Commonly gleaned macro-benthic invertebrates in a small offshore island of Cawili, Cagayancillo, Palawan, Philippines

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ABSTRACT

The inhabitants of small offshore islands are highly dependent on the health and availability of their resources. However, pieces of information about the commonly gleaned species in some remote areas are sparsely documented. In this study, we inventoried the species composition of the widely gleaned macro-benthic invertebrates such as gastropods, bivalves, and sea cucumbers in Cawili Island, a small inhabited island in the middle of the Sulu Sea in Palawan, Philippines. The samples obtained from fishers and snorkeling activities in shallow areas revealed a total of 86 species belonging to 27 families. Most of these were gastropods, composed of 68 species under 20 families. The list includes nine protected species (four gastropods, two bivalves, and three sea cucumbers). Gastropods and bivalves were mostly used for food and display in the house of the fishermen (souvenir), while the sea cucumbers were exclusively harvested for trade. Sustainable fishery activities are needed in this small offshore island where people heavily rely on their marine resources.

Keywords: bivalves, coastal communities, echinoderms, gastropods, reef-walking

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INTRODUCTION

There are around 22,000 species of mollusks in the Philippines. The marine species constitute the largest number with the gastropods representing about 68% (Cabrera 1987). Intertidal mollusks such as macro-benthic marine gastropods and bivalves play major roles in promoting a balanced ecosystem. Coastal communities heavily rely on these resources as food source of livelihood and revenues, which include the multi-million-dollar shell craft industry (Gallardo et al. 1995; Whittingham et al. 2003; Floren 2003; Dolorosa et al. 2016). The shells of *Rochia nilotica* or topshell form part of the lucrative pearl button industry (Floren 2003; Bell et al. 2005). On the other hand, the large shells of giant clams (*Tridacna gigas* and *T. derasa*) are used as carving materials (Larson 2016; Neo 2017), or polished into fake giant clam pearls (Krzemnicki and Cartier 2017). Consequently, mollusk

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populations are in decline in spite of their huge social, economic, and cultural values (Floren 2003; Rogers-Bennett et al. 2013; Neo et al. 2015, 2017).

The sea cucumbers are also popular target species (Choo 2008; Hasan and Abd El-Rady 2012) because of their high market value (Purcell 2014), and as sources of substances with pharmacological importance (Choo 2008). They also play an essential role in enhancing the ocean's productivity by recycling of sediments (Uthicke 2001; Conand 2006). Worldwide, there are over 1,400 sea cucumber species (Kerr and Kim 2001), and medium-high valued species had been overexploited in most countries (Lovatelli et al. 2004). In Palawan, Philippines, there are more than one hundred sea cucumber species (Jontila et al. 2017), and overharvesting has also been reported for some species in small islands proximate to the mainland Palawan (Dolorosa et al. 2017; Jontila et al. 2018).

In offshore islands with limited land areas for agriculture, the lives of the people are highly dependent on the health and availability of its marine resources. Unregulated fishing which includes gleaning or reef walking can cause habitat degradation, reduction in the abundance of target species (Ashworth et al. 2004; Cardinale et al. 2011; Al-Wazzan et al. 2020), localized extinction (Neo and Todd 2013), and massive impact on the lives of those highly dependent on fishing. While there were studies about the mollusks (Dolorosa et al. 2015; Hombre et al. 2016), and sea cucumbers (Jontila et al. 2014, 2017; Dolorosa et al. 2017) in some areas of Palawan, many small island communities are understudied. Identifying the commonly gleaned species in Cawili Island can, therefore, provide information on what species are available, what are its potential uses, which species are protected, and offer insights in crafting effective management and conservation policies for the island.

METHODS

Cawili Island (8°16'42" N, 120°48'57" E) in the middle of the Sulu Sea, is about 232 km southeast of Puerto Princesa City, Palawan (www.GoogleEarth.com). It is one of the major islands of Cagayancillo, a 6th class municipality in the Province of Palawan. Covering about 0.75 km^2, the generally flat (2 m above sea level) sandy-rocky island support only a limited variety of crops, including corn and coconut palm. The 150 families living on the island mostly depend on fishing, seaweed farming, gleaning, and harvesting of sea cucumbers (Dygico 2016).

Commonly gleaned species were photo-documented on several occasions from April to May 2018. Shells of gastropods and bivalves displayed in the houses of the residents were photo-documented. Snorkeling activities on shallow seagrass beds and walking on rocky areas during day low tides were conducted to record the occurrence of the species in their natural habitats. The

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sizes of photographed species were noted. The locals were also asked about the vernacular names and the uses of the species, categorized into three: for food, souvenir (display only in the house of fishers), and trade. The species were grouped by family and arranged alphabetically. The photos were arranged in the same order of their occurrence on the table. The figure caption included the scientific name and size of each species in the picture.

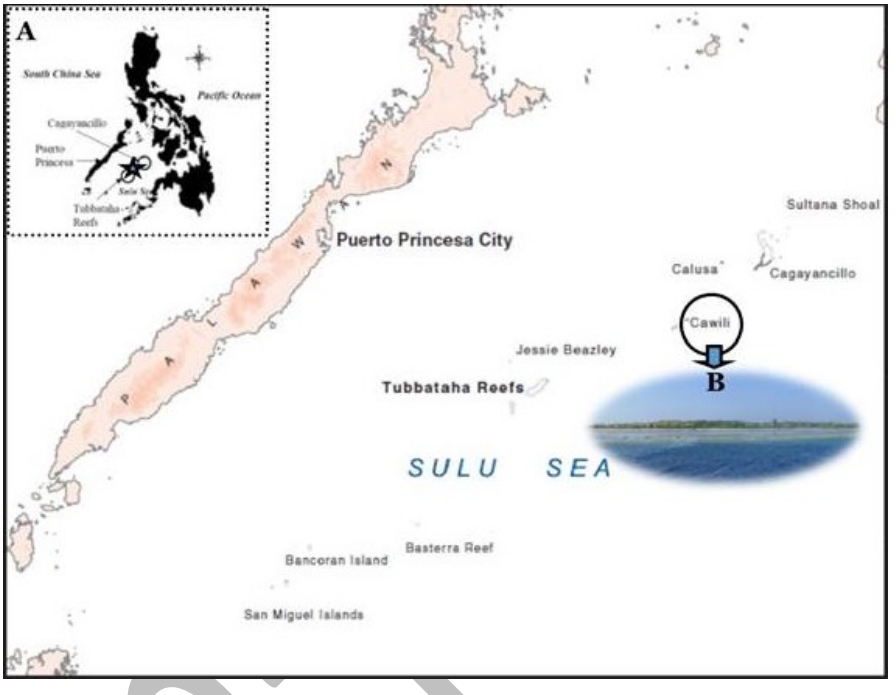

Figure 1. Map of the Philippines (A) and the location of Cawili Island (B) where the study was conducted.

