large scale marine spatial planning. *Marine Policy* 35:226–232.

Baharuddin N., Marshall D. J., 2014 Common aquatic gastropods of Brunei. Educational Technology Centre, Universiti Brunei Darussalam, Brunei, 20 p.

Baharuddin N., Zakaria N. A., 2018 The biodiversity and conservation status of the marine gastropod (Mollusca; Gastropoda) in Pulau Bidong, Terengganu, Malaysia. AACL Bioflux 11(4):988-1000

Bednar, Cassie, "Human Impacts on Rocky Intertidal Gastropods: Are Marine Protected Areas Effective?" (2015). Master's Theses. Paper 4529.

Berkman International, Inc. 2011a. Participatory Resource Appraisal - Resource Social Assessment (PRA-RSA) of the Municipality of Rizal - Final Report.

Cabral, R. B., Aliño, P. M., Balingit, A. C. M., Alis, C. M., Arceo, H. O., Nañola, C. L., & Geronimo, R. C. (2014). The Philippine Marine Protected Area (MPA) Database. *Philippine Science Letters*, *7*(2), 300–301.

Cabral RB, Aliño PM, Pomeroy R, Jatulan W. Assuring Sustainable Fisheries Development. In: Asian Development Bank 2014: Economics of Fisheries and

Aquaculture in the Coral Triangle. Asian Development Bank, Mandaluyong City, Philippines, 2014:141-172.

Ceccherelli, G., Pinna, S., Navone, A., & Sechi, N. (2011). Influence of geographical siting and protection on rocky-shore gastropod distribution at a western Mediterranean Marine Protected Area. *Journal of Coastal Research*, *276*, 882–889. https://doi.org/10.2112/jcoastres-d-10-00027.1

Cowie R. H., Regnier C., Fontaine B., Bouchet P., 2017 Measuring the sixth extinction: what do mollusks tell us? The Nautilus 131(1):3-41.

De Guzman, A., Sumalde, Z., Rance, G. M., Colance, M. D., & Ponce, M. F. (2019). Contribution of Gleaning Fisheries to Food Security and nutrition of poor coastal communities in the Philippines. *Journal of Environmental Science and Management*, 58–71. https://doi.org/10.47125/jesam/2019_sp1/06

Dolorosa, R. G., Picardal, R. M., & Conales, S. F. (2015). Bivalves and gastropods of Tubbataha Reefs Natural Park, Philippines. *Check List*, *11*(1), 1506. https://doi.org/10.15560/11.1.1506

Duffy, J. E. (2006). Biodiversity and the functioning of seagrass ecosystems. *Marine Ecology Progress Series*, *311*, 233–250. https://doi.org/10.3354/meps311233

English S., Wilkinson C. R., Baker V. J., 1997 Survey manual for tropical marine resources. Australian Institute of Marine Science, Australia.

Fortunato, H. (2016). Mollusks: Tools in environmental and climate research*. *American Malacological Bulletin*, *33*(2), 310–324. https://doi.org/10.4003/006.033.0208

Furkon, Nessa, M. N., & Ambo-Rappe, R. (2019). Invertebrate gleaning: Forgotten fisheries. *IOP Conference Series: Earth and Environmental Science*, *253*, 012029. https://doi.org/10.1088/1755-1315/253/1/012029

Furkon, Nessa, N., Ambo-Rappe, R., Cullen-Unsworth, L. C., & Unsworth, R. K. (2019). Social-ecological drivers and dynamics of Seagrass Gleaning Fisheries. *Ambio*, *49*(7), 1271–1281. https://doi.org/10.1007/s13280-019-01267-x

Japar Sidik, B., Muta Harah, Z., Mohd. Pauzi, A., & Madhavan, S. (1999). Halodule species from Malaysia — distribution and morphological variation. *Aquatic Botany*, *65*(1-4), 33–45. https://doi.org/10.1016/s0304-3770(99)00029-7

Leal, J. H. (n.d.). *Gastropods* . Retrieved January 23, 2022, from http://www.ibiologia.unam.mx/links/peces/fao/WCAidSheets/Vol%201/y4160e08.pdf

Litaay, M., Deviana, M. & Priosambodo, D. 2017. Biodiversity and Distribution of Gastropods at Seagrass Meadow of Balangdatu Waters Tanakeke Island South Sulawesi Indonesia. *International Journal of Applied Biology. 1(2):58-66*

Lovejoy TE. 1997. Biodiversity: what is it? In: Reaka-kudla MK, Wilson DE, Wilson EO, editors. *Biodiversity ii: Understanding and Protecting our Biological Resources.* Washington DC: Joseph Henry Press pp. 7-14

Manríquez, P. H., & Castilla, J. C. (2001). Significance of marine protected areas in central Chile as seeding grounds for the gastropod Concholepas concholepas. *Marine Ecology Progress Series*, *215*, 201–211. https://doi.org/10.3354/meps215201

Maypa, A. (2012). *Mechanisms by which marine protected areas enhance fisheries benefits in neighboring areas* (Doctoral dissertation, [Honolulu]:[University of Hawaii at Manoa],[December 2012]).

Miclat E, Ingles J. Standardized terms and definitions for use in marine protected area management in the Philippines. In: Arceo HO, Campos WL, Fuentes F, Aliño PM, eds. Proceedings of the Workshop Toward the Formulation of the Philippine

Marine Sanctuary Strategy. Quezon City: Marine Science Institute, University of the Philippines. 2004:3-8.

