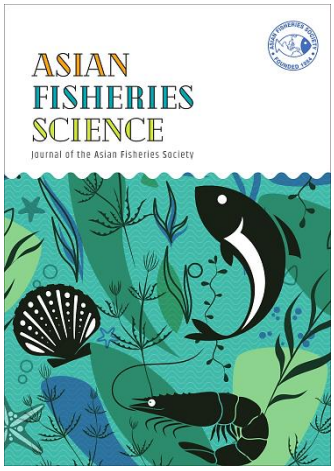

Species Composition, Abundance and Conservation Status of Some Economically Important Macrobenthic Invertebrates In Pag-asa Island, Kalayaan, Palawan, Philippines

RODULF ANTHONY BALISCO*, BENJAMIN GONZALES, ROGER DOLOROSA
College of Fisheries and Aquatic Sciences, Western Philippines University, Puerto Princesa City, Palawan 5300, Philippines

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Abstract

Pag-asa Island is the largest and the only civilian inhabited island in the Kalayaan Island Group (KIG) in the West Philippine Sea. The waters around these islands are important fishing grounds; however, little information is available on the status of macrobenthic invertebrates within the vicinity of the island. In this study, we assessed the species composition, abundance and conservation status of some commercially important macrobenthic invertebrates in shallow reefs and seagrass beds surrounding the island. The sampling was conducted during day time of dry season for 6 days (May 9-14, 2018) through wading, snorkelling and scuba diving which recorded a total of seven species, mostly bivalves and echinoderms. Bivalve species included the giant clams *Tridacna maxima* (Röding, 1798) and *Tridacna crocea* Lamarck, 1819; echinoderms included *Bohadschia argus* Jaeger, 1833, *Bohadschia vitiensis* (Semper, 1868), *Holothuria atra* Jaeger, 1833, *Holothuria leucospilota* (Brandt, 1835) and *Tripneustes gratilla* (Linnaeus, 1758). These species occurred more abundantly in seagrass beds than in coral reefs, ranging from 46.7–1,346.7 ind.ha^{-1}. Most of the species were of "Least Concern" status according to International Union for Conservation of Nature (IUCN) Red List. The absence of previously reported high valued species in the surveyed sites, such as topshell *Rochia nilotica* (Linnaeus, 1767) and lobsters *Panulirus versicolor* (Latreille, 1804) could be an effect of unregulated harvesting. Effective resource management in this part of KIG is needed to allow the recovery of reduced populations and ensure food security for the inhabitants of the island.

Keywords: exploitation, coastal resource management, food security, marine resources, resource assessment

Introduction

The Pag-asa (Thitu) Island is the largest and the only inhabited island among the seven islands that comprise the Kalayaan Island Group (KIG) in the West Philippine Sea. The wide seagrass beds and reef flats surrounding the island is home to diverse marine organisms (Balisco, 2015; Hombre et al., 2016) which serve as a fishing ground for Filipinos and nationalities of other claimant countries (Gonzales et al., 2008). As part of the contested Spratly Group of Islands, the ecosystems around Pag-asa and all other islands are subjected to unregulated exploitation which caused the deterioration of marine resources. Despite the evidence of widespread overexploitation, no strong political will and governance are in place to prevent the further deterioration of its resources and ensure sustainable fisheries in the future (Teh et al., 2017).

One of the exploited fisheries resources in Pag-asa Island is the macrobenthic invertebrates which are traditionally gleaned in intertidal, reef flat, mudflat, sandy, seagrass and rocky substrates of coastal areas and small islands as a major source of food (Szabo and Amesbury, 2011). Macrobenthic invertebrates also provide cleaning, nutrient recycling and other ecosystems services in marine ecosystems (Neo et al., 2015). The presence of macrobenthic invertebrates is also used as indicators of reef health, level of exploitation and environmental deterioration (Wildsmith et al., 2011). Macrobenthic invertebrates are among the common residents of shallow waters and can occur in significant numbers in well-protected reefs. In Tubbataha Reefs Natural Park (TRNP), a large

protected area in the middle of Sulu Sea, Philippines, the reef-dwelling species such as: (a) boring clam *Tridacna crocea* Lamarck, 1819, occurred at a mean of 22 ind. m^{-2} at the exposed coral heads (Conales et al., 2015), while (b) top shell *Rochia nilotica* (Linnaeus, 1767) can occur up to 1 ind.m^{-2} in rocky intertidal areas (Dolorosa et al., 2016).