The works of Springsteen and Leobrera (1986), Carpenter and Niem (1998), Kerr et al. (2006), and Jontila et al. (2014) aided the identification of the different species. The updated scientific names were obtained from the World Register of Marine Species (WoRMS 2020).

RESULTS

A total of 86 species belonging to 27 families were recorded. Gastropods had the most number (68 species), followed by sea cucumbers (10 species) and bivalves (7 species) (Table 1-3; Figure 2-7). Among the gastropods, family Cypraeidae had the highest number (21%) represented by 14 species, followed by family Strombidae with 11 (16%) species (Figure 8a).

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Bivalves were mainly composed of families Cardiidae and Tellinidae, each represented by two species (29%) (Figure 8b). Family Holothuriidae had the most number (90%) of species among the sea cucumbers (Figure 8c). Thirty species of gastropods were used as food, while 20 species were for display only (Table 1; Figure 9). Of the seven species of bivalves, six were exploited for food and the shells were mostly used for display or souvenir (Table 2; Figure 9). Majority (90%) of the sea cucumbers fall under the family Holothuriidae, and all species were collected for trade purposes (Table 3; Figure 9).

Table 1. List and usage of commonly gleaned species of gastropods in Cawili, Cagayancillo, Palawan. F- food, S – souvenir, T – trade.

Family Name	English Name	Scientific Name	Local Name (Cagayanen)	Usage		
				F	S	T
Astraeinae	Common Delphinula	*Angaria delphinus*	Bokotan		/	
Bullidae	Ampulle Bulla	*Bulla ampulla*	Bonbolan		/	
Cassidae	Vitex Bonnet	*Casmaria erinaceus*	Sosobla		/	
	Horned Helmet	*Cassis cornuta*	Tambuli	/	/	
	Bullmouth Helmet	*Cypraecassis rufa*	Tambuli	/	/	
	Few-wrinkled Bonnet	*Phalium glaucum*	Sosobla		/	
Cerithiidae	Necklace Cerith	*Clypeomorus batillariaeformis*	Gibaw gibaw		/	
	Rough Vertagus	*Rhinoclavis aspera*	Gang gasang		/	
	Banded Vertagus	*Rhinoclavis fasciata*	Tetendaw	/	/	
	Common Vertagus	*Rhinoclavis vertagus*	Pepindaw	/	/	
Conidae	Abbreviated Cone	*Conus abbreviatus*	Tambroso		/	/
	Hebrew Cone	*Conus ebraeus*	Tambroso		/	/
	False Virgin Cone	*Conus emaciatus*	Tambroso	/	/	
	Turtle Cone	*Conus ermineus*	Tambroso	/	/	
	Red Sea Cone	*Conus erythraeensis*	Tambroso	/	/	
	Lettered Cone	*Conus litteratus*	Tambroso	/	/	
	Magical Cone	*Conus magus*	Tambroso	/	/	
	Feathered Cone	*Conus pennaceus*	Uyok-uyok	/	/	
	Flea-Bite Cone	*Conus pulicarius*	Tambroso		/	/
	Virgin Cone	*Conus virgo*	Tambroso	/	/	
Cymatiidae	Trumpet Triton	*Charonia tritonis*	Trumpet	/	/	

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Family Name	English Name	Scientific Name	Local Name (Cagayanen)	Usage		
				F	S	T
	Cosmopolitan hairy triton	*Monoplex aquatilis*	Lampas	/	/	
Cypraeidae	Turtle Cowrie	*Chelycypraea testudinaria*	Tamblilo		/	/
	Tiger Cowrie	*Cypraea tigris*	Tamblilo		/	/
	Wandering Cowrie	*Erronea errones*	Tamblilo		/	/
	Map Cowrie	*Leporicypraea mappa*	Mapa-mapa		/	
	Pacific Deer Cowrie	*Lyncina vitellus*	Tamblilo		/	/
	Arabian Cowrie	*Mauritia arabica*	Baboy-baboy	/	/	
	Depressed Cowrie	*Mauritia depressa*	Mangyan		/	/
	Eglantine Cowrie	*Mauritia eglantina*	Baboy-baboy	/	/	
	Gold-ringer Cowrie	*Monetaria annulus*	Sigay mama	/	/	/
	Money Cowrie	*Monetaria moneta*	Sigay		/	/
	King's Cowrie	*Naria bernardi*	Baboy-baboy		/	
	Erosa Cowrie	*Naria erosa*	Tamblilo	/	/	
	Graceful Cowrie	*Purpuradusta gracilis*	Tamblilo		/	/
	Teres Cowrie	*Talostolida teres*	Tamblilo		/	/
Fasciolariidae	Threaded Band Shell	*Filifusus filamentosus*	Tabaco		/	/
Mitridae	Episcopal Miter	*Mitra mitra*	Mitra-mitra		/	/
	Papal Miter	*Mitra papalis*	Mitra-mitra		/	/
Nassariidae	Whitesh Nassa	*Nassarius albescens*	Suso		/	/
		Nassarius limnaeiformis	Tangad-tangad		/	
		Nassarius velatus	Suso		/	
	Lovely Nassa	*Nassarius venustus*	Suso		/	
Naticidae	Black-mouth Moon snail	*Mammilla melanostoma*	Bonbolan		/	
	Pear-shaped Moon snail	*Polinices mammilla*	Bonbolan		/	
Neritidae	Horny Nerite	*Neritodryas cornea*	Lebeng-lebeng		/	
	Little Bear Conch	*Canarium urceus*	Siksikad	/		
	Strawberry Conch	*Conomurex luhuanus*	Silan	/		
Strombidae	Diana Conch	*Euprotomus aurisdianae*	Langa-langa	/		
	Bubble Conch	*Euprotomus bulla*	Langa-langa	/		