Naguit, D. M. R. A., Edayan, A. C., Cabrera, R. B., & Alavanza, G. A. (2017). Aliguay Island Protected Landscape and Seascape Coastal and Marine Environment Comprehensive Management Program (CMECMP).

REGIONAL FISHERIES LIVELIHOODS PROGRAMME FOR SOUTH AND SOUTHEAST ASIA: PHILIPPINES GCP/RAS/239/SPA: RFLP Philippines Baseline Study for Dipolog, Katipunan, Manukan and Roxas, Zamboanga del Norte, Philippines Final Report. (2011). Naguit, M. R.,Campiseño, E., Laput D., Bidad, C., Romarate, C.,Gilaga, B., Laranjo, R., & Malate, Renato. 10.13140/RG.2.2.12508.41609.

Odum, E.P. 1993. Ecology. Gadjah Mada University Press. Yogyakarta

Palomares, M. L. D., & Pauly, D. (Daniel). (2014). Philippine Marine Fisheries Catches : A Bottom-up Reconstruction, 1950 to 2010. Faculty Research and Publications. R, University of British Columbia. Fisheries Centre. Retrieved May 4, 2022, from https://open.library.ubc.ca/collections/facultyresearchandpublications/52383/items/1.0354317

Picardal, R. M., & Dolorosa, R. G. (2014). The molluscan fauna (gastropods and bivalves) and notes on environmental conditions of two adjoining protected bays in Puerto Princesa City, Palawan, Philippines. *Journal of Entomology and Zoology Studies*, *2 (5)*, 72–90. https://doi.org/ISSN 2320-7078

Pipuli Foundation, Inc. 2002. The Ecosystem Assessment Report: Understanding the Uniqueness of Murcielagos Bay.

Pulley, R. V. (2003). *Philippines Environment Monitor 2003: Water quality*. Department of Environment and Natural Resources, Philippines.

Rawat, U. S., & Agarwal, N. K. (2015). Biodiversity: Concept, threats and conservation. *Environment Conservation Journal*, *16*(3), 19–28. https://doi.org/10.36953/ecj.2015.16303

Russ, G. R., Alcala, A. C., Maypa, A. P., Calumpong, H. P., & White, A. T. (2004). Marine Reserve Benefits Local Fisheries. *Ecological Applications*, *14*(2), 597–606. https://doi.org/10.1890/03-5076

Russ, G. R., Alcala, A. C., & Maypa, A. P. (2003). Spillover from marine reserves: The case of Naso Vlamingii at Apo Island, the Philippines. *Marine Ecology Progress Series*, *264*, 15–20. https://doi.org/10.3354/meps264015

Russ, G. R., & Alcala, A. C. (2011). Enhanced Biodiversity Beyond Marine Reserve boundaries: The Cup spillith over. *Ecological Applications*, *21*(1), 241–250. https://doi.org/10.1890/09-1197.1

Sala, E., Mayorga, J., Bradley, D., Cabral, R. B., Atwood, T. B., Auber, A., ... & Lubchenco, J. (2021). Protecting the global ocean for biodiversity, food and climate. *Nature*, *592*(7854), 397-402.

Short, F., Carruthers, T., Dennison, W., & Waycott, M. (2007). Global Seagrass Distribution and diversity: A bioregional model. *Journal of Experimental Marine Biology and Ecology*, *350*(1-2), 3–20. https://doi.org/10.1016/j.jembe.2007.06.012

Tabugo, S. R. M., Pattuinan, J. O., Sespene, N. J. J., & Jamasali, A. J. (2013). Some Economically Important Bivalves and Gastropods found in the Island of Hadji Panglima Tahil, in the province of Sulu, Philippines. *International Research Journal of Biological Sciences, Vol. 2(7), 30-36, July (2013)* . https://doi.org/ISSN 2278-3202

Thomas, R. D., Runnegar, B., & Matt, K. (2020). *pelagiella exigua* , an early Cambrian stem gastropod with Chaetae: Lophotrochozoan heritage and Conchiferan Novelty. *Palaeontology*, *63*(4), 601–627. https://doi.org/10.1111/pala.12476

Tomascik T, A.J. Mah, A. Nontji, M.K. Moosa. 1997. The Ecology of The Indonesian Seas. Part Two. Periplus Edition (HK) Ltd. Singapore

Uy, W.H. 2006. Seagrasses. Participatory Coastal Resource Assessment of Rizal, Zamboanga del Norte. A study conducted by MSU-Naawan Foundation for Science & Technology Development, Incorporated and funded by the Partnership for Rural and Technical Services (PARTS), Inc.

Voronezhskaya, E. E., & Croll, R. P. (2015). Mollusca: Gastropoda. *Structure and Evolution of Invertebrate Nervous Systems*, 196–221. https://doi.org/10.1093/acprof:oso/9780199682201.003.0020

White AT, Aliño PM, Cros A, Fatan NA, Green AL, Teoh SJ, Laroya L, Peterson N, Tan S, Tighe S, Venegas-Li R, Walton A, Wen W. Marine protected areas in the Coral Triangle: progress, issues, and options. Coastal Management 2014; 42(2)