In spite of their varied ecological and economic importance, many of these species face local extinction due to recruitment overfishing and unregulated fishing (Szabo and Amesbury, 2011). For example, the size structure of the commercial top shell *R. nilotica* in TRNP was heavily reduced after 2 years of poaching with more than 70 % population lost in some stations (Dolorosa et al., 2016). The triton shell *Charonia tritonis* (Linnaeus, 1758) are important natural controller of coral predators (e.g. crown-of-thorns) but are at high risk of overfishing (Hall et al., 2017). Macrobenthic invertebrates are also found at the lower part of the food chain and their overexploitation may severely affect the populations of organisms depending on them (Gonzales et al., 2014). In addition, the ill effects of the dwindling fishery resource in the coastal communities are expected to worsen in 2050s as the human population continue to increase. Thus, it is very important that fisheries resources are well managed to ensure food security for future generations, particularly in coastal areas (Bell et al., 2018).

Like any small offshore island, the residents of Pag-asa Island are highly dependent on the wealth of its dwindling marine resources. Its remoteness makes the island inaccessible to scientific studies and information on the status of its marine resources is wanting. Few studies were conducted which are mostly resource assessment and on the checklist of sea urchins, gastropods and bivalves (Balisco, 2015; Hombre et al., 2016). The study of Gonzales et al. (2008) encountered six commercially important macroinvertebrate species in coral reefs only, and does not include the seagrass beds which also harbour several macrobenthic invertebrate species. Half (50 %) of the species reported by Gonzales et al. (2008) were of "Least Concern", one (16.67 %) Threatened, and the rest (33.33 %) were "Not Assessed" (IUCN, 2019). Seagrass beds serve as breeding, feeding, nursery and habitat of various macrobenthic invertebrates including sea urchins, sea cucumbers and molluscs (Balisco, 2015; Dolorosa et al., 2017; Jontila et al., 2017; Ardines et al., 2020).

Because of its remoteness, we assumed that Pag-asa Island's marine resources are more intact than those small islands near the mainland Palawan. With the limitation of available data that can be used for policy formulation, this study was conducted to assess the different species of macrobenthic invertebrates, their abundance and conservation status in areas surrounding Pag-asa Island, Kalayaan, Palawan, Philippines. Policymakers with genuine interests in the sustainable use of fisheries resources could use the gathered information in crafting management measures for Pag-asa Island.

Materials and Methods

Pag-asa Island, a 32.7 ha oceanic low-lying island in the municipality of Kalayaan, province of Palawan in the West Philippine Sea (11°3.194′ N/ 114°17.094′ E; Fig. 1), is about 280 nautical miles (450 km) north-west of Puerto Princesa City, the capital of Palawan, Philippines. Surrounding the island is a wide reef flat with patches of sand and seagrass beds.

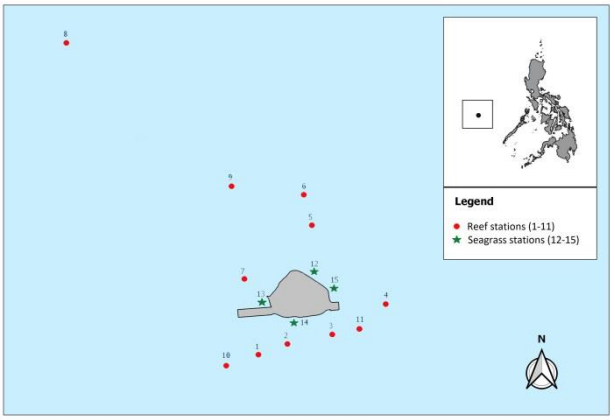

Fig. 1. Location of sampling stations for commercially important microbenthic invertebrate in coral reefs and seagrass beds surrounding Pag-asa Island, Kalayaan, Palawan, Philippines. Eleven stations were established for reef areas (red dots) and four for seagrass beds (green stars).