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Family Name	English Name	Scientific Name	Local Name (Cagayanen)	Usage		
				F	S	T
	White Hump Conch	*Gibberulos gibberulus*	Siksikad	/		
	White hump-back Conch	*Gibberulos gibberulus albus*	Siksikad	/		
	Gibbo Conch	*Gibberulos gibberulus gibbosus*	Siksikad	/		
	Chiragra Spider Conch	*Harpago chiragra*	Salagra		/	/
	Orange Spider Conch	*Lambis chrocata*	Pangahan	/		
	Milled Spider Conch	*Lambis millepeda*	Pangahan	/	/	
	Silver Conch	*Lentigo lentiginosus*	Langa-langa	/		
Terebridae	Marlinspike	*Oxymeris maculata*	Onsoy-onsoy		/	
	Spotted Auger	*Terebra guttata*	Onsoy-onsoy		/	
Tonnidae	Pacific Grinning Tun	*Malea pomum*	Subla-subla		/	
	Pacific Partridge Tun	*Tonna perdix*	Subla-subla		/	
Trochidae	Commercial Trochus	*Rochia nilotica*	Samong		/	/
	Maculated Top	*Trochus maculatus*	Dipulos		/	
Turbinellidae	Common Pacific Vase	*Vasum turbinellus*	Lomboy-lomboy		/	
Turbinidae	Gold-mouth Turban	*Turbo chrysostomus*	Bugtungan	/	/	
	Tapestry Turban	*Turbo petholatus*	Bogtungan	/	/	
Turridae	Bayer's Turrid	*Glyphostoma bayeri*	Tangad-tangad		/	
Volutidae	Bat Volute	*Cymbiola vespertilio*	Uk-uyok	/	/	
TOTAL				30	59	18

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Table 2. List and usage of commonly gleaned species of bivalves in Cawili, Cagayancillo, Palawan. F- food, S – souvenir, T – trade.

Family Name	English Name	Scientific Name	Local Name (Cagayanen)	Usage		
				F	S	T
Mactridae	Smooth Beach Clam	*Atactodea striata*	Basala	/	/	/
Ostreidae	Black lip pearl oyster	*Pinctada margaritifera*	Tabah	/		
Psammobiidae	Agrutan	*Asaphis violascens*	Beggat-beggat		/	
Tellinidae	Cat's tongue tellin	*Scutarcopagia linguafelis*	Tuway	/	/	
	Virgate tellin	*Tellinella virgata*	Tuway	/	/	
Cardiidae	China clam	*Hippopus hippopus*	Basa	/	/	/
	Floated/Scaly clam	*Tridacna squamosa*	Manelet	/	/	/
TOTAL				6	6	3

Table 3. List and usage of commonly gleaned species of sea cucumber in Cawili, Cagayancillo, Palawan. F- food, S – souvenir, T – trade.

Family Name	English Name	Scientific Name	Local Name (Cagayanen)	Usage		
				F	S	T
Holothuriidae	Leopard fish	*Bohadschia argus*	Batik-batik			/
	Chalky sea cucumber	*Bohadschia marmorata*	Tagekan			/
		Bohadschia sp.	Tagekan			/
	Brown sandfish	*Bohadschia vitiensis*	Tagekan			/
	Black beauty	*Holothuria atra*	Sapatos			/
	Ashy pink sea cucumber	*Holothuria fuscocineria*	Batonan			/
	White teatfish	*Holothuria fuscogilva*	Susohan			/
	Sandfish	*Holothuria scabra*	Koltero			/
	Prickly redfish	*Thelenota ananas*	Talipan			/
Stichopodidae	Selenka's sea cucumber	*Stichopus horrens*	Hanginan			/
TOTAL						10

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Figure 2. Commonly gleaned species of gastropods collected in Cawili, Cagayancillo, Palawan. A) *Angaria delphinus*, 3.8 cm*;* B) *Bulla ampulla*, 4.5 cm; C) *Casmaria erinaceus*, 4.6 cm; D) *Cassis cornuta*, 8.3 cm; E) *Cypraecassis rufa*, 7.9 cm; F) *Phalium glaucum*, 5.2 cm; G) *Clypeomorus batillariaeformis*, 2.2 cm; H) *Rhinoclavis aspera*, 3.2 cm; I) *Rhinoclavis fasciata*, 6.9 cm; J) *Rhinoclavis vertagus*, 5.1 cm; K) *Conus abbreviatus*, 2.9 cm; L) *Conus ebraeus*, 3.7 cm; M) *Conus emaciatus*, 6.8 cm; N) *Conus ermineus*, 3.6 cm; O) *Conus erythraeensis*, 3.8 cm; P) *Conus litteratus,* 7 cm; Q) *Conus magus*, 5.6 cm.

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Figure 3. Commonly gleaned species of gastropods collected in Cawili, Cagayancillo, Palawan. A) *Conus pennaceus*, 10.9 cm; B) *Conus pulicarius*, 4.5 cm; C) *Conus virgo*, 5.8 cm; D) *Charonia tritonis*, 14.9 cm; E) *Monoplex aquatilis*, 8.5 cm; F) *Chelycypraea testudinaria*, 10 cm; G) *Cypraea tigris*, 7.2 cm; H) *Erronea errones*, 2.6 cm; I) *Leporicypraea mappa*, 8 cm; J) *Lyncina vitellus*, 5.2 cm; K) *Mauritia arabica*, 4.7 cm; L) *Mauritia depressa*, 2.6 cm; M*) Mauritia eglantina*, 5.7 cm; N) *Monetaria annulus*, 2.5 cm; O) *Monetaria moneta*, 2.8 cm; P) *Naria bernardi*, 4.4 cm; Q) *Naria erosa*, 3.4 cm.