The survey was conducted during the day time of the dry season (8:00 AM–3:00 PM) for 6 days on 9–14 May 2018. Fifteen sampling stations in two coastal habitats were surveyed: 11 stations in coral reefs and four in seagrass beds (Fig. 1). Of these, eight stations established by Gonzales et al. (2008) were revisited. Scuba diving was conducted in reef stations (3–16 m deep), while snorkelling and wading in seagrass beds were carried out during low tide (0.25–1 m deep).

Three 5 m × 30 m belt transects in each coral reef station were laid parallel to the shoreline. On the otherhand, three 5 m × 100 m belt transects were laid perpendicular to the shoreline for seagrass bed stations to record and photodocument the economically important macrobenthic invertebrates. Only commercially important species (i.e. gathered for consumption by local fishermen) that were visibly found on the surface of the substrates were photographed *in situ* (no collection was made). Identification of the species was based on their morphological features using the locally available references (Jontila et al., 2014; Dolorosa et al., 2015; Hombre et al. 2016), and valid scientific names were verified using the World Register of Marine Species (http://www.marinespecies.org/index.php) and

SeaLifeBase (https://www.sealifebase.ca/) websites. The abundance or density of each species on the reef was separately computed with those found on seagrass beds. Only the mean and standard deviation of the species abundance were determined. For each species found and identified, the conservation status was determined using the Red List of Threatened Species by the International Union for Conservation of Nature (IUCN, 2019).

Results

Species composition

Only two major groups of commercially important macrobenthic invertebrates were encountered during the survey: bivalves (Class Bivalvia) with two species, and echinoderms (Echinodermata: Holothuroidea and Echinoidea) with five species. Bivalves were represented by giant clams *Tridacna maxima* (Röding, 1798), and *T. crocea*, while echinoderms include the sea cucumbers *Bohadschia argus* Jaeger, 1833, *Bohadschia vitiensis* (Semper, 1868), *Holothuria atra* Jaeger, 1833, *Holothuria leucospilota* (Brandt, 1835) and the gracious sea urchin *Tripneustes gratilla* (Linnaeus, 1758). Giant clams occurred only in coral reefs, while most sea cucumbers (except *B.* argus) and sea urchins were recorded in seagrass beds only (Figs. 2 and 3).

In terms of occurrence per habitat, more than half (56 %) of all species were only encountered in seagrass beds, two (22 %) species in coral reefs only, and the other two (22 %) were found both in coral reefs and seagrass beds stations (Fig. 4). The *Tridacna* spp. were encountered only in coral reefs, but not in seagrass beds. Sea cucumbers *B. argus* and *H. leucospilota* were noted both in coral reefs and seagrass beds, while *B. vitiensis, H. atra* and *T. gratilla* were recorded in seagrass beds only.

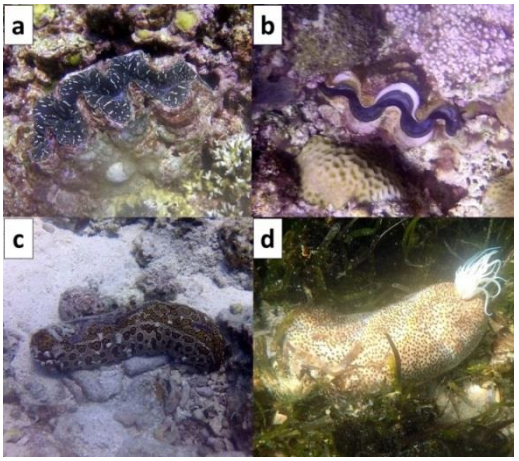

Fig. 2. Some commercially-important macrobenthic invertebrates encountered in the coral reefs and seagrass beds surrounding Pag-asa Island, Kalayaan, Palawan, Philippines: small giant clam *Tridacna maxima* (a), boring giant clam *Tridacna crocea* (b), leopard sea cucumber *Bohadschia argus* (c), and brown sandfish *Bohadschia vitiensis* (d).