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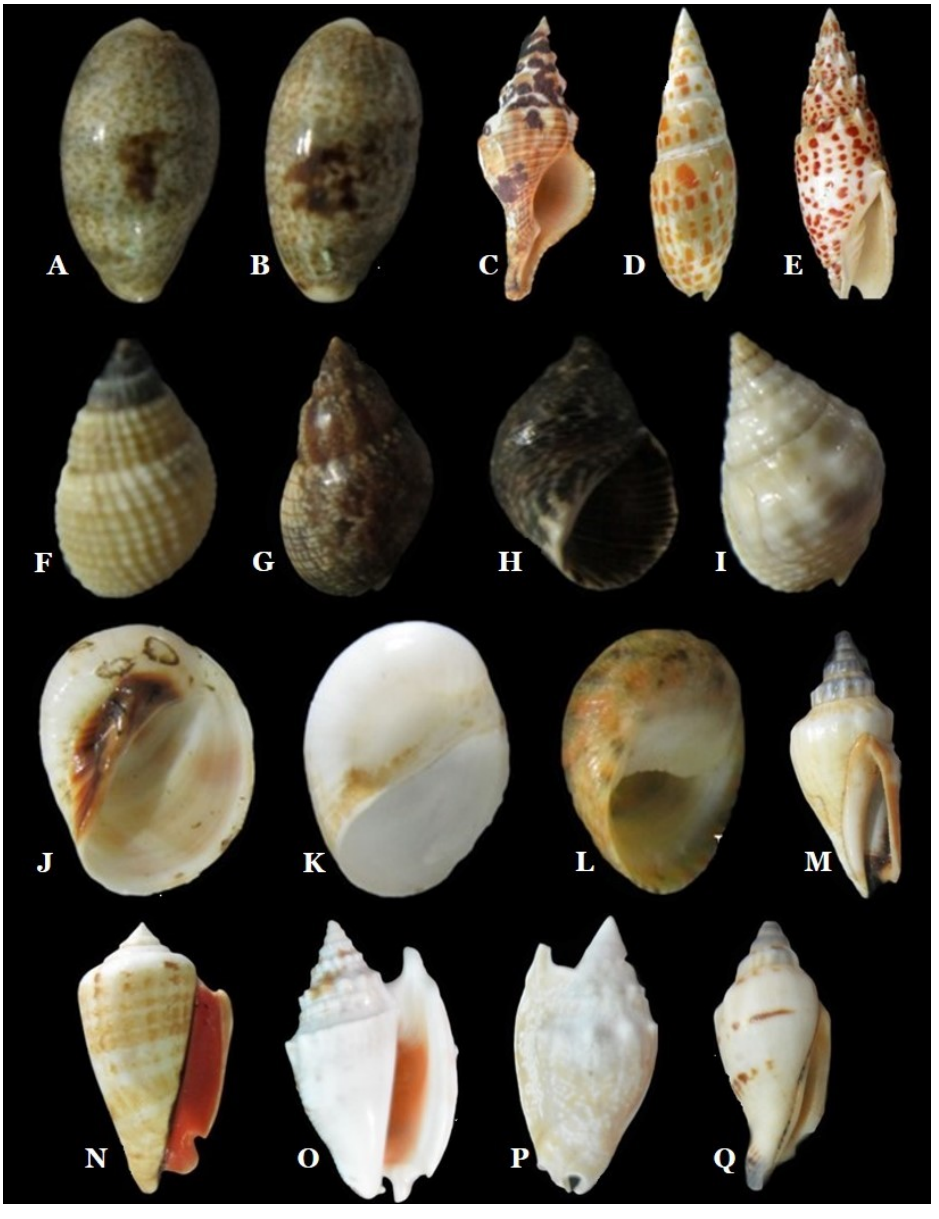

Figure 4. Commonly gleaned species of gastropods collected in Cawili, Cagayancillo, Palawan. A) *Purpuradusta gracilis*, 2.3 cm; B) *Talostolida teres*, 2.3 cm C) *Filifusus filamentosus*, 9 cm; D) *Mitra mitra*, 9.6 cm; E) *Mitra papalis*, 11.1 cm; F) *Nassarius albescens*, 1.5 cm; G) *Nassarius limnaeiformis*, 1.8 cm; H) *Nassarius velatus*, 1.7 cm; I) *Nassarius venustus*, 2.7 cm; J) *Mammilla melanostoma*, 3.5 cm; K) *Polinices mammilla*, 4.2 cm; L) *Neritodryas cornea*, 2.7 cm; M) *Canarium urceus*, 4.8 cm; N) *Conomurex luhuanus*, 5.6 cm; O) *Euprotomus aurisdianae*, 7.1 cm P) *Euprotomus bulla*, 7 cm; Q) *Gibberulus gibberulus*, 4.2 cm.

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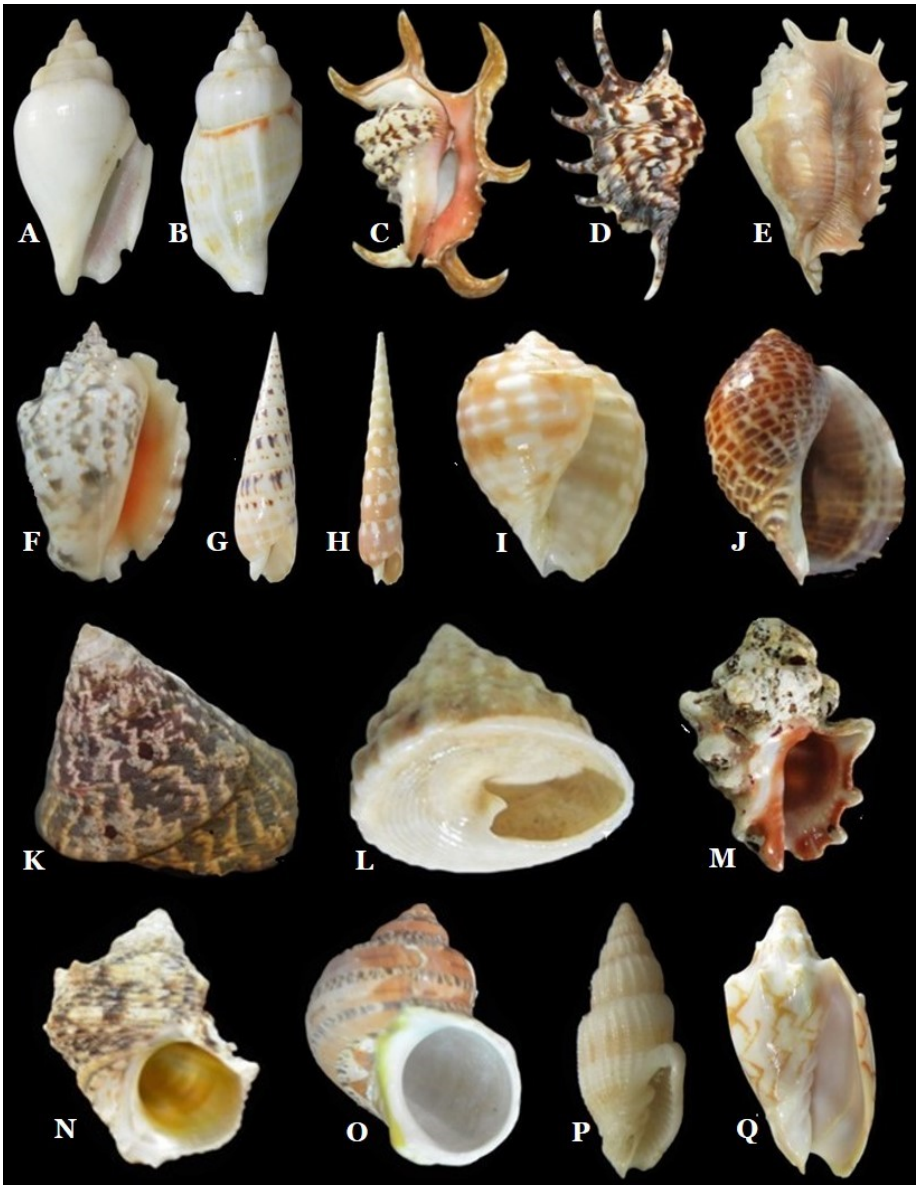

Figure 5. Commonly gleaned species of gastropods collected in Cawili, Cagayancillo, Palawan. A) *Gibberulus gibberulus albus*, 4.1 cm; B) *Gibberulus gibberulus gibbosus*, 7 cm; C) *Harpago chiragra*, 7.3 cm; D) *Lambis chrocata*, 6.1 cm; E) *Lambis millepeda*, 9.2 cm; F) *Lentigo lentiginosus*, 6.9 cm; G) *Oxymeris maculata*, 13.6 cm; H) *Terebra guttata*, 10.8 cm; I) *Malea pomum*, 4.8 cm; J) *Tonna perdix*, 6.9 cm; K) *Rochia nilotica*, 10 cm; L) *Trochus maculatus*, 3.6 cm; M) *Vasum turbinellus*, 5.2 cm; N) *Turbo chrysostomus*, 5.2 cm; O) *Turbo petholatus*, 6 cm; P) *Glyphostoma bayeri*, 2.6 cm; Q) *Cymbiola vespertilio,* 7.5 cm.

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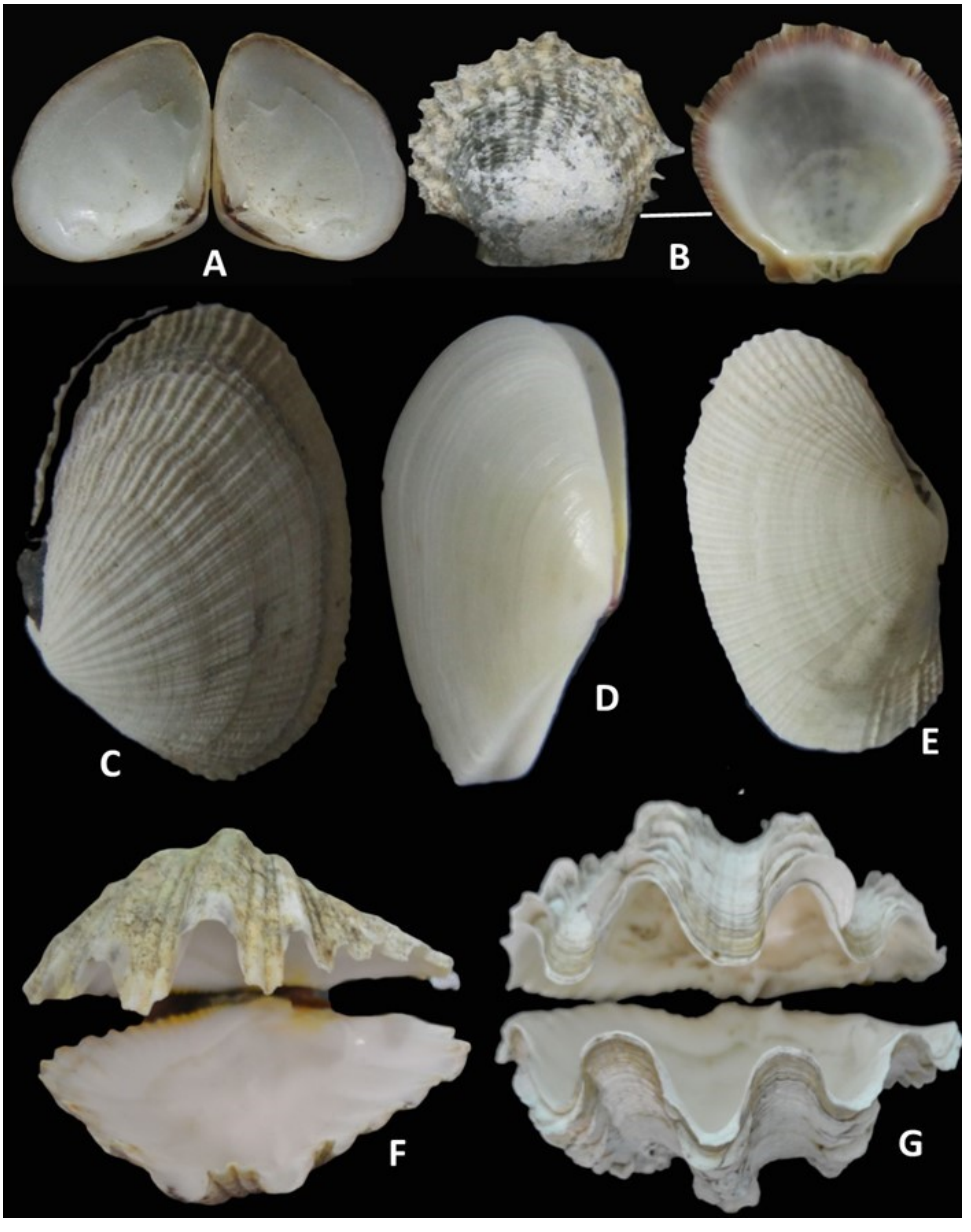

Figure 6. Commonly gleaned species of bivalves collected in Cawili, Cagayancillo, Palawan. A) *Atactodea striata*, 2.5 cm; B) *Pinctada margaritifera*, 4.9 cm; C) *Asaphis violascens*, 6.1 cm; D) *Tellinella virgata*, 4.1 cm; E) *Scutarcopagia linguafelis*, 4.3 cm; F) *Hippopus hippopus*, 14.3 cm; G) *Tridacna squamosa*, 13.2 cm.