Abundance

In the coral reefs, the giant clams had population density ranging from 66.6 to 266.4 ind.ha^{-1} (mean 127.2 ind.ha^{-1}), followed by sea cucumbers (12.11 ind.ha^{-1}). In seagrass beds, the sea urchin *T. gratilla* was the most abundant and occurred in all stations with population density ranging from 53.3 to 1,346.7 ind.ha^{-1} (mean 656.6 ind.ha^{-1}). Stations 12 and 15 had the highest sea urchin density. Sea cucumbers occurred at 38.35 ind.ha^{-1} in 2 of 4 stations (Table 1).

Conservation status

Based in the IUCN Red List, the giant clams *Tridacna* spp., leopard fish *B. argus*, lollyfish *H. atra* and white threadfish *H. leucospilota* were under the "Least Concern" category. The brown sandfish *B. vitiensis* fall under "Data Deficient" category, while the gracious sea urchin *T. gratilla* population was "Not Assessed/Evaluated" (Table 2).

Discussion

Species composition

Only seven commercially important macrobenthic invertebrate species were recorded. This low number of species could be attributed to both sampling and rate of local exploitation. Species noted by Gonzales et al. (2008) during 2008 survey such as sipunculids, lobster *Panulirus versicolor* (Latreille, 1804) and topshell *R. nilotica* were not recorded in the recent survey; however, there are species that were not noted during the 2008 survey but were encountered in this study (Table 3). Some nocturnal organisms may not have been recorded during the day survey; however, lobster (a nocturnal species) could still be noted even during the day (Gonzales et al., 2008).

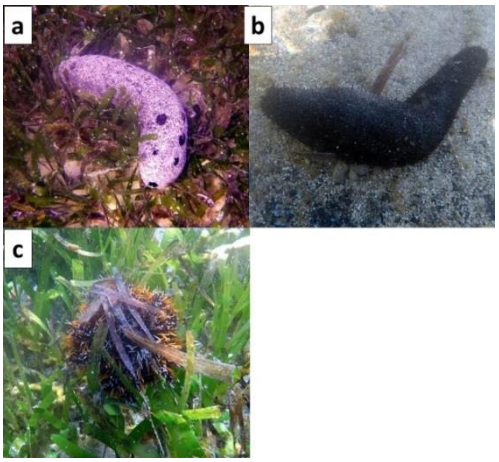

Fig. 3. Some commercially-important macrobenthic invertebrates encountered in the coral reefs and seagrass beds surrounding Pag-asa Island, Kalayaan, Palawan, Philippines: lollyfish *Holothuria atra* (a), white threadfish *Holothuria leucospilota* (b), and gracious sea urchin *Tripnesteus gratilla* (c).

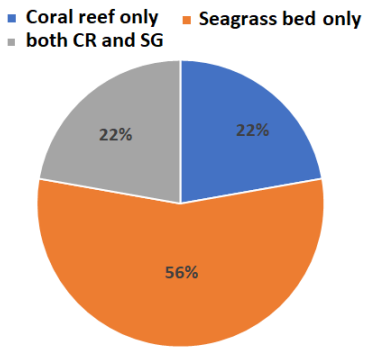

Fig. 4. Habitat distribution of some commercially-important macrobenthic invertebrates in coral reefs and seagrass beds surrounding Pag-asa Island, Kalayaan, Palawan, Philippines.