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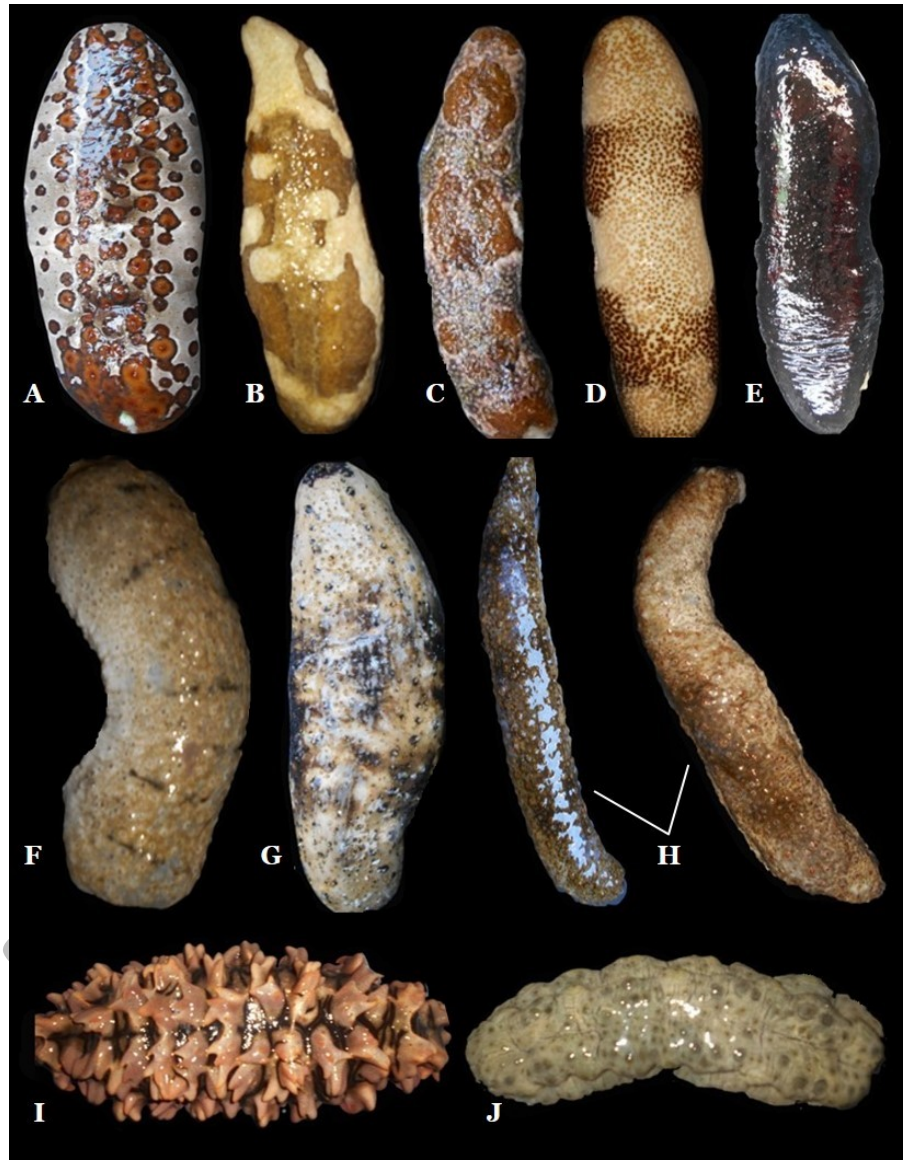

Figure 7. Commonly gleaned species of sea cucumbers collected in Cawili, Cagayancillo, Palawan. A) *Bohadschia argus,* 16.5 cm; B) *Bohadschia marmorata* 15.2 cm; C) *Bohadschia* sp., 19.3 cm; D) *Bohadschia vitiensis,* 20.1 cm; E) *Holothuria atra,* 18.2 cm; F) *Holothuria scabra,* 13.5 cm; G) *Holothuria fuscogilva,* 22.5 cm; H) *Holothuria fuscocineria,* 24.3 cm; I) *Thelenota ananas*, 18 cm; J) *Stichopus horrens,* 17.7 cm.