There are 78 gastropod and bivalve species previously reported by Hombre et al. (2016) of which most of them were not noted in this study which may also suggest overharvesting.

In spite of the presence of a Philippine military base, areas around the island are continuously fished by various claimant countries (Mangosing, 2020). Forms of harvesting in Pag-asa are destructive (IMOA, 2020), which further push many species into the brink of extinction. One example is the true giant clam *Tridacna gigas* (Linnaeus, 1758) where only the shells were found in many areas within Palawan, and only a few living individuals occurred in well-managed reserves (Mecha and Dolorosa, 2020), suggesting that the once abundant species has been decimated by overharvesting. There are eight species of giant clams in the Philippines, and all of these occurred in Palawan (Ecube et al., 2019). Seven species were reported in TRNP (Dolorosa et al., 2015), but only two species were found in Pag-asa Island during the current survey. The largest giant clam species could occur even in shallow areas (Mecha and Dolorosa, 2020), but only a shell of *T. gigas* was found in Pag-asa. In spite of national laws which prohibit the collection and trade of these resources (Department of Agriculture, 1990, 2001), illegal fishing remains a

Table 1. Estimated mean density (ind.ha^{-1}) of commercially-important macrobenthic invertebrates in the coral reefs and seagrass beds surrounding Pag-asa Island, Kalayaan, Palawan, Philippines.

Station	Giant clams	Sea cucumbers	Sea urchins	Total
Reefs				
1	266.4	66.6	-	333.0
2	133.2	-	-	133.2
3	266.4	66.6	-	333.0
4	-	-	-	-
5	66.6	-	-	66.6
6	-	-	-	-
7	133.2	-	-	133.2
8	-	-	-	-
9	199.8	-	-	199.8
10	133.2	-	-	133.2
11	199.8	-	-	199.8
Mean (± SD)	127.15 (± 100.8)	12.11 (± 26.9)	-	139.25 (± 120.82)
Seagrass beds				
12	-	-	1,066.6	1,066.6
13	-	106.7	160.0	266.7
14	-	46.7	53.3	100.0
15	-	-	1,346.7	1,346.7
Mean (± SD)	-	38.35 (± 50.61)	656.65 (± 646.77)	695.00 (± 605.60)

Table 2. Conservation status of commercially-important macrobenthic invertebrates encountered in the coral reefs and seagrass beds surrounding Pag-asa Island, Kalayaan, Palawan, Philippines based on International Union for Conservation of Nature Red List status (IUCN, 2019).

Species	English name	Conservation status
Phylum Mollusca		
Tridacna crocea Lamarck, 1819	Boring giant clam	Least Concern
Tridacna maxima (Röding, 1798)	Small giant clam	Least Concern
Phylum Echinodermata		
Bohadschia argus Jaeger, 1833	Leopardfish	Least Concern
Bohadschia vitiensis (Semper, 1868)	Brown sandfish	Data Deficient
Holothuria atra Jaeger, 1833	Lollyfish	Least Concern
Holothuria leucospilota (Brandt, 1835)	White thread fish	Least Concern
Tripneustes gratilla (Linnaeus, 1758)	Gracious sea urchin	Not Assessed

Table 3. Occurrence of macrobenthic invertebrates encountered in the coral reefs and seagrass beds surrounding Pag-asa Island, Kalayaan, Palawan, Philippines during the 2008 and 2018 surveys. (Note: positive (+) sign means presence of such macrobenthic invertebrates during the survey).

Species	Gonzales et al. (2008)	This study
Phylum Mollusca		
Tridacna maxima (Röding, 1798)	+	+
Tridacna crocea Lamarck, 1819	+	+
Rochia nilotica (Linnaeus, 1767)	+	
Phylum Echinodermata		
Bohadschia argus Jaeger, 1833		+
Bohadschia vitiensis (Semper, 1868)		+
Holothuria atra Jaeger, 1833		+
Holothuria leucospilota (Brandt, 1835)		+
Panulirus versicolor (Latreille, 1804)	+	
Sipunculid	+	
Tripneustes gratilla (Linnaeus, 1758)	+	+

problem as manifested by over a ton of empty giant clam shells been recently confiscated in Taytay, Palawan (PCSD, 2020). This volume may only represent a small portion of the whole illegal shell trading industry, hence, the control of these destructive activities require more vigilance on the part of our authorities and concerned citizens.