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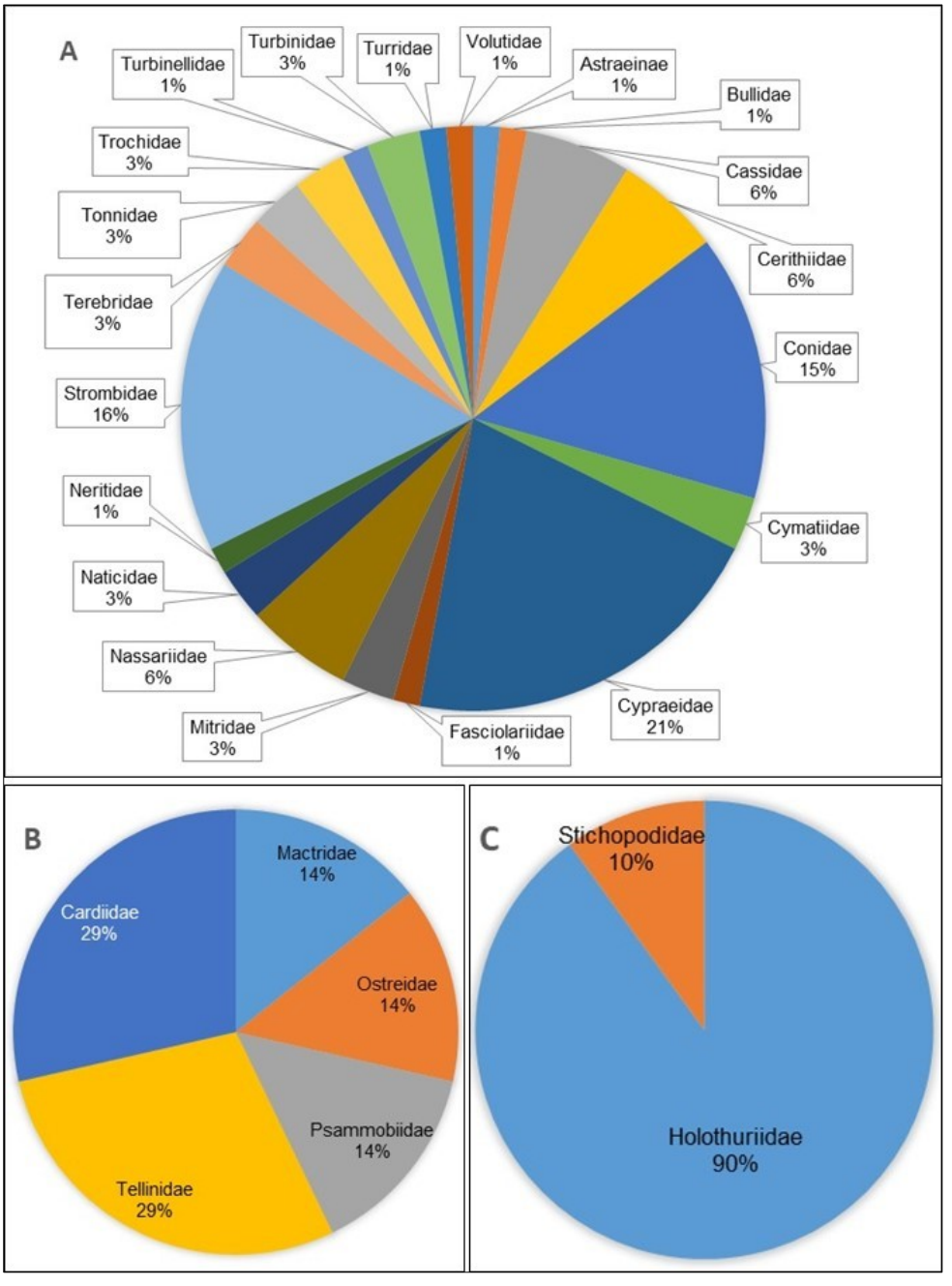

Figure 8. Percent composition of recorded species under the class Gastropoda (A), Bivalvia (B) and Holothuroidea (C).

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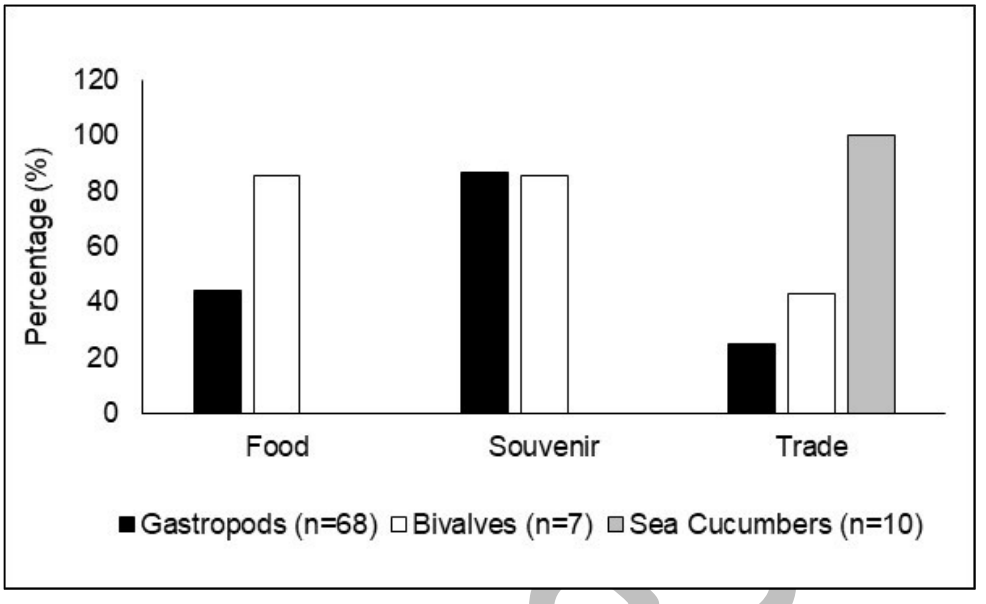

Figure 9. Percent usage of the commonly gleaned macrobenthic invertebrates in Cawili Island, Cagayancillo, Palawan, Philippines.

DISCUSSION

The number of recorded gastropod species in Cawili was comparable to other areas in Palawan, but not for bivalves and sea cucumbers (Table 4). Habitat complexity and level of disturbance (e.g., gleaning) are known to influence the number of marine species (Beauchamp and Gowing 1982; Dissanayake and Stefansson 2010; Pawar and Al-Tawaha 2017). Gleaning is a traditional unregulated method of collecting edible, and high valued marine macro-benthic invertebrates by walking on exposed habitats and shallow waters during the day and night low tides (Whittingham et al. 2003; Palomares et al. 2014; De Guzman et al. 2016). It is an essential source of food and an alternative livelihood (Whittingham et al. 2003; Nieves et al. 2010; De Guzman et al. 2016), but these activities can bring damage on the reef (Woodland and Hooper 1977) and overharvesting (Jontila et al. 2018). Habitat alteration and decline in abundance of target species could therefore, affect the health and well-being of coastal communities, especially for a remote island like Cawili where land resources for agriculture are limited.

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Table 4. Comparison in the number of commonly gleaned gastropods, bivalves, and sea cucumber from Cawili, Cagayancillo, Palawan to different studies, and localities in Palawan. (*) asterisk sign in the right column (Sources) is for the sea cucumber citation paper.