In terms of sea cucumbers, only four commercially exploited species were encountered during the survey. This number is much lesser compared to the species richness of sea cucumbers in Palawan. There are 36 commercially exploited sea cucumber species that has been recorded in the whole province of Palawan (Jontila et al., 2014), 24 species in Rasa Island (Dolorosa et al., 2017), 18 species in TRNP (Dolorosa, 2015), 14 species in Arreceffi Island (Jontila et al., 2017) and 10 species in Cawili Island (Ardines et al., 2020). The accessible habitats and other characteristics such as slow movement and growth, make the sea cucumbers highly prone to overharvesting. In fact, local extinction has already been reported in some places (Anderson et al., 2010; Jontila et al., 2014).

Lobsters, although active during the night, could have been documented in Pag-asa even during the day sampling as has been reported by Gonzales et al. (2008) and in other areas in the Philippines (Juinio-Meñez and Gotanco, 2004). Three commercially exploited lobster species in Palawan include *Panulirus ornatus* (Fabricius, 1798), *Panulirus longipes longipes* (A. Milne-Edwards, 1868), and *P. versicolor* (Gonzales and Taniguchi, 1995), but none of these were spotted during the day survey in coral reefs of Pag-asa Island in 2018 survey. Lobster is one of the most expensive and exploited macrobenthic invertebrates and could have been overharvested in the island. These species were once abundant in many parts of Southeast Asia particularly in the Philippines, but has disappeared following extensive harvest and habitat destruction (Juinio-Meñez and Gotanco, 2004).

Other large reef gastropods could have been easily spotted on the reefs, but were not noted during the survey. Top shells *R. nilotica* and horned helmet *Cassis cornuta* (Linnaeus, 1758) are commonly encountered in the intertidal areas of TRNP, but were no longer noted in many open access reef areas in Palawan (Dolorosa et al., 2015). There are many areas where localised extinction of some large reef gastropods were noted in Palawan (Dolorosa et al., 2015; Dolorosa et al., 2016) and South China Sea (Neo et al., 2017).

Large and high valued species are the first target and when overexploitation occurs, it is followed by a shift in fishery, targetting the smaller and less valued species (Jontila et al., 2014). Also, as the nearshore fishing grounds deteriorate, the fishers tend to go further offshore in search of new fishing grounds (Bell et al., 2018). The influx of fishing vessels (mostly of foreign countries) in offshore areas especially in the West Philippine Sea (Mangosing, 2020) suggests that most open access areas near coastal communities in the mainland were overfished (Gonzales et al., 2008).

Abundance

The mean density of giant clams (*Tridacna* spp.) (127.15 ind.ha^{-1}) in this study is higher compared to the previous record (43 ind.ha^{-1}) of Gonzales et al. (2008). This increase is attributed by the local fishers/residents to the protection of nearby reefs in recent years, although this variation could be sampling related. Continued monitoring may prove the claims of the fishers. Giant clam density in the island is lower compared to the reported density of giant clams in other parts of Palawan such as Apulit Island, a high-end resort which helps protect the surrounding marine resources (Gonzales et al., 2014) (Table 4). Studies have shown the essential contribution of private sectors (e.g. resorts) in global

resource conservation (Bhattacharya and Managi, 2012; Jontila et al., 2017), thus there is a need for a strong public-private partnership to ensure effective protection of the marine resources.