Area	Number of species recorded			Sources
	Gastropods	Bivalves	Sea Cucumbers	
Iwahig River-Estuary, PPC	50	15	-	Dolorosa and Dangan-Galon 2014
Tubbataha Reefs, Cagayancillo	79	17	16	Dolorosa et al. 2015; Dolorosa 2015*
Kalayaan Group of Island	69	9	-	Hombre et al. 2016
Turtle and Binunsalian Bay, PPC	89	19	-	Picardal and Dolorosa 2014
WPU-BMRS, Puerto Princesa City	64	8	-	Hombre 2015
Arreciffe Island, Honda Bay, PPC	-	-	14	Jontila et al. 2017*
Roxas, Palawan			16	Saclet 2013*
Balabac, Palawan	-	-	21	Idlan 2013*
Rasa Island, Narra, Palawan	-	-	24	Dolorosa et al. 2017*
Cawili, Cagayancillo	**68**	**7**	**11**	**This study**

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Many of the gastropods and bivalve shells are used for display, while the sea cucumbers are exclusively harvested for trade (Tables 1-3; Figure 8). Many of the displayed shells are of low value but these are used in the shell craft industry (Floren 2003). Included in the list of commonly gleaned marine resources in Cawili are nine protected species. Two gastropods: *C. cornuta* and *C. tritonis* are protected under the Fisheries Administrative Order (FAO) No. 158 of 1986 (Floren 2003; BFAR 2019), while the other two (*R. nilotica* and *C. rufa)* are protected under the Fisheries Administrative Order (FAO) No. 208 (DA 2001). The giant clams *Tridacna* spp. are listed in Appendix II of CITES, which means that the species are not necessarily threatened with extinction, but in which trade must be controlled, in order to avoid utilization

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incompatible with their survival (CITES 2020). All giant clams species in the Philippines are also protected under FAO No. 208 (DA 2001). On the other hand, the International Union for the Conservation of Nature (IUCN) classified the sea cucumber *Holothuria fuscogilva* as vulnerable. On the other hand, *Holothuria scabra* and *Thelenota ananas* are considered endangered (IUCN 2020). The presence of nine threatened species from the harvest of local fishers makes Cawili an important ecological refuge.

The prevalent harvest and consumption of protected species could further reduce their abundance (Newton et al. 1993; Dolorosa et al. 2016; Jontila et al. 2018). In spite of penalties for violators as stipulated in the Philippine law, the collection, consumption, and trade of threatened species remained a common problem in the Philippines (Floren 2003; Dolorosa et al. 2016; PCSD 2020) and elsewhere (Deines 2018; Patankar 2019; Gamboa-Alvarez et al. 2020). The inclusion of threatened species as part of the catch in Cawili Island might be associated with the remoteness of the area, weak law implementation, lack of awareness on the part of the fisherfolks, and the tradition of having these creatures as part of their diets.

Many studies have shown that unregulated exploitation has resulted in a population decline of mollusks (e.g., Rogers-Bennett et al. 2013; Dolorosa et al. 2016) and sea cucumbers (Purcell 2010; Jontila et al. 2018; Gamboa-Alvarez et al. 2020). These species are less mobile and highly visible in their shallow habitats, which make them vulnerable to overharvesting. The overharvesting of threatened species like *C. cornuta* and *C. tritonis* is considered a contributing factor in the outbreak of their prey like the Crown-of-Thorn starfish *Acanthaster planci* (Tewfik and Scheuer 2013), which fed on coral polyps and created significant damage on the reef (De'ath et al. 2012). It is, therefore, essential to conserve these vanishing species to avoid the unprecedented impact of ecological imbalance.

Of the eight giant clam species found in the country (Dolorosa et al. 2015; Ecube et al. 2019), only two species have been encountered in Cawili. The absence of other giant clam species may suggest localized extinction as also been reported in many areas within Palawan (Mecha and Dolorosa 2020), the Philippines (Gomez and Mingoa-Licuanan 2006), and other countries (Neo and Todd 2013; Neo et al. 2019). Only in well-managed reserves/resorts where populations of giant clams remained high (Conales et al. 2015; Daño et al. 2020). The giant clams are ecologically important as reef builders, shelter, and food source to many reef organisms (Neo et al. 2015). Hence, their presence in high numbers could enhance fish abundance (Cabaitan et al. 2008).

Sea cucumber fishery provides an essential source of income for the unemployed (Choo 2008; Dolorosa et al. 2017), especially for the inhabitants of Cawili Island. This study did not record the sizes of dried sea cucumbers,

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but judging from the observed sizes of dried sea cucumbers in Cawili, many were already undersized based on the dried size limits from other countries. Size limits vary per species and country (see Purcell et al. 2012), which could have been based on sizes at sexual maturity. For example, New Caledonia implements the following size limits for *H. scabra* (30 cm live, 11 cm dried), *H. fuscogilva* (25 cm live, 16 cm dried), and *T. ananas* (45 cm live and 20 cm dried). These size limits could be adapted in Cawili, pending studies on size at sexual maturity of commercially harvested sea cucumber species in the country.

The inclusion of juvenile sea cucumbers in the fishery may lead to overfishing and disappearance of species. Sea cucumber overfishing can significantly reduce species diversity and density (Jontila et al. 2018) and may cause ecosystem imbalance. If this situation continues, recruitment failure may occur (Purcell et al. 2013), affecting not only the ecosystem but also the income of local fishers and the country's export revenue.

According to Purcell (2014), the prices of dried sea cucumbers in Chinese stores varied up to ten-fold and were mostly influenced by species, body size, and quality. For example, the price of large (12 cm dried length) *H. scabra* is about seven times higher than the small ones (5 cm dried length). High earnings from sea cucumber gathering could be, therefore, sustained by implementing size limits. When effectively practiced, size limits could ensure steady supplies of recruits (because the species are allowed to breed at least once before being captured and processed) and sustained the sea cucumber fishery on the island. An education campaign about the ecological values of the species and the consequences of overharvesting may help change the attitudes of the people and win their full support to conservation initiatives.

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ACKNOWLEDGEMENTS

We are thankful to the residents of Cawili, Cagayancillo, Palawan for their assistance. Also, thanks to Escubin family and Pastor J. Cayaon for providing the local names of the species. Appreciation is also extended to the two anonymous reviewers.

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ARTICLE INFO

Received: 08 May 2019
Revised: 23 April 2020
Accepted: 07 May 2020
Available online:____ 2020

Role of authors: RBA – collected the data and wrote the manuscript; NJMFM – wrote and edit the manuscript; RGD - conceptualized the study, and wrote and edit the manuscript.

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