High abundance giant clams provide a significant contribution to the complexity of the reef. They provide food and shelter to various organisms and have been found to help increase fish abundance. There is a worldwide decline in giant clam population because of overharvesting (Mingoa-Licuanan and Gomez, 2007; Neo et al., 2015; Neo et al., 2017) and several efforts were made to reverse this trend, including the release of hatchery produce juveniles in the Philippines. Mingoa-Licuanan and Gomez (2007) restocked 271 adult/sub-adults and 2,314 juvenile giant clams in Pag-asa Island, but the current state of restocked clam has not been reported. The success of any restocking activity mainly depends on the cooperation of local counterparts. Hence, collaborative efforts among various sectors are needed to maintain the abundance of these species.

In terms of sea cucumber density, this study recorded a higher population density (71.65 ind.ha^{-1}) than in 2008 survey which again could be attributed to the more protection of nearby reefs in recent years. This data is also higher compared to the density records in other reefs in Palawan, such as TRNP (41.93 ind.ha^{-1}) (Dolorosa, 2015) and Rasa Island, Narra (52.95 ind.ha^{-1}) (Dolorosa et al., 2017), but much lower than in Arreceffi Island (358.53 ind.ha^{-1}) (Jontila et al., 2017) (Table 5). The study in TRNP only included large individuals exposed on a reef slope and did not cover the intertidal area where many juveniles are found. On the other hand, Arreceffi Island houses a world-class resort which effectively protects the surrounding areas from fishing, including the harvesting of sea cucumbers.

There is also a variation in the density of gracious sea urchin *T. gratilla* among stations. The higher densities in Stations 12 and 15 could be associated with its wider seagrass beds, a usual habitat of gracious sea urchin. The overall mean density (656.65 ind.ha^{-1}) in Pag-asa Island is lower compared to the previous study of Balisco (2015) in the same stations with 3,500 ind.ha^{-1} (Table 6). It is also lower compared to southern Guimaras (2,600 ind.ha^{-1}) and northwestern Luzon (1,000 ind.ha^{-1}) (Juinio-Meñez et al., 2008; Regalado et al., 2010). The 2008 survey estimated only 18 ind.ha^{-1} (Gonzales et al., 2008) Variations in densities could be related to different habitats, the effect of predation, and level of exploitation (Dolorosa et al., 2017).

The occasional harvesting of sea urchins for food by the residents of Pag-asa may not be a big threat to its population. Sustainable harvesting of sea urchin roe (i.e. gonad) for export could be a potential source of income. It could also be introduced to tourists as exotic food (Gonzales et al., 2008; Balisco, 2015), which may help improve the living conditions of the residents. If commercial harvesting will be done, it is important to regulate the harvest process to avoid the collapse of this fishery as what had happened in some parts of the country (Juinio-Meñez et al., 2008).

Conservation status

The global populations of giant clams only fall under the "Least Concern" status (IUCN, 2019), but all giant clam species in the Philippines are protected (Department of Agriculture, 1990, 2001) because of continued threat in their populations (Neo et al., 2017). These species are protected through the enactment of the Republic Act 9147 or Wildlife Protection and Conservation Act (Republic Act, 2001) and the Republic Act 8550 or The Fisheries Code of the Philippines as amended by Republic Act 10654 (Republic Act, 2010). At the same time, giant clams in Palawan are locally protected through Resolution No. 10-413 of the Palawan Council for Sustainable Development (PCSD, 2010). Other efforts are also made to increase the wild populations thru hatcheries and stock enhancement. For example, the Western Philippines University in partnership with the Malampaya Foundation, Inc. and the University of the Philippines Marine Science Institute is currently working on the propagation of giant clams for restocking purposes. However, the challenges faced by many restocking initiatives require additional scientific information for this group of macrobenthic invertebrates when crafting conservation and management policies especially in areas where they are considered locally-extinct (Neo et al., 2017).

The sea cucumbers listed in this study are also of Least Concern/Data Deficient in IUCN Red List (2019). However, the local populations of these species are heavily affected by unregulated harvesting (Jontila et al., 2014). With the disappearance of high valued species, many of the harvested species are now of "low" value and undersize which means that these are possibly juveniles (Anderson et al., 2010; Dolorosa et al., 2017). When uncontrolled, this situation can lead to recruitment overfishing (Anderson et al., 2010) and the eventual collapse of the fishery.

The sea urchin *T. gratilla* is generally harvested for sustenance but several studies have shown that overfishing caused the decline of its natural populations (Juinio-Meñez et al., 2008). Trials on the grow-out culture of this important echinoid species have been carried out in some parts of the Philippines (Juinio-Meñez et al., 2008) for food and conservation purposes.

While IUCN Red List (2019) listed *B. argus* and *H. atra* as "Least Concern", it is also important to note that these are heavily exploited in some parts of mainland Palawan (Jontila et al., 2014). In the case of *B. vitiensis* where its IUCN status is "Data Deficient", population

Table 4. Population density (ind.ha^{-1}) of giant clams in different locations in Palawan, Philippines.

Station	Location (Municipality)	Density (ind.ha^{-1})	Source
Apulit Island	Taytay	681.0	Gonzales et al. (2014)
Tubbataha Reefs	Cayancillo	22,000.0	Conales et al. (2015)
Pag-asa Island	Kalayaan	53.0	Gonzales et al. (2008)
Pag-asa Island	Kalayaan	174.8	This study

Table 5. Population density (ind.ha^{-1}) of sea cucumbers from different locations in Palawan, Philippines.

Station	Location (City/Municipality)	Density (ind.ha^{-1})	Source
Tubbataha Reefs	Cagayancillo	41.93	Dolorosa (2015)
Arreceffi Island	Puerto Princesa City	358.53	Jontila et al. (2017)
Rasa Island	Narra	52.95	Dolorosa et al. (2017)
Pag-asa Island	Kalayaan	53.00	Gonzales et al. (2008)
Pag-asa Island	Kalayaan	174.80	This study

Table 6. Population density (ind.ha^{-1}) of gracious sea urchin *Tripneustes gratilla* from different locations in the Philippines.

Location	Density (ind.ha^{-1})	Source
North western Luzon	1,000.00	Juinio-Meñez et al. (2008)
Southern Guimaras	2,600.00	Regalado et al. (2010)
Pag-asa Island	18.00	Gonzales et al. (2008)
Pag-asa Island	3,500.00	Balisco (2015)
Pag-asa Island	656.65	This study

assessment of this species must be conducted as bases for local conservation initiative. Not all sea cucumbers are well studied, and most of these organisms are in the brink of local extinction if not properly managed before they can be studied (Anderson et al., 2010; Jontila et al., 2014). Inclusion of the known sea cucumber habitats in marine protected areas may help restore the reduced populations. In addition, artificial propagation, hatchery, and stock enhancement may be carried out in areas where there is a strong partnership between government and people's organisation.

Conclusion

The species richness of economically harvested species was low. The absence of six giant clam species such as *Hippopus hippopus* (Linnaeus, 1758), *Hippopus porcelanus* Rosewater, 1982, *Tridacna derasa* (Röding, 1798), *T. gigas*, *Tridacna noae* (Röding, 1798), *Tridacna squamosa* Lamarck, 1819, and some common large gastropods such as *R. nilotica*, and *C. cornuta* is an indication of localised extinction. The low species richness is further supported by the low abundance of target species, except for sea urchin as these are not processed or preserved yet but are consumed only within the island. The paucity of the species around the island is further supported by their respective conservation status. Only Data Deficient or Least Concern species were found suggesting that endangered species are already difficult to find in the area. The areas around Pag-asa Island and the whole of the West Philippine Sea is exposed to unregulated fishing in spite of their remoteness, which could have heavily impacted the less mobile and easy to harvest macrobenthic invertebrates. Effective long-term protection of these species and their habitats could help restore the depleted populations which in the future could be promoted as part of eco-tourism.